Vertical co-ordination in the New Zealand lamb supply chain: implications for breeders, finishers and processors

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Abstract

In 1998, the New Zealand sheep industry exported approximately 347,100 tonnes of sheepmeat to international markets. In 1996, the total number of sheep in the country was 47.3 million head with 9.5 million hectares dedicated to sheep and beef cattle enterprises. Traditionally, sheepmeat has been directed towards commodity markets, but a more recent strategy has been to target premium markets for specialised lamb cuts. Vertical co-ordination among participants in the New Zealand lamb meat supply chain (breeders, finishers, processors, marketers and retailers) is necessary to compete in premium markets overseas.

New Zealand's seasonal pastoral systems are characterised by their heavy dependence on external variation (i.e. weather, market prices). Seasonal pasture production determines a well-defined lamb supply pattern and affects the price that farmers receive for their produce. Adequate price setting for vertically co-ordinated participants is therefore necessary in order to achieve a consistent supply of sheepmeat for international markets.

Long-term contracts between New Zealand producers and processors would be a feasible vertical co-ordination mechanism. However, contracts can only be established if participants agree on product specifications and price. Farmers therefore need to know their cost of production on a $/kg lamb meat basis in order to be able to negotiate a price for their sheep.

The aim of the research was to appraise the importance of vertical co-ordination through forward contracting for the New Zealand lamb industry and to assess measures to control the risk exposure of lamb producers and processors. The research also aimed to provide processors, finishers and breeders with a better understanding of producers' risk-return profiles.

The source of physical and financial information was the New Zealand Sheep and Beef Cattle Farm Survey for the 1995-96 season. The software Stockpol® was used to simulate the biological performance of sheep enterprises on different pastoral production systems. Activity-Based Costing (ABC) was then applied to determine cost of lamb production for participants in the supply chain. A discrete stochastic programming (DSP) model was also developed to evaluate the impact of variation in lamb production cost for participants under alternative conditions for business and financial risk. Risk was considered by simulating different weather conditions and by varying biological production and financial parameters.

The average cost of production of a kilogram of lamb meat at the farm gate for all farm classes was estimated at NZ$ 2.88. This break-even point is the market price at which direct and overhead expenses, including the cost of capital, are covered. The average price received by farmers for lamb meat during the 1995-96 season analysed was NZ$ 1.97/kg. This price was NZ$2.33 /kg in 1997 and the estimate price for 1998 is NZ$ 2.13 /kg. This cost of production varied for the farm case studies according to their financial structure, biological efficiency parameters (lambing percentage, wool production lamb growth rates) and wool and lamb purchase prices. The simulation results showed that pasture production and utilisation (influenced mainly by weather conditions and farm management skills) has a big impact on the cost of lamb production. The modelling exercise suggested that a mix of contractual arrangements for the premium produce of the farm and spot market bargaining power for the remainder would be the optimum alternative for farm managers.

The use of ABC for farm planning purposes can be considered as a means to control both 'risk exposure' and 'risk impacts'. The assessment of cost of production under possible scenarios of DM production could be used to evaluate innovative contractual arrangements between producers and processors.

The study showed that supply chain synchronisation in the New Zealand lamb industry is necessary for targeting premium markets, and that a deep knowledge of participants' risk-return profiles is essential for building trust between participants in the supply chain. Traditionally, New Zealand farmers have worked in an adversarial environment, while new market requirements for their products require the opposite.

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1 General introduction

1.1 The New Zealand lamb industry

Sheep and beef cattle farming is a major economic activity in New Zealand. In 1987, sheep and beef products sales represented 7.7 % of New Zealand's gross domestic product (GDP). This figure reached 8.4 % in 1993 and 7.7 % in 1996 (MAF 1996). Meat exports contributed 18% of total merchandise trade earnings in 1996 (NZMWBES 1997a).

New Zealand is the dominant world exporter of sheep meat. In 1996, 81 % of its total sheep meat production was exported, or 53.4% of the world mutton and lamb exports (NZMWBES 1997a; Taylor 1998). A total of 344,500 tonnes of sheep meat were exported in 1997, and it is expected 347,100 tonnes will be exported in 1998 (SONZA 1997).

The New Zealand sheep industry seeks to achieve international competitive advantage by improving the efficiency of sheep production through breeding technologies, genetic improvement, pasture production and flexible management systems. These technologies and the competence of its farmers enable New Zealand to be recognised as a specialised supplier of lamb. This specialisation is reflected in the increments of the volume of lamb exported as specialised meat cuts rather than undifferentiated carcasses (Thomson 1994; AgResearch undated). In 1980, 20% of sheepmeat exports to the European Union were in cut form. This increased to 60% in 1990 and 75% in 1995 (Burtt and Francis 1996).

The land area used for sheep and beef cattle farming in New Zealand has declined by 14% from 11.4 million hectares in 1985 to 9.5 million hectares in 1996. Sheep numbers have also declined from 68 million in 1986 to 47.3 million in 1996 (MAF 1996). These negative trends are a consequence of the relatively low profitability of sheep and beef cattle enterprises in comparison to other livestock operations and the greater perceived profitability of land uses not involving livestock (i.e. horticulture, forestry, cropping or non-agricultural enterprises) (The National Bank 1996). For example, according to Burtt (1997), hill country sheep breeding enterprises in the 1996-97 season generated a gross margin of $27.62 per stock unit (su) and beef breeding enterprises $18.45/su, while dairy operations produced $134/su, and deer breeding $40.05/su. At a stocking rate of 15 su/ha, sheep and beef cattle enterprises would generate a gross margin of approximately $400/ha, while cropping wheat would produce $953/ha (in 6-7 months), and export apples up to $13,691/ha (depending on land suitability).

New Zealand sheep products are exposed to changing economic and market circumstances (Martin 1996). Wool, lamb and mutton prices fluctuate depending on global production, the climate, currency exchange rates, economic growth and product access to different markets. Sheep product prices also depend on domestic issues, including trends in sheep numbers and the financial performance of processors (The National Bank 1997). For example, the average lamb export schedule price (nominal) to farmers rose from $31.13/head in 1990 to $43.00/head in 1997 in response to fewer lambs slaughtered, and external factors such as the BSE scare in the United Kingdom. The export price for mutton increased from $17.98/head to $33.50/head over the same period (NZMWBES 1997a).

1.2 Scope and purpose of the research

The overall aim of the research was to appraise the importance of vertical co-ordination to the New Zealand lamb industry and to assess measurements to control the risk exposure to individual lamb producers and processors through the use of forward contracting. The hypothesis tested by the research was:

"The assessment of the cost of production for lamb production systems can be used as a negotiating tool for considering forward contracts for lamb meat."

The research objectives related to this hypothesis were:

1. To define and identify, through a literature search, the components and associations of global best practice in demand-driven production systems within agricultural and non-agricultural industries.

2. To model the biophysical elements of New Zealand sheep and beef farm classes for a productive season, in order to identify the diversity in the current lamb supply chain in terms of feed production and utilisation.

3. To apply the Activity-Based Costing system (ABC) and to conduct a Break-even Point (BEP) analysis to all farm classes to calculate their cost of production of lamb meat.

4. To model business and financial risk in the calculation of the cost of production of lamb meat for a farm class, in order to illustrate the effects of external variability in the physical and financial performance of New Zealand farm systems.

5. To illustrate the use of risk analysis and computer simulation technologies in estimating the cost of production of specific lamb supply patterns for individual producers.

In many instances the relationship between the components are difficult to quantify and qualitative assessments were required to complete the data set. The participants in the supply chain included in the scope of this research were producers (breeders and finishers) and primary processors. The implications on the entire supply chain (i.e. further processing, marketing, selling, transport, retailing) therefore were not quantified.

1.3 Outline of the study

Relevant literature associated with vertical co-ordination issues is reviewed in the second Chapter. Sources of competitive advantage for the New Zealand lamb industry are identified. Strategic alliances in the supply chain and considerations for its implementation in the lamb industry are outlined. The third chapter contains a description of the New Zealand sheep and beef cattle farm classes used for the study. The data collection is described, the modelling process is explained and the use of specific software justified. The importance of determining the cost of production of lamb meat is described in Chapter 4. The methodology employed to conduct the risk analysis on a farm class is explained in Chapter 5. This chapter also contains an illustration of how computer simulation can be utilised to consider the use of contractual situations for a farm class. The sixth and final chapter contains general discussion about the findings from the study, a review of the strengths and weaknesses of the methods employed, conclusions, and an outline of relevant points to consider for further research.

2 Vertical co-ordination in the New Zealand lamb supply chain

2.1 Introduction

Global markets in today's business environment provide many opportunities for export enterprises, but they also bring fierce world-wide competition. An understanding of *competitive advantage* and *value chain* (Porter 1985) provides the basis for a wide variety of concepts and management tools aimed at establishing successful business strategies. Porter (1985) defined value as the amount that buyers are willing to pay for what a firm can provide. Thus, the common strategy among firms is to increase the value of their products to achieve customer requirements faster and better than competitors. Burtt & Francis (1996), den Ouden *et al.* (1996) and Dijkhuizen (1998) reported that consumers and society in many countries have shown increasing interest in methods of production and product quality in agriculture, particularly concerning issues such as animal welfare, environmental pollution, food safety, use of HGP (Hormone Growth Promotants), residues, and BSE. This increased interest of customers justifies vertical co-operation and product differentiation in agricultural supply chains (Boehlje *et al.* 1998; Bunte and van Tongeren 1998; Dijkhuizen 1998; Huirne and Hardaker 1998). On the other hand, Farrell & Tozer (1996) pointed out that the more the final consumer knows about product quality (tenderness, fat percentage, cooking loss, pH and flavour), the greater the barrier to entry into specialised lamb markets. This chapter contains a literature review conducted over a broad range of business publications concerning adding value within supply chains. Much of the literature is not directly related to agricultural businesses. Nevertheless, these theories and empirical studies can be applied to New Zealand pastoral enterprises to develop world 'best practices', in order to expand the national sheep industry's competitive advantage in international sheepmeat markets.

2.2 Benchmarking the industry

Benchmarking can be defined as "the process of identifying, understanding and adapting outstanding business practices to help improve performance" (Cook 1995, p. 13). It is considered as a tool for improvement, and is usually achieved through comparison with other organisations recognised as the best within the area (Andersen & Pettersen, 1996). New Zealand sheep farmers could benefit by comparing their business practices with those of other livestock or non-agricultural industries. The principal aim of benchmarking is to modify current business processes according to the best practice available, in order to accomplish customer's expectations better and faster than the competition.

Broadly, benchmarking can be divided into the following areas: internal, competitive, functional and generic (Andersen & Pettersen, 1996). Internal benchmarking is generally used by large corporations where different units are evaluated and compared to each other. Competitive benchmarking is an extension of competitor analysis, focusing on best practice rather than the industry average. Functional benchmarking is accomplished by evaluating partners (customers and suppliers) within the same industry. Finally, generic benchmarking involves finding companies in totally unrelated industries that perform similar processes and adapting their best practice according to local needs. Benchmarking is "essential to the successful management of any farm or agribusiness firm" (Boehlje, 1994, p. 109) and for establishing farm strategies (Kirton *et al.* 1994).

In New Zealand, publications like the New Zealand Sheep and Beef Farm Survey (NZMWBES, 1997b), and the Farm Monitoring Report (MAF, 1998) enable farmers to compare their own financial and physical performance with averages in the industry. These publications show the physical and financial performance of groups of similar farms within New Zealand. Sheep farmers should keep in mind that conducting this comparative analysis cannot be considered as a complete benchmarking process. These types of benchmarking analyses usually focus on outstanding particular examples that can be reported in a wide range of business publications and adapted to local needs.

2.2.1 The search for competitive advantage

According to Porter (1985), the main sources of competitive advantage are either a lower relative cost advantage or differentiation. Dapiran (1992) and Ashkenas *et al.* (1995) suggested that the new success factors in contemporary business are speed, flexibility, integration and innovation. This suggests that traditional differentiation factors, such as quality assurance, do not separate firms anymore in terms of market share. For example, according to Upton (1997), quality assurance cannot be claimed as a competitive advantage for New Zealand producers given the fact that low cost producer countries such as Chile, Argentina or Zimbabwe are also able to meet high quality standards. These new competitive factors (speed, flexibility) can be accomplished through better management of logistics and the implementation of new ways to integrate the whole supply chain. The term 'supply chain' refers to "...linking each element of the production and supply process from raw materials through the end customer" (Scott & Westbrook 1991 p. 23).

Holmes (1995) showed that logistics would become a competitive factor within European businesses through cost reductions and improved customer service. This author defined logistics as "the strategic management of the entire supply chain, from product and market development to cash collection" (p. 19). It is important to recognise that every supply chain is different because of product and industry characteristics: the associated logistics management is usually complex. Each chain has a variety of roles, functions and trade partners. European firms consider that planning and using real-time information throughout the supply chain will enable them to respond quickly to change, and these are the processes that require more attention in their organisations (Holmes 1995).

Just in time (JIT) delivery has been a crucial practice for the survival of companies in the 1990s (Schonberger 1990; Whickhan 1993; Goldratt 1997). Improving the flow of products through the supply chain reduces costs, improves quality and increases the firm's flexibility. According to authors reviewed by Waters-Fuller (1995), JIT purchasing practices include: small purchase lot sizes delivered in exact quantities, trends to reduce the number of suppliers, supplier selection and evaluation based on quality and delivery performances, quality inspection at the supplier's facilities, deliveries synchronised with the buyer's production schedule, geographic proximity of suppliers and improved data exchange. For JIT delivery to work, it is vital to exchange comprehensive planning and scheduling data before production commences (Waters-Fuller 1995). The exchange of data can include schedule changes, quality or delivery problems or costing, purchase orders, advanced shipping notes and invoices.

2.2.2 Customer driven production systems

Key factors for achieving demand-driven production systems were identified by Dapiran (1992) and Christopher (1994). These included: developing a logistics vision and a complete understanding of how each functional area can be integrated to deliver customer satisfaction; clearly understanding the distribution channels of the organisation; and developing a customer-oriented manufacturing process that is flexible and responsive to customer demand. It is also important to determine the right combination of in-house competencies and outsourcing, including centralising high-technology operations such as scheduling systems and information processing. Customer-driven systems require a high level of planning, a strong commitment to external alliances with suppliers and an investment in state-of-the-art information technology.

For Christopher (1994) the main barrier to the implementation of the logistics concept is the rigid organisational structure of established companies. The flow of information and materials between sources and users should be co-ordinated and managed as a unique system. Thus, it is very important to seek out long-term partnerships with both suppliers and customers because customer orders and their associated information flow constitute the "heart" of the business. The *Customer Order Management* shown in Figure 2.1 is a planning framework that links information with the physical flow of materials in terms of forecasts, requirement plans, material and production control, and purchasing. The main reason for supply chain inefficiencies is the lack of co-ordination between the various parties in the chain. Partnership and co-operation between companies are therefore essential if the full benefits of a customer order system are to be achieved.

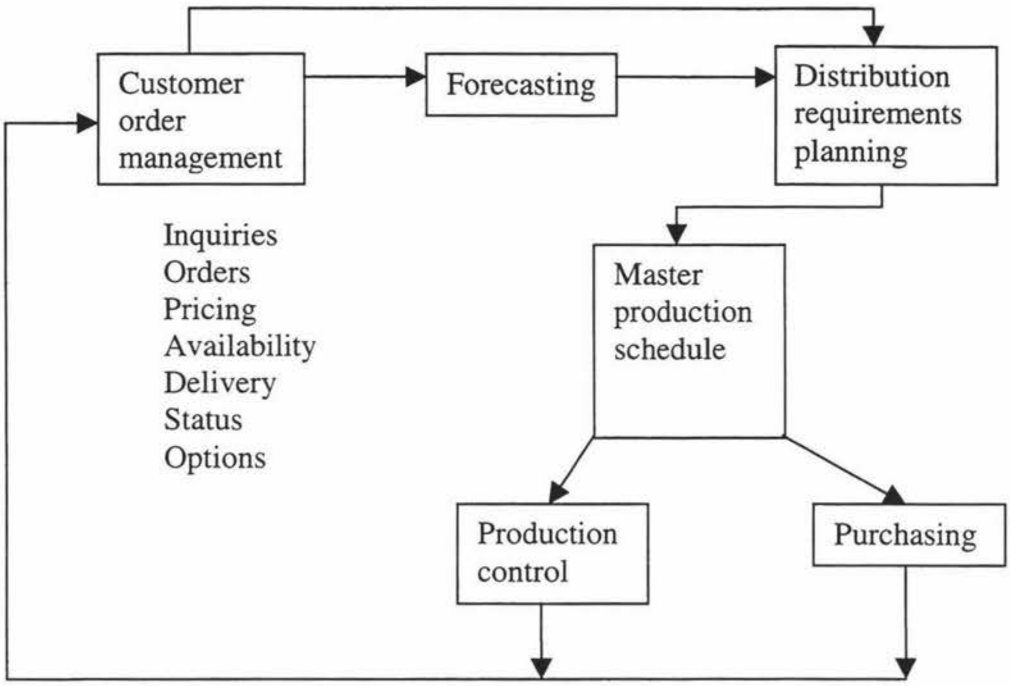

Figure 2.1 Customer order management framework.
Adapted from Christopher (1994).

Proud (1995) and Gumaer (1996) suggested that a major source of competitive advantage for companies is the ability to speed up the supply chain process, from customer demand to manufacturing to distribution. The major challenge for a master scheduling system is to balance product demand with supply. Master scheduling is a demand-driven process, with a high dependence on the accuracy of sales forecasts. Processors are responsible for controlling the flow of materials to fulfil customer orders from suppliers. Thus, it is very important for them to receive accurate forecast information from retailers and to transmit production orders to suppliers. Master scheduling systems are essential to co-ordinate this flow. Historically, manufacturing firms have used systems to help them to meet production management challenges (Gumaer 1996). These tools have evolved from Manufacturing Resource Planning (MRP II) and Enterprise Resource Planning (ERP) in the 1960's to Supply Chain Management (SCM) solutions in the 1990's. The tools for SCM include software packages that combine real-time information exchange with advanced planning technologies.

A good information system monitors and controls performance, and facilitates the co-ordination of inter-related functions (Anonymous 1991). Davis and Olson (1985) defined an information system as "an integrated, user-machine system for providing information to support operations, management, analysis and decision-making functions in an organisation" (p. 1465). Electronic Data Interchange (EDI) refers to the exchange of standardised, formatted data between computer systems via remote data transmissions (Hunt *et al.* 1998). This has been recognised as a key factor in linking the market place with manufacturing processes (Dapiran 1992). It allows firms to adapt rapidly and constantly to changing customer preferences. The purpose of a common information system is to provide end-to-end visibility of the logistics pipeline from order through delivery (Christopher 1994). Information and communication technology (ICT) is therefore vital to manage supply chains (Hunt *et al.* 1998).

An ICT should enable food supply chains to track all relevant food information from its original source to the final customer. This tracking capability can give competitive advantage to firms by enabling them to provide customers with information regarding the source of food products. It is now possible to use non-expensive software and equipment to communicate along the supply chain by combining EDI, bar coding, databases and Internet/Intranet technologies. Information technology (IT) enables suppliers and manufactures in the supply chain to achieve accuracy and timeliness in fulfilling orders and to transfer information to business partners (Hunt *et al.* 1998). Today's information society makes IT essential to increase customer's belief in agricultural products.

The Internet can be use effectively to transmit information regarding lamb products (Boeve 1998). Combining bar coding, databases, and communication networks can result in a powerful marketing tool. An example of such application is the system IVI® (Integrated Veal Information, Boeve 1998). IVI® uses IT that makes it possible to transfer bar codes from the calves' ear tags to the product label. Therefore full traceability of the product is ensured. Each product label contains an Internet address and a password. On entering a product code (tag identification number) into the Internet site, all relevant product information is available concerning the origin of the animal, farm location, all the medication (s) the animals have received during their lifetime, information on quality systems, results of ante and post mortem controls, logistics and packaging information, commercial services and recipes. It is also possible to prompt for feedback into the system. The benefits of such a system have not yet been quantified, though it is clearly a potentially powerful marketing strategy to target 'safe food' consumers.

2.2.3 Example of successful supplier co-ordination

Establishing strategic alliances between processors and suppliers has been identified as a success factor for many industries. Strategic alliances give companies the ability to deal with changing market realities, improve quality and reduce response time and total cost. Mobil Oil's strategy in terms of strategic alliances is shown in Figure 2.2. According to Underhill (1996) many companies in the US are following the same trend. Mobil Oil recognised the need to reduce its supplier base when they realised that 91% of Mobil's purchases came from 15% of its suppliers. Therefore the cost of maintaining 85% of its supplier base for only 9% of purchases did not make good business sense. The forecast for 1999 indicates that strategic alliances will dominate as the preferred structure for relationships with company suppliers.

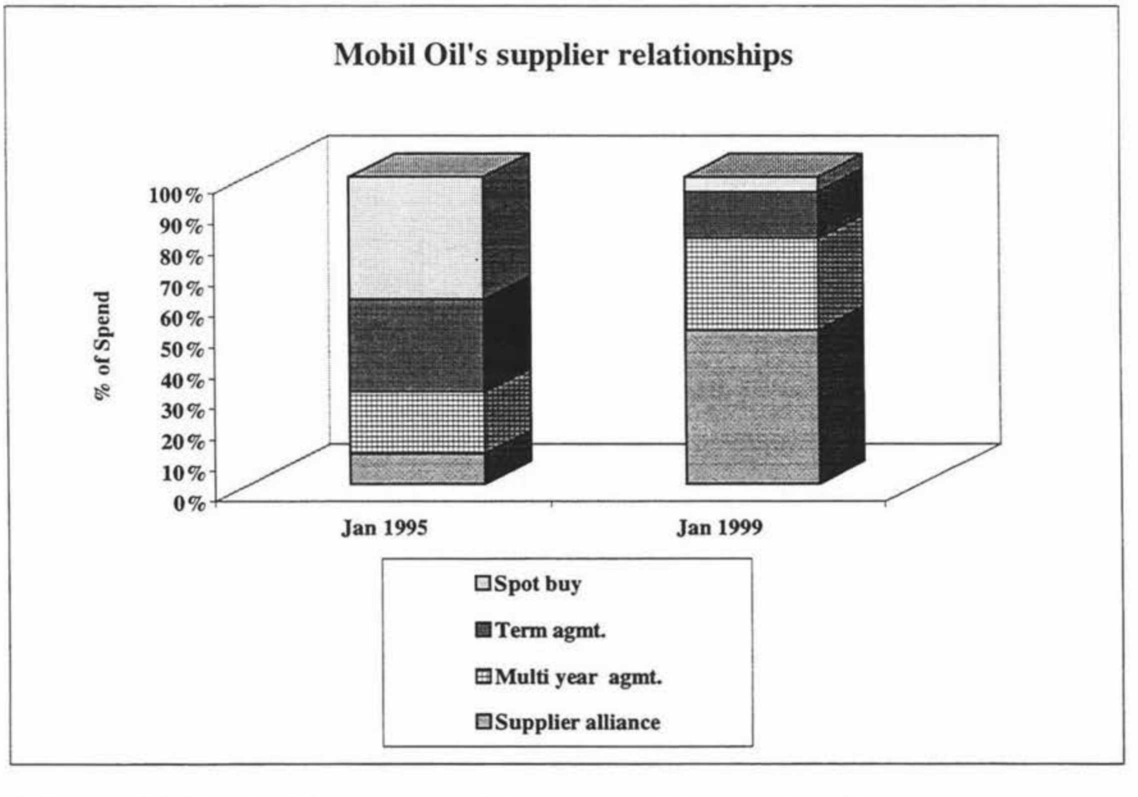

Figure 2.2 Mobil Oil's current and future supplier relationships.
Source: Underhill (1996, p. 42).

Marks & Spencer is the fourth most profitable retailer in the world. Its main competitive advantage can be attributed to its co-operative relationships through the supply chain: from raw material producers to transport contractors. It is also recognised as an example of best practice in partnering with its suppliers (The Centre for Strategic Business Studies 1997b).

Benetton is recognised for rewarding co-operation and relationship building. The company links 180 raw material suppliers, 450 sub-contractors that carry out the manufacturing operations, and 6,000 retailers in 83 countries (Dapiran 1992). The firm provides its suppliers with production planning, planning for material requirements (scheduling), quality control, technical assistance and financial aid for leasing and buying equipment. In return, suppliers have to produce exclusively for the company. They benefit from a guaranteed market and high levels of capacity utilisation. They also recognise that co-operation facilitates stability and reduces risks (Dapiran 1992; The Centre for Strategic Business Studies 1997c). The application of EDI enables Benetton to regularly transmit customer orders from retailers in several countries to Benetton's head office. This knowledge of the market is updated every 24 hours. The result is that the firm tracks and reacts to demand by only manufacturing garments required by customers. Benetton's information system eliminates the filters between the end customer and production. Thus, the competitive advantage for Benetton resides in its ability to effectively integrate the components of the value chain (Dapiran 1992).

IKEA is the world's largest retailer of home furnishing. One key success factor for this company has been its relationships with suppliers (The Centre for Strategic Business Studies 1997d). The relationship of IKEA and suppliers is based on their mutual interest in success. IKEA provides technical assistance to achieve quality standards. Supplying IKEA means access to international markets, technical guidance, and help with security finance or leasing equipment.

The US pork industry is evolving from a spot market of small independent producers and processors to a contract co-ordinated industry with fewer and larger firms (Lawrence *et al.* 1997). The vertical co-ordination of these producers and processors has been established via joint ventures, ownership or production contracts. Vertical co-ordination has brought diversified risk, assured supplies and markets, facilitated information exchange and synchronised output and production flow, and achieved economies of scale. Trends in co-ordination arrangements between 45 large packers and producers in the US are shown in Table 2.1. According to Lawrence *et al.* (1997) these trends are likely to become more common in the future.

Table 2.1 Marketing methods of 45 large US pork packer-producer co-ordination arrangements.

Marketing methods	1993 (%)	1998 (%) forecast
Open spot markets	74.2	10
Forward contracts	18.1	73
Packer producer & joint venture	7.9	17

Source: Lawrence *et al.* (1997 p. 27).

Farmland Industries is the largest beef cattle regional US co-operative. It is a Fortune 200 company with over US$9 billion in sales. The company has offered a branded premium beef (Farmland Black Angus Beef™) since 1993. Farmland's main problem had been the procurement of Black Angus cattle of consistent superior quality. The company implemented sourcing alliances through the supply chain and this resulted in improved quality supplies and higher premium payments to participants (Pierce & Kalaitzandonakes 1998). Key success factors in achieving better returns were the effective communication of market signals throughout the supply chain via premiums for achieving quality standards and the transmission of performance and carcass information for each animal to producers in order to ensure quality adjustments. Collaborating producers obtain more information about the carcass quality of their animals, and they can search for competitive premiums among alternative value added programs (Pierce & Kalaitzandonakes 1998).

A final example is the broiler industry in the US which started developing in 1955. Around 90 percent of the broilers have been working under contracts since then. Broiler consumption in the US has increased from 0.3 kg per capita in 1935 to 32 kg in 1996, and has surpassed beef consumption since 1993. This industry provides an excellent example of the importance of industry organisation in the food industry (Martinez 1998).

2.3 Vertical co-ordination

Because both quality and quantity of deliveries are vital (Schonberger 1990; Waters-Fuller 1995), one of the greatest problems encountered in working JIT systems is a lack of communication with suppliers and therefore a lack of support. Integration of different participants in the supply chain could help to avoid or minimise these problems. Carlisle & Parker (1989) defined the traditional adversarial approach to supply chain management as: "haggling in the hope of making their own piece of the transaction pie larger than the one received by the other party" (p. 8) This approach inhibits business effectiveness for several reasons. First, each firm develops its strategies and plans independently of the others. Second, firms are deficient in problem-solving and sharing key information and, as a consequence, both parts in the value chain are motivated by their own rewards and immediate targets. Third, firms do not share resources that could be used to the benefit of the complete chain. Thus, resources are sub-utilised (Ashkenas *et al.* 1995).

2.3.1 Supply chain integration

Some authors contend that company competitiveness depends on the effectiveness of the value chain as a whole (Schonberger 1990; Ashkensas *et al.* 1995; Lewis 1995; den Ouden *et al.* 1996; Goldratt 1997). In fact, the Theory of Constraints (TOC) states that the performance and efficiency of the overall supply chain depends on its weakest link (Goldratt 1997). Moreover, den Ouden *et al.* (1996) and Huirne & Hardaker (1998) argued that the optimisation of individual links in the supply chain might cause sub-optimal performance by the chain as a whole. Consequently, JIT purchasing aims to reinforce relationships with suppliers through long-term contracts and co-operation. Long-term relationships with suppliers encourage loyalty, reduce risk of interruption to supply, eliminate re-tendering costs and ensure that costs are reduced in the long term through repetition (Manoochehri 1984; Schonberger & Ansari 1984; Larson

1994). The vendor must deliver total quality products and responsibility is placed on the supplier to achieve and sustain total quality. Buyers have to select and evaluate suppliers according to quality, long-term relationship and co-operation, delivery performance, geographical location, price structure, management attitudes, and planning and technical capabilities (Waters-Fuller 1995).

There is a perception that JIT sourcing pushes responsibilities and costs from the processor to the suppliers. Specifically, the supplier becomes responsible for quality, delivery and inventory. It seems that most of the benefits accrue to the buyers, while most costs are borne by the suppliers (Waters-Fuller 1995). On the other hand, power is shifted from the buyer to the suppliers because the buyer becomes highly dependent on the performance of its supply base. A more positive perception may be achieved through the creation of mutual dependency, resource abundance and homogeneity of goals and interests. Schonberger (1990) stated that JIT purchasing benefits both buyers and suppliers through lower overall costs, higher productivity and improved quality. However, Waters-Fuller (1995) pointed out that many authors have reported cases of suppliers being forced to hold inventory for their customers at high costs.

According to Underhill (1996), two thirds of alliances between companies in the US encounter serious financial or managerial problems within the first two years, and only fifty percent are considered to be successful. The main reason for failure is that the alliance is not a "win-win" situation for both parties. Thus, companies need to understand each other's cost drivers in order to improve satisfaction for all participants. Market imperfections and conflicting interests were attributed as possible causes of problems in supplier-customer alliances by den Ouden *et al.* (1996). Possible areas of conflict between alliance participants include inconsistencies in the overall goal of the operation, incomplete information exchange, inequitable distribution of returns, capture of control over decisions, and unequal sharing of risks.

2.3.2 Strategic alliances for competitive advantage

There are different definitions in literature for the terms strategic alliance, partnership sourcing and vertical co-ordination. All of them refer to co-operation between two or more participants in the supply chain. Vertical co-ordination can be achieved through vertical integration or through formal contracts (King 1992). den Ouden *et al.* (1996), and Farrell & Tozer (1996) distinguished between *vertical integration* and *vertical co-operation.* Both concepts involve the combination of two or more stages of a production-marketing chain. However "vertical co-operation refers to the vertical relationships between two or more adjacent stages without full ownership or control, in which the partners fundamentally maintain their independence" (den Ouden *et al.* 1996, p. 281). It can take different forms such as sub-contracting agreements, franchising, or joint ventures (Pierce & Kalaitzandonakes 1998; Poole & Del Campo Gomisvi 1998). These modes differ in duration, type, and degree of control or ownership. According to King (1992) vertical co-ordination arrangements can help processors and retailers to ensure predictable supplies and consistent quality. For producers, on the other hand, they can offer price stability and access to information. Companies can source supplies from the spot market, term arrangements, multi-year arrangements or *strategic alliances*. A strategic alliance can then be defined as a "combined effort by two or more companies linked together in the supply chain to reduce the total cost of acquisition, possession, and disposal of goods and services for the benefit of all parties" (Underhill 1996, p. 1). For some other authors, however, a strategic alliance also implies an effort to jointly improve quality and productivity (Larson 1994).

According to Underhill (1996), supplier alliances minimise costs, reduce supplier risk and eliminate buying variation. This enables suppliers to meet customers' requirements more easily. Farrell & Tozer (1996) suggested that alliances are established in order to develop the market for products with particular specifications and to increase market share by developing inter-sectorial loyalty. Strategic alliances can also bring collaborative working, agreed objectives, mutual learning, creativity, innovation, greater efficiency and effectiveness to the supply chain (The Centre for Strategic Business Studies 1997a). It has been argued that the main reason for agricultural firms to consider vertical co-ordination is the minimisation of production and transaction costs (Frank & Henderson 1992). The contracts established between firms under vertical co-ordination can be market specification, production management and resource providing. These co-ordination methods reflect the degree of control that one firm exercises over the other. These authors also pointed out that vertical co-ordination involves both the value of input-output interdependencies between firms and the degree of administrative control that is consolidated by the contractor.

Partnership sourcing can result in more flexible responses to market changes and more focused product development (Ashkenas *et al.* 1995). Partnership sourcing requires increased movement of information and resources. Lewis (1995) stated that the integration of suppliers and customers can double their competitive resources, reduce costs, enhance quality, reduce processing times, increase product differentiation and improve customer satisfaction without added expense. The comparison of market transactions and customer-supplier alliances under different forms of contracts are presented in Table 2.2.

Table 2.2 Customer-supplier alliances compared to market transactions.

	Market		**Customer-Supplier**
	Fixed Contract	Incentive Contract	Alliances
Behaviour	Comply with contract terms	Supplier stretches	Both stretches for continuous improvement
Result determined by	The market	Supplier's skills	Both firm's skills
Use when	Customer wants standard values	Customer wants additional value	Customer wants maximum value
Improvement requirement	Market-paced improvement is acceptable	Supplier controls improvement	Both contribute to improvement
Relationship and period	Arm's length short term	Arm's length	Partners: high trust long term

Source: Lewis (1995, p. 11).

Several types of alliances were identified by Underhill (1996). As shown in Table 2.3, they differ according to the cost drivers on which the alliance is focused.

Table 2.3 Characteristics of some strategic alliances.

Alliance type	Characteristics
Single sourcing	The customer purchases everything from one source. The supplier reduces its price in return for reduced risk. This arrangement is often advantageous to the customer
Partnering	Active interest in reducing total cost aspects beyond price. Cost drivers involved are scheduling, order processing, quality, delivery, paper work.
Supply chain management	The focus is to go beyond the immediate link in the supply chain and involve multiple companies to reduce total channel costs.

Adapted from Underhill (1996).

On the other hand, Holmes (1995) suggested that firms tend to establish closer links with suppliers and customers at two levels. The first involves straightforward *transactions* between customers and suppliers while the second entails agreement between the parties to operate the whole supply chain through a *process of strategic integration*. This integration involves electronic data interchange (EDI), JIT, bar coding, partnership agreements, sharing of sales information and joint marketing plans, improvement programmes, joint planning and scheduling.

2.3.3 Contracts

Agricultural systems are exposed to uncertainty, complexity and imperfections in the economic environment; thus control over the supply chain is needed (Poole & Del Campo Gomisvi 1998). Transaction costs can be reduced by contracts specifying physical, technical and economic characteristics of the product and the terms of the transaction. Poole & Del Campo Gomisvi (1998) proposed a diagram that represents the environment and determinants of contractual arrangements between agricultural firms (Figure 2.3). The exchange of products can be co-ordinated through spot markets, contractual arrangements or vertical integration. Utility is calculated from transaction benefits and risk. Transaction benefits are total revenues less total costs. Risk is a function of risk aversion and the probability of loss attached to different contractual forms. Uncertainty is related to the characteristics of the transactions, the behaviour of individuals and firms, and information exchange.

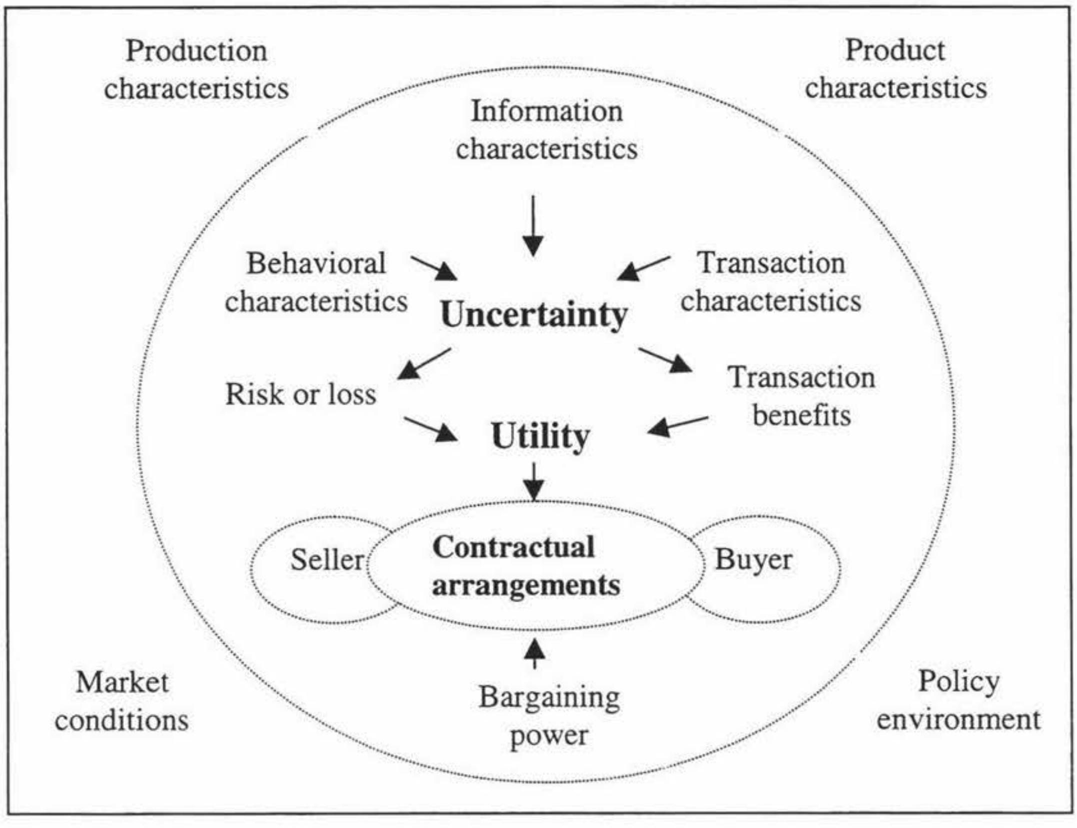

Figure 2.3 The environment for, and determinants of, contractual arrangements.
Source: Poole & Del Campo Gomisvi (1998, p. 201).

Gaucher *et al.* (1998) suggested that contracting can be conducted under two main frameworks: incentive theory-pricing rules and anti-trust policy. For the former, the principles for developing co-ordinating contracts are: to develop global strategies to increase the value of the whole supply chain; to design a collective plan for the whole chain and to design quantity and price regulation once the common strategy and the management roles have been accepted. This means the intervention of all actors and their expectations. In this process it is very important to highlight the link between global strategies and management practices. Anti-trust policies, on the other hand, refer to trading practices characterised by lack of adequate information exchange and opportunistic behaviour among participants. These policies are perceived to have negative effects in vertical co-ordination efforts.

2.3.4 Factors affecting vertical co-ordination in the lamb industry

The concept of a supply chain in the lamb industry embodies breeders, finishers, processors, exporters, carriers and retailers. The "raw materials" that flow through the supply chain are lambs from when they are innate, finished and then processed to produce fresh, chilled and frozen lamb cuts (final product). Farrell & Tozer (1996) indicated that "strategic alliances are not a new concept in the food market, but are relatively new in the primary production stage of the market" (p. 145). Australian farmers established alliances within the lamb industry to develop the market for products with certain specifications and to increase market share by developing inter-sectorial loyalty (Farrell & Tozer 1996). Alliances are also established in order to avoid quality problems and extra inspection costs, or due to the inability to adopt a JIT production system and the cost of carrying extra inventory (Larson, 1994). Lawrence *et al.* (1997) reported that strategic alliances also provide greater synchronisation of animal quality attributes and volume of supply demanded by today's markets. Some of the incentives for chain formation in the pork and poultry industries in the U.S. are to capture efficiencies and control costs, to reduce risk and to respond to consumer demands (Boehlje *et al.* 1998).

Boehlje *et al.* (1998) and McDermott & Shadbolt (1998) contend that under spot market arrangements it is becoming increasingly difficult to co-ordinate messages concerning animal product attributes (quality, quantity and timing) and transaction characteristics. Thus other co-ordination options such as contracts, alliances or integration should be investigated. The risk derived from the free-market (risk premium or cost to the final lamb product) can be dissipated through the effective management of a supply alliance (Farrell & Tozer 1996). These authors also point out that the lamb industry can gain competitive advantage and establish entry barriers for other competitors if they understand market requirements, quality control from farm to plate, and product promotion. According to Lawrence *et al.* (1997) pork packers in the US perceived that market contracts with suppliers improved the quality of hogs, consistency of supply and increased volume of animals supplied. They also detected some potential disadvantages such as increased packer price risk, reduced flexibility and possible higher prices paid for hogs under contract. On the other hand, producers recognised the main disadvantage of working under contracts to be the inability to take advantage of better price bids from other packers. The most important benefits for producers were access to 'shackle' space, reduced market risk and reduced transaction costs. Barry *et al.* (1992) detected that farm-level product differentiation leads to vertical integration or contracting between participants in the market system. They found that the main concerns among participants were the amount of transaction costs, the redefinition of boundaries of the firms and the linkages between firms' financial structures. Schrader (1986) also identified that agricultural firms co-ordinate with others to increase efficiency, gain market advantage, reduce risks, obtain finance and reduce transactions costs. Farrell and Tozer (1996) identified some characteristics that lamb farmers should have attained in order to establish strategic alliances with processors (Table 2.4). These farmer attributes could be considered as supplier selection criteria by the lamb processors.

Table 2.4 Farmer attributes to establish strategic alliances in the lamb supply chain.

Understand all operations and functions of other participants in the alliance
Use improved genetics
Control nutrition
Know how to estimate dressing percentages
Understand factors affecting meat quality

Source: adapted from Farrell and Tozer (1996).

Farrell and Tozer (1996) highlighted the importance of receiving feedback from the processors and monitoring progress regularly, because it is essential that lambs supplied through the alliance are delivered according to a planned schedule. The implementation of a JIT production system within the New Zealand lamb industry faces the problem of erratic supply-demand patterns due to seasonal production (McDermott and Shadbolt 1998).

Distrust is another important factor affecting lamb supply chains in New Zealand. According to McDermott and Shadbolt (1998) "the store market does not assist the finisher's need for a profitable and continuous supply of quality lambs; nor does it offer the breeder a stable price for lambs" (McDermott and Shadbolt 1998, p. 593).

The same authors comment: "The many years spent by the industry operating in an 'open adversarial' commodity market has meant a strong distrust between suppliers (breeders and finishers) and consumers (processors)" (p. 594). The lack of trust among participants limits profit and risk sharing arrangements (Boehlje *et al.* 1998).

There is a tendency for one firm to become the contractor who takes control of others in the supply chain. Schrader (1986) pointed out that an important incentive for agricultural producers is the sense of independence or the avoidance of being an employee of another firm. Contracts can bring a high control by the contractor, making the grower's independent business status questionable. This is a challenge for New Zealand farmers who are usually "individualists and fiercely independent" (McDermott and Shadbolt 1998, p. 592). If an alliance is established it is necessary to define the purpose of the alliance, agree on common objectives, identify mutual needs and sources of risk, appreciate different perspectives on the impact of risk-returns, and find ways to assure a "win-win" relationship.

2.3.5 Current developments in New Zealand

Meat New Zealand (formerly New Zealand Meat Board) has launched a new marketing strategy to compete in the world's premium lamb markets. The objective is to achieve a more customer-driven production system (New Zealand Executive Government News 1996a; Smith 1996; Upton 1997, Stephens 1998b). All stakeholders will therefore be required to change or adapt current production practices, communication networks and alliances in order to accomplish new customer requirements. It is necessary to estimate the impact of these changes within the current lamb supply chain in order to be aware of the new market opportunities that this new production approach will bring to the New Zealand sheep industry. It is also necessary to anticipate the new system's requirements and be prepared to modify current practices.

The New Zealand lamb industry has also become concerned about livestock tracking systems. Wilson and Clarke (1998, p. 667) defined food traceability as "the information necessary to describe the production history of a food crop and any subsequent transformations or processes that the crop might be subject to on its journey from the farmer's field to the plate of the consumer." Traceability systems that can identify the animal from which cuts came from and a more customer-driven production system are prerequisites (New Zealand Executive Government News 1996a; Upton 1997; Stephens 1998b) for New Zealand products to have future access to the UK and European markets. The communication requirements for tracking systems involve information concerning marketing, sales, order receipt and acceptance, product check, operations, invoices, performance indicators, benefits and costs and statistics (Sandelands 1994).

Meat New Zealand, breed societies, the Beef Improvement Group (BIG), MAF and the Livestock Improvement Corporation (LIC) are working together on the implementation of a traceability system in the New Zealand meat industry (Stephens 1998b). The system will enable customers and supply-chain participants to access information regarding animal health management, genetic improvement, animal productivity measurement, supply chain management and farm quality assurance. Expected benefits from the implementation of such systems to participants in the lamb supply chain include improved returns; increased customer responsiveness (quick response to changes on product requirements); specialised lamb production; improved planning practices; and improved communication among participants. These systems, however, demand co-ordinated efforts through the entire food supply chain to improve quality, communication and overall production efficiency.

2.4 Concluding remarks

The literature reviewed in this chapter suggests that contemporary businesses are ruled by new competitive advantage factors: speed, flexibility, integration and innovation. JIT systems are a powerful tool to integrate those competitive factors into the supply chain. The implementation of a JIT system requires a careful supplier selection, in which planning and schedule information is shared without restrictions. Companies successful in establishing strategic alliances with suppliers generally centralise high-tech operations such as scheduling systems and information processing, have strong commitment to external alliances with suppliers (i.e. trusty, long-term relationships, technical assistance) and invest in state-of-the-art information technologies (i.e. EDI, bar coding, databases, intranet, internet).

Lack of co-operation between participants is the main jeopardy for synchronised supply chains. This encourages problems such as inconsistencies in overall goals, incomplete information exchange, inequitable distribution of returns, isolation in problem solving and unequal sharing of risk.

The New Zealand lamb industry is adopting strategies to accomplish the new market requirements via synchronisation of the production chain. However, the main threat for the establishment of co-ordination mechanisms in the industry is the current strong distrust between breeders, finishers and processors. The attitude of all participants therefore should shift from individualist and independent to co-operative in order to assure "win-win" relationships. It is necessary for the participants to understand better the risk-return profile of each other to equilibrate the distribution of returns and risk-sharing through the supply chain.

3 Simulating lamb production systems

3.1 Introduction

The productive characteristics of lamb producers in New Zealand are described in this Chapter. Lamb producers have different biophysical, productive and financial structures that determine their capacity to produce quality lamb meat. The objective of the modelling process was to obtain relevant physical and financial information for different New Zealand lamb producers in order to illustrate the differences in their risk-return profiles. The data collection process, a brief introduction to modelling concepts and a description of the farms under study are outlined. Stockpol® was used to evaluate the biological feasibility and performance level results for the livestock systems on each farm.

3.1.1 Data collection

Physical and financial information for the farms used in this study was obtained from the New Zealand Sheep and Beef Cattle Farm Survey 1995-96 (NZMWBES 1997b). The survey provides a picture of the sheep and beef sector in New Zealand. It groups farms according to their geographic location (i.e. the sample includes approximately 545 farms over the main sheep and beef cattle farming districts), flock size and farm class. The definition of the farm classes and the physical and financial information used in this study are shown in Appendix 1. The information provided by the survey for each farm class provides physical production, financial returns and the capital structure of groups of similar farms within New Zealand. This survey is widely used for industry planning purposes. The farm data was used to illustrate the different lamb production levels and costs depending on farm class.

3.1.2 Modelling agricultural systems

Even though computer models are an imperfect representation of a farming system, they provide a method to visualise and understand agricultural systems (Dent & Backie 1979). The process of modelling agricultural systems comprises two main phases for the designer: the construction of the model and its application to decision support. The description of the general process in the construction of simulation models is shown in Figure 3.1.

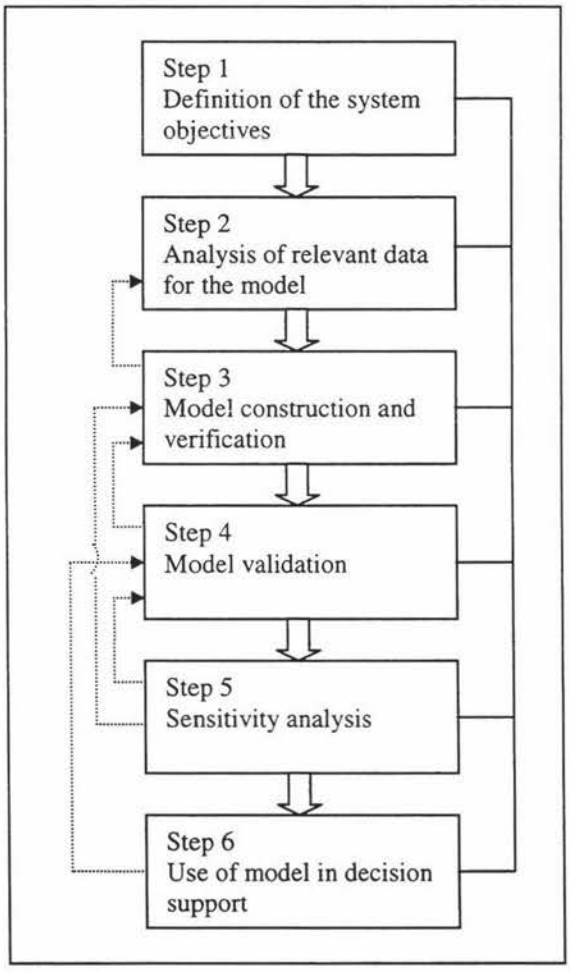

Figure 3.1 The basic steps of systems simulation.
Source: Dent and Blackie (1979, p. 14).

The main issue when simulating pastoral systems is to understand the pattern of feed supply and demand. Feed supply is determined by pasture growth rate, pasture cover and supplements. Feed demand, on the other hand, is a function of the number of animals on the farm and target levels of production in terms of liveweight, liveweight gain and physiological status. Feed supply can be estimated through net herbage accumulation expressed in kgDM/ha/day, while feed demand can be expressed in terms of kgDM/ha/day or as metabolisable energy (MJ ME/day) (Milligan *et al.* 1987). Commercial software like Stockpol® is adequate for simulating the balance of feed supply and demand for New Zealand pastoral systems (Marshall *et al.* 1991).

3.1.3 The use of Stockpol®

Stockpol® is a computer program designed to support management decision-making on pastoral sheep, beef cattle and deer farms. The model was designed to help consultants compare the profitability of different stock policy options for a farm (Marshall *et al.* 1991). Stockpol® was selected for this study because it can produce a biologically realistic model for a complex farm system. Also the program is well recognised by consultants in New Zealand (McCall & Tither 1993; Sherlock 1994).

The main use of Stockpol® in this study was to test the biological feasibility of alternative livestock systems. User-defined target liveweights and production levels were used to calculate livestock energy requirements (in kgDM/day). Together with the number of livestock in each class, these values were used to determine pasture DM intake. The model calculated the minimum pasture cover requirements needed to enable these intake levels. Pasture and animal growth were dynamically simulated. Stockpol® reported a farm system as feasible or infeasible by comparing the minimum pasture cover required by the livestock with the "actual" pasture cover calculated by the model.

Other information required by Stockpol® was date of mating, weaning and shearing policies for each farm under study. The livestock reconciliation for each class farm during the 1995-96 season, land use (i.e. cash crops, conservation activities) and the production parameters required by the simulation are displayed in Appendix 1. Pasture growth was calibrated to the pasture cover required to meet the needs of livestock reported for each farm class. The software allows the used to define the number of lambs to be sold to the processor or to the yards (information provided by the survey, see Appendix 1). Stockpol® will automatically "draft" the heaviest lambs each month, when they reach a pre-defined liveweight. The aim was to obtain an average drafting liveweight of 35 kg to maximise the number of carcasses falling into the premium price grades (Bray 1984). Lamb and beef carcass weights and grading and crop yields for each system analysed were also reported. The biological feasibility report included the total feed consumed by each livestock class, and the total DM production for the farm. A normal distribution for lamb weights and GR measurements was assumed and results showed the proportion of animals that would fall into each grade classification, for each of the farm classes investigated.

3.1.4 The lamb grading system

The income generated from lamb sales depends on the proportion of carcasses that grade into the various meat classification classes. These classes are defined according to carcass weight and GR measurement. The GR measurement of sheep meat refers to "the total tissue thickness between the surface of the carcass and the rib taken in the region of the 12th rib, 11 cm from the mid line of the carcass" (Standard Association of New Zealand 1987, p. 8). Under this classification system every carcass grade combines a symbol for GR content and another for carcass weight, except for grade A, which represents the lightest carcass weight without GR classification. The grade YL, for example, represents a 10 to 13 kg carcass weight with less than 7 mm GR. The grade PH, on the other hand, represents a heavier carcass (between 18 and 23 kg) with a GR between 7 and 12 mm (Table 3.1).

Table 3.1 Classification of lamb meat carcasses for sale to the New Zealand market.

	Lamb GR Classification			
Symbol	Y	P	T	F
	≤ 7 mm	> 7 mm, ≤ 12 mm	> 12 mm, ≤ 15 mm	> 15 mm
	Lamb carcass weight classification			
Symbol	A	L	M	X,H
	< 9 kg	> 10 kg, < 13 kg	> 13.5 kg, < 17 kg	> 18 kg, < 23 kg

Source: Standard Association of New Zealand (1987), The New Zealand Farmer (1998).

The price per kg carcass weight received by the farmer depends on the GR and carcass weight classifications. The total income per lamb can be obtained multiplying this price by the carcass weight and adding pelt and wool pull income. The October 1995 - February 1996 average price for the YX and PX grades was 260 and 261 c/kg, respectively. The price of A and FH on the other hand was 172 and 191 c/kg, respectively (The New Zealand Farmer 1995, 1996). For example, average lamb schedule prices obtained from *The New Zealand Farmer* from October 1995 to February 1996 are presented in Table 3.2.

Table 3.2 Average lamb schedule prices (1995-96).

Grade	Price (c/kg net)
YL	227
PL	236
TL	172
FL	172
YM	257
PM	257
TM	226
FM	182
YX	260
PX	261
TH	235
FH	191

Source: The New Zealand Farmer (1995, 1996).

The average price per head received by farmers according to the meat classification system in 1995-96 was compared to the New Zealand's 1995 lamb production classified into meat grades. Although heavier lambs earn more income per head, New Zealand farmers predominantly produce lambs that fall within the medium size carcass ranges (Figure 3.2).

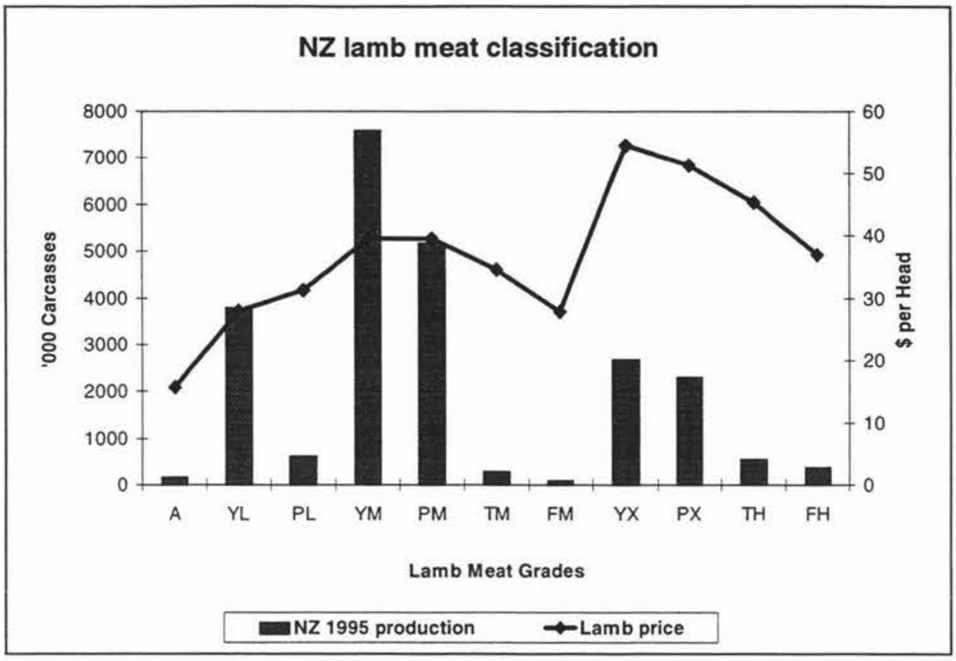

Figure 3.2 New Zealand 1995 export lamb production and average price per head by meat grade.
Sources: NZMPB (1995), The New Zealand Farmer (1995, 1996).

3.2 Materials and methods

The definition of farm classes simulated are shown in Table 3.3, and selected physical characteristics of the farms under study are exhibited in Table 3.4 (refer to Appendix 1 for more detailed information).

Table 3.3 Nomenclature for the farm classes used in the study.

Name	Farm class	Main location
1SIHigh	South Island high country	Marlborough, Canterbury, Otago
2SIHill	South Island hill country	Canterbury
3NIHard	North Island hard hill country	East and west coasts and central plateau of North Island
4NIHill	North Island hill country	Throughout the North Island
5NIFin	North Island intensive finishing	South Auckland, West Coast North Island, Hawkes Bay
6SIFB	South Island finishing-breeding	Canterbury, Otago
7SIFin	South Island intensive finishing farms	Southland, South and West Otago
8SIMix	South Island mixed finishing farms	Canterbury
All classes	Weighted average all classes	n/a

Source: NZMWBES (1997b, p. 8).

Table 3.4 Physical characteristics of the farm classes simulated.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Effective hectares	555	9867	1449	659	397	238	425	220	275
Hectares on pasture	523	9851	1437	657	394	229	400	207	143
Cash crops (ha)	32	16	12	2	3	9	25	13	132
Hay & Silage (ha)	18	63	35	4	10	13	31	18	13
Normal rainfall (mm)	1,087	739	766	1,520	1,408	1,190	780	927	685

Source: NZMWBES (1997b, p. 8).

3.2.1 Dry matter (DM) production

The pasture growth rates (PGR) for the farm classes were estimated using the Stockpol®'s "pasture sites" database. Thus, PGR corresponded to the standard pasture growth curve for each NZ geographic region. Figure 3.3, for example, represents the pasture growth rates used for the 1SIHigh, 2SIHill, 6SIFB and 8SIMix classes (Canterbury-North Otago region).

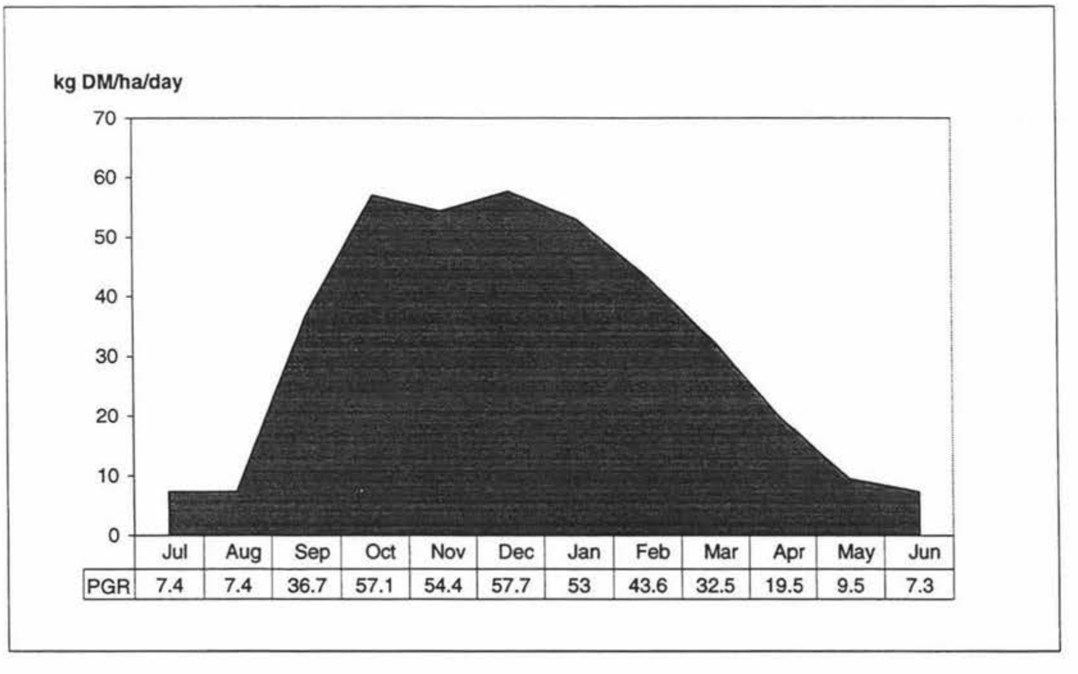

Figure 3.3 Pasture growth curve for the Canterbury–North Otago region, medium rainfall and flat slope.

Source: Stockpol®.

Annual pasture production averaged 11,737 kg DM/ha per year. Pasture quality was assumed to be "medium" (10.5 MJME/kgDM). Stockpol® also modelled conservation and cropping policies, as shown in Table 3.5.

Table 3.5 Crop & cultivation areas (ha) for the farm classes simulated.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Summer feed	2		2	1	1	2	4		
Winter feed	11	18	23		2	5	21	9	31
New grass	7	14	9	1	3	4	14	6	22
Cash crops	10	2	3	2		5	9	7	110
Small seeds	2						1		38
Oversown	2	77	1		1		1	1	
Hay & silage	18	63	35	4	10	13	31	18	13
Total area cultivated	24	30	33	3	5	11	38	18	134

Source: NZMWBES (1997b, p. 29).

3.2.2 Livestock policies

The Stockpol® model was calibrated to balance animal intake and the current system pasture covers to calculate the total DM required by the farm to support its livestock. The sheep and cattle policies and production parameters are shown in Table 3.6. Sheep and cattle numbers, conservation practices and the cropping system were as for the 1995-96 season.

Table 3.6 Livestock policies and production parameters of the farm classes simulated.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Sheep at open (hd)	2,835	8.960	4,881	3,560	2,542	1,618	3,305	2,675	1,540
Lambing %	104.9	86.4	97.1	98.5	107.1	106.8	102.4	114.4	119.8
Ewe mating date	29-Mar	10-May	15-Apr	26-Mar	20-Mar	10-Mar	8-Apr	10-Apr	22-Mar
Lambs sold (hd)	1,431	1,076	1,935	1,231	1,188	917	1,851	1,807	1,244
Wool sold (kg)	12,757	34,984	19,436	16,635	12,395	7,814	1,3701	12,886	6,294
Cattle on open (hd)	234	339	271	432	370	269	133	25	96
Calving %	83.8	84.2	82.9	79.9	84.5	85.7	84.8	83.3	100
Cow mating date	15-Nov	2-Dec	21 Nov	18-Nov	16-Nov	3-Nov	12-Nov	27-Nov	16-Nov
Cattle sold (hd)	114	110	88	164	180	173	69	11	40

Source: NZMWBES (1997b, pp 14, 16, 18, 23).

3.3 Results

The results from the Stockpol® simulation for all the farm classes during the 1995-96 season are displayed in Table 3.7 and Figures 3.4 and 3.5. All of them show only the performance of the pastoral operation within the farm system.

Table 3.7 Dry matter utilisation for the simulated farm systems for the 1995-96 season.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Effective hectares	555	9867	1449	659	397	238	425	220	275
Hectares in pasture	523	9851	1437	657	394	229	400	207	143
Cash crops (ha)	32	16	12	2	3	9	25	13	132
Sheep intake (kgDM)	1482670	3948377	2774434	1763061	1424175	889606	1830195	1779463	930287
	64%	**75%**	**72%**	**54%**	**52%**	**48%**	**76%**	**92%**	**71%**
Cattle intake (kgDM)	788190	1142717	846681	1502794	1296253	946606	457335	96152	340345
	34%	**22%**	**22%**	**46%**	**47%**	**51%**	**19%**	**5%**	**26%**
Conservation (kgDM)	59072	147113	253372	11998	23369	35061	111941	51084	36896
Total DM utilised (kgDM)	2329933	5238208	3874488	3277854	2743798	1871273	2399471	1926700	1307529
Intake per ha. (kgDM/ha)	**4,342**	**517**	**2,520**	**4,971**	**6,905**	**8,018**	**5,719**	**8,535**	**8,886**

The total DM utilisation for all farm classes and the use of land for pastoral enterprises and cash crops are shown in Table 3.7. Geographical location and land suitability are the main determinants of pasture supply on New Zealand farm systems (Figure 3.4). For example, the 1SIHigh farm system had the biggest pastoral area, but also the lowest DM livestock utilisation per hectare (520 kgDM/ha), reflecting the relative low production of pasture in the Marlborough, Canterbury and Otago areas (Stockpol®). Intensive finishing farms (5NIFin, 7SIFin and 8SIMix) had the smallest pastoral areas, but the highest DM utilisation per hectare (over 8,000 kgDM/ha consumed by livestock), reflecting the high capacity of those farm systems in terms of DM production (Stockpol®).

The proportion of pasture utilised by the different livestock enterprises is presented in Table 3.7 and Figure 3.4. South Island farm classes dedicated over 70% of DM production to sheep. In contrast, North Island farm classes presented a better balance with cattle enterprises (sheep intake represented between 48% to 54% of the DM utilisation for these farm classes). All farm classes, except 8SIMix farm systems (48%), dedicated less than 6% of their land to cropping enterprises.

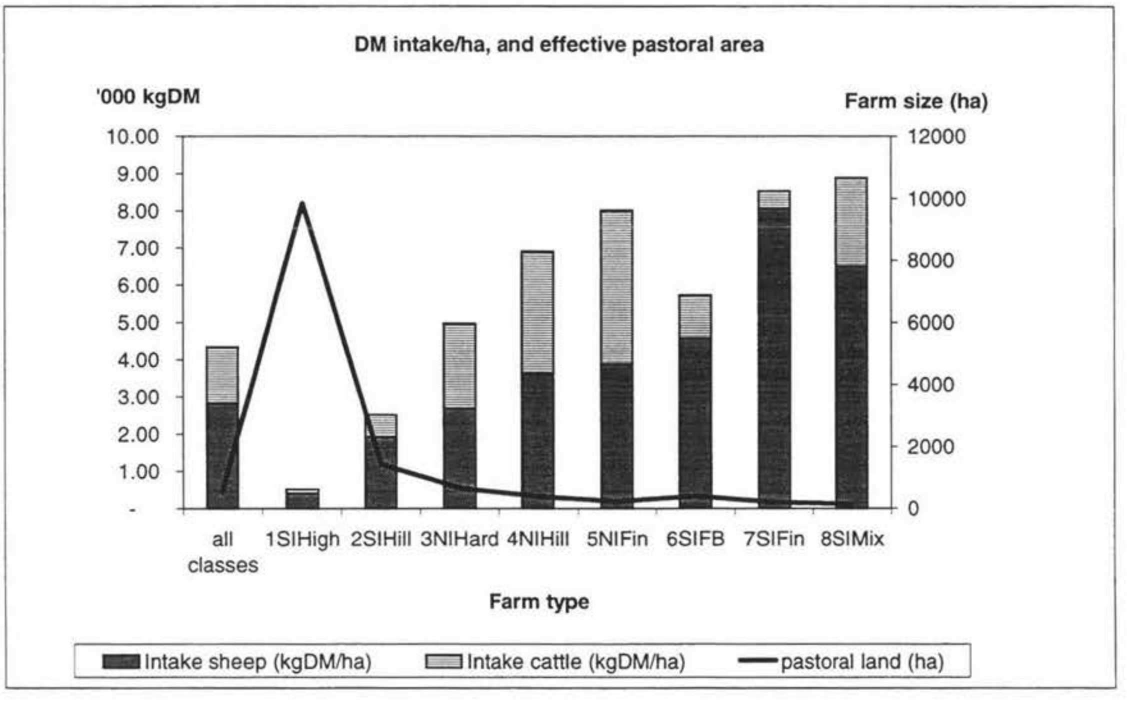

Figure 3.4 Simulated sheep and cattle intakes per hectare and the area in pasture for all farm classes.

The composition of revenue for all farm classes is displayed in Figure 3.6. 8SIMix farm systems obtained 70% of their income from cash crops and only 22% from sheep. The rest of the South Island farm classes obtained over 74% of their revenue from sheep. In contrast, North Island farm systems earned between 43% to 66% of their total revenues from sheep enterprises.

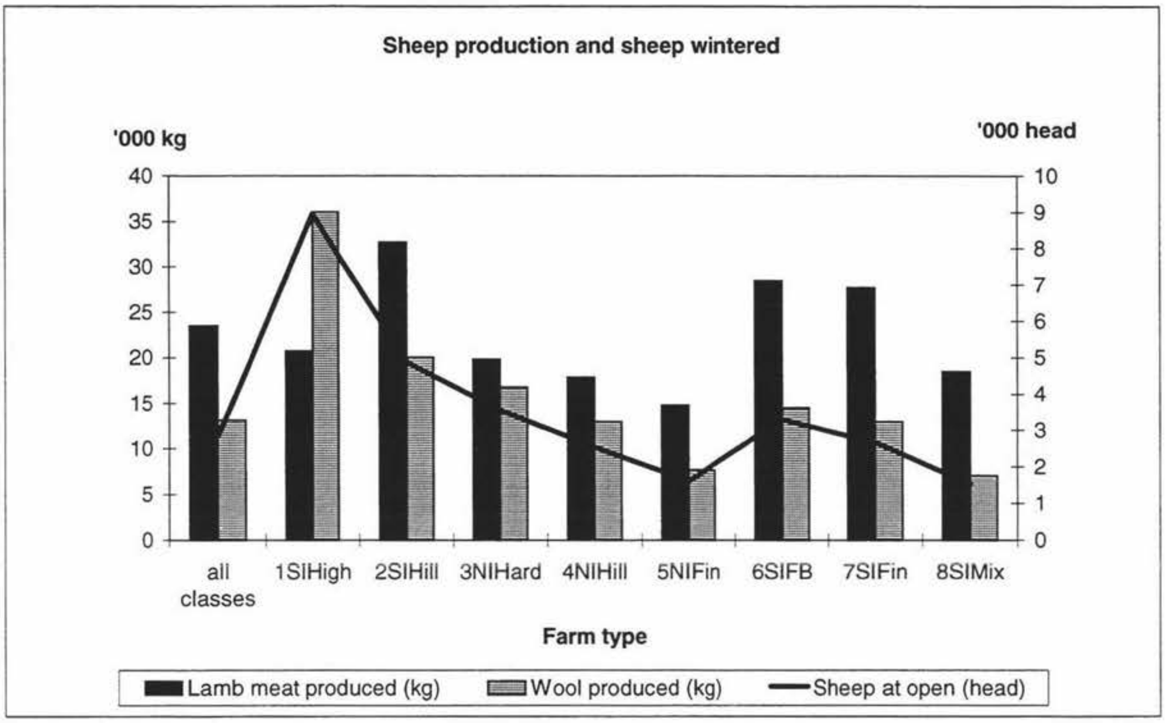

Figure 3.5 Sheep enterprise production and sheep numbers at opening (1 July) for all farm classes.

The revenue generated per tonne of DM consumed by sheep is shown in Table 3.8. Finishing farm systems transformed DM more efficiently into economic revenue for their sheep enterprises. For finishing farms, however, the cost of DM production is not the only important issue in terms of revenue generation. Sheep revenue usually relates also to trading margins.

Table 3.8 Revenue generated from sheep enterprises per tonne DM consumed.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Sheep intake (tonnes DM)	1482	3948	2774	1763	1424	889	1830	1779	930
Sheep revenue ($)	99642	231366	148529	107406	87195	57093	119146	116130	63641
Sheep revenue/tonne DM consumed	**67.20**	**58.60**	**53.53**	**60.92**	**61.22**	**64.18**	**65.10**	**65.28**	**68.41**

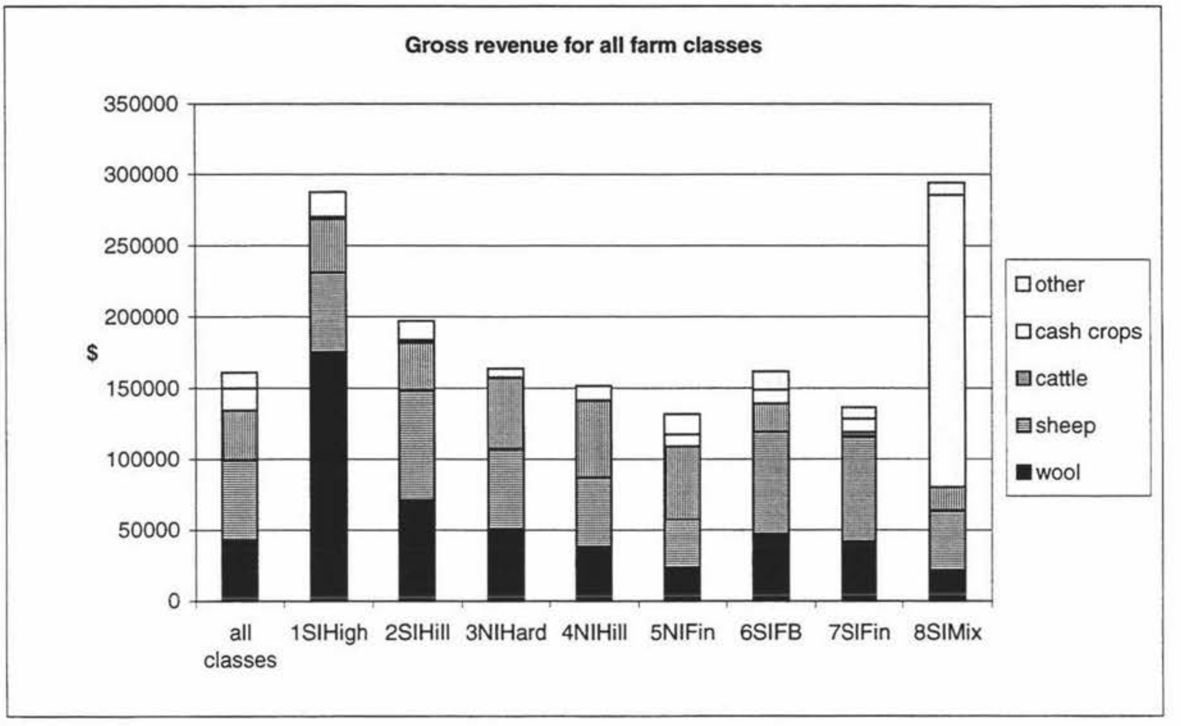

Figure 3.6 Gross farm revenue for all farm classes, season 1995-96.

Figure 3.5 was used to contrast the volume of lamb meat (simulated by Stockpol®) and wool produced for all farm classes with the revenue obtained from these products. Only 1SIHigh farms obtained more revenue per ssu from wool than meat production (Table 3.9 and Figure 3.7). This farm class generated 76% of its sheep revenue from wool. The rest of the farms generated more than 50% of their sheep revenue from lamb meat sales (NZMWBES 1997, p.37). Intensive finishing farm classes (5NIIFin, 6SIIFB, 7SIIFin and 8SIMix) obtained 20% more revenue per ssu from lamb than the average for all farm classes. They also obtained the highest lamb meat production per ssu (20% greater than the average). On the other hand, 1SIHigh farm systems obtained 43% more revenue per ssu from wool than the average, even when their wool production level per ssu was 5% below the average wool production for all farm classes (Table 3.9).

Table 3.9 Farm classes comparison of sheep production volume, wool and lamb revenues per ssu.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Sheep stock units	2,594	7,485	4,424	3,219	2,315	1,469	3,073	2,503	1,433
Lamb meat production (kg/ssu)	9.06	2.77	7.38	6.16	7.71	10.06	9.26	11.06	12.89
Wool production (kg/ssu)	5.08	4.81	4.53	5.21	5.60	5.19	4.72	5.18	4.92
Lamb meat revenue ($/ssu)	22.03	7.44	17.49	17.53	21.02	23.16	23.26	29.52	29.01
Wool revenue ($/ssu)	16.39	23.47	16.08	15.83	16.64	15.70	15.51	16.87	15.40

Source: NZMWBES (1997b, pp 14, 23, 34).

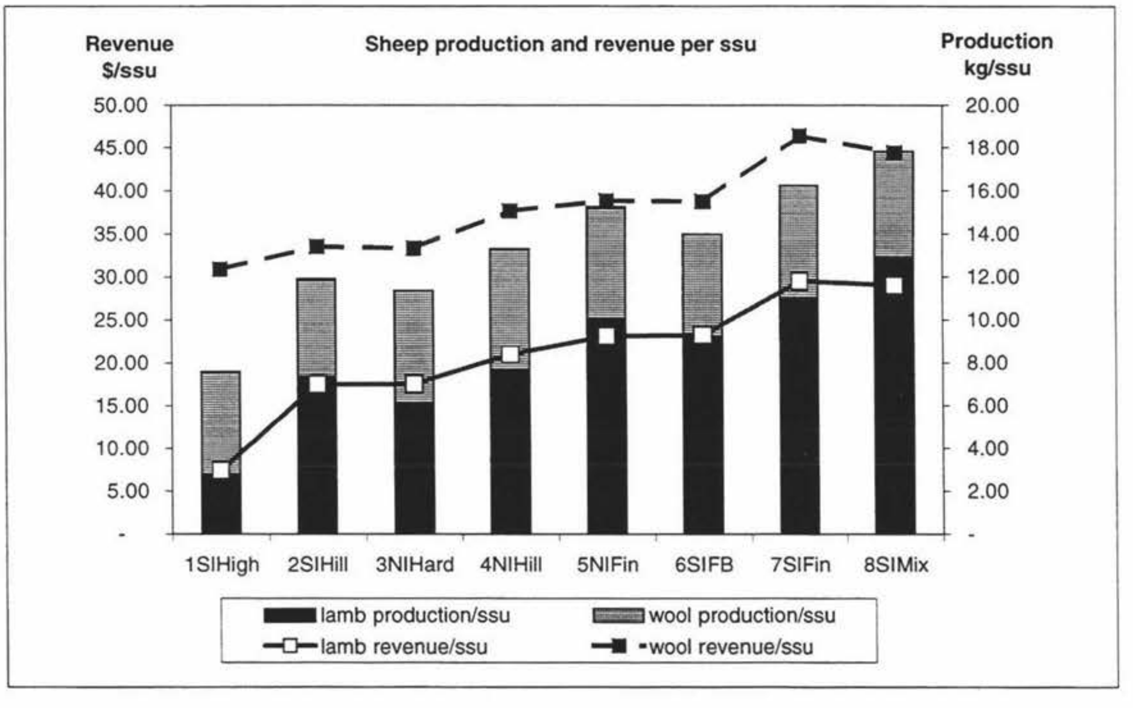

Figure 3.7 Relationship between sheep production and revenue per ssu for all farm classes.

3.4 Discussion

The information provided by the NZMWBES survey was able to illustrate the diversity that exist among suppliers of the New Zealand lamb industry. The use of computer models was also able to facilitate the understanding of the different biological components that determine the physical and financial performance of farm systems (Dent and Blackie 1979).

The Stockpol® model was useful for quantifying the performance of the biological systems within the different farm classes. Stockpol® was able to represent DM generation and livestock performance for the farm systems on a standard basis. Relative rather than absolute differences indicate the primary distinguishing characteristics of the farm system. It is important to note that the availability of pasture in the real systems determines purchase and selling policies. For the simulation, PGR was modified to satisfy livestock requirements according to the livestock reconciliation provided by the NZMWBES survey. Marked differences in actual pasture production could therefore be expected because the efficiency of pasture management was not formally quantified.

The software was also able to simulate lamb performance. The number of lambs purchased and sold was strictly based on the survey numbers. However, because of the lack of detailed drafting and purchase information, liveweights and carcass weights in the data set, these were replaced with Stockpol® parameters. These parameters are essential for balancing pasture supply and demand in the pastoral system. This issue is further discussed in Chapter 5. Changes in the pasture supply-demand relationship modify both the biological and economic efficiencies of the sheep enterprise (Gutierrez *et al.* 1991).

The meat classification system adopted for New Zealand lamb companies could encourage specialisation due to the fact that carcass weights and fatness determine the financial return of lamb meat (Kirton, *et al.* 1984). Thus, considering forward contracts for specific quality requirements could result beneficial for lamb producers. The modelling tools presented in this Chapter illustrated how to estimate the physical performance of lamb systems. The link between these tools with the evaluation of financial performance is addressed in the next chapters.

4 Costing lamb production

4.1 Introduction

New Zealand sheep and beef farmers perceive that changes in product prices are the most important risk to their business (Martin 1996). Thus, price control could be a powerful reason for farmers to choose specific marketing channels. Lamb producers can use cost accounting as a tool to assess the lamb meat price that meets their profit expectations. Cost accounting can also be used as a negotiation tool as it informs supply chain participants about the cost of lamb production for each other stakeholder.

Revenue from farm produce: crops, beef, wool and lamb meat can be easily differentiated. However, the cost of production for these products cannot be determined in the same straightforward way. This chapter outlines the methodology developed to cost lamb production systems for farms.

4.1.1 The ABC system

A cost accounting system aims to provide decision makers with useful and relevant information regarding the current and future cost of products or services produced and sold (Dearden 1973, Woolf *et al.* 1985, Burch 1994). Four main elements determine production cost: direct materials, direct labour, variable overhead and fixed overhead. Direct expenses are relatively easy to measure, but overheads are a problem because a determination has to be made on how much of each overhead expense should be charged to a product or service produced by the firm.

For example, a farmer that produces 10 tons of wheat, 4,000 kg of beef, 23,000 kg of lamb meat and 6,000 kg of wool per season faces the problem of allocating overhead costs to each product. Farmers receive payments for their produce in a $/kg basis, but how can they determine or forecast the cost of a kg of wheat or wool, if both products share the same resources (i.e. labour, vehicles, cost of capital). Traditional cost allocation based on volume of production has some disadvantages because it over-estimates the costs of high-volume production items and under-estimates those for low-volume ones (Burch 1994). In contrast, the Activity-Based Costing System (ABC) provides a process for assigning overhead expenses to products, services, jobs, projects, or other cost objects based on what really drives costs and charges a cost object only the overhead it actually consumes. The elements in the ABC system are shown in Figure 4.1.

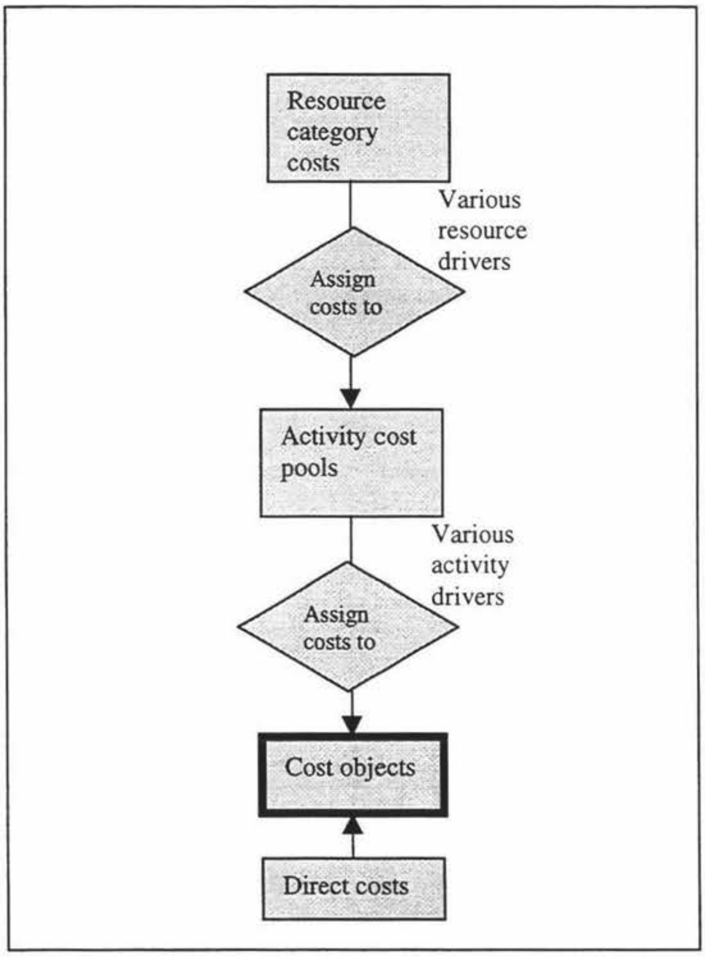

Figure 4.1 General model of the Activity-Based costing system.
Source: Burch (1994, p 446).

The ABC system aims to determine the real cost drivers of the production system. Activity analysis is the process of identifying, defining and describing productive activities within the firm and their corresponding cost drivers. ABC is widely used for manufacturing enterprises and farmers can adopt it to help improve farm economic efficiency.

Efficiency in lamb production can be expressed in terms of biological and economic efficiency. The first category includes flock reproductive performance, lamb growth rates and lamb survival. Economic efficiency refers to the cost of production per weight of live animal marketed, net return to the sheep enterprise and return on investment (Gutierrez *et al.* 1991). The cost of production of lambs in a pastoral enterprise depends mainly on weather variation, DM production, total livestock farmed, the biological efficiency of the sheep enterprise and management skills. Estimates of the cost of lamb production should be able to be extracted from farm financial statements using the ABC system.

A Cost-Volume Profit (CVP) analysis could be applied to the lamb enterprise once the cost of production is determined by the ABC system. CVP aims to create an equation that can be used to estimate profits. It is a function of variable costs per unit, fixed costs, volume of production, product mix and product price (Burch 1994) and considers the effects of changes in livestock policies, biological efficiency and weather variability. Different market channels could be evaluated for lamb producers once the cost of production is known and the profit generation equation is defined. Scenarios can be created and compared using the CVP equation for individual producers.

4.1.2 Cost elements

The cost elements of lamb meat production are: the running costs of breeding ewes, direct expenses such as animal health and freight, and feed consumed by lambs before drafting. Comparing the lamb production system with a manufacturing environment, lamb meat is the final product and the breeding ewes can be considered the "production department". The final product also incorporates the cost of running replacements, dry ewes and rams (non-productive departments). The ABC system assumes that a lamb is cheaper to produce if it is weaned earlier, grows faster, its growth coincides with the production of the lowest monthly cost of DM, and also if it uses "cheap to run" breeding ewes. In New Zealand pastoral systems, the biological breeding cycle typically coincides with the seasonal pattern, and hence least expensive, production of pasture (Milligan *et al.* 1987). The cost of production of lamb meat and wool are the sum of the direct expenses associated with the sheep breeding enterprise and a proportion of the farm overhead expenses (Table 4.1).

Table 4.1 Total costs associated with a sheep breeding enterprise.

Direct expenses	Farm overhead expenses
Shearing	Wages
Woolshed expenses	Electricity
Animal health	Repairs and maintenance
Cartage	Vehicle expenses
Selling charges / commissions	Administration
Livestock purchases	Insurance
Breeding expenses	Depreciation
Forage crop costs	Rates
Grazing and feed costs	General expenses
	Management reward
	Tax
	Cost of capital

4.2 Materials and methods

4.2.1 Determining overhead costs for New Zealand farming systems

The total *operating costs* (direct expenses plus overhead costs excluding tax and the cost of capital), calculated from Table 4.1 and the *cost of capital* (cost of debt and cost of equity) for each farm class are shown in Table 4.2. Operating costs are used in the calculation of financial indicators such as operating profit (Economic Farm Surplus) and return on assets, which are important measures of the financial performance of farming enterprises. However, tax and cost of capital have to be taken into account to reflect a more holistic farm view and value creating activities to determine the profit margin the business requires to meet such commitments. Farmers could use measurements of their 'value creating activities' to analyse the sustainability of the farming system or the enhancement of future values towards security, succession or retirement (Kirton *et al.* 1994, Parker *et at.* 1994). Thus, the value created of a business assumes payments of *profit margin* covering debt and equity payments are available for reinvestment (Shadbolt 1998). Cost of capital reflects opportunity costs of equity capital invested in the business rather than somewhere else, source of funds and the collateral and repayment risk involved (Boehlje 1994). However, Kirton *et al.* (1994) suggested that "there is a need for a 'truer and fairer' framework in which to explore on-farm and beyond farm performance" (p. 428). Traditionally, cost of capital for primary sector industries can be estimated as a percentage of total assets, which is the same way it can be calculated for manufacturing or service sectors. However, cost of capital rarely changes with asset value, suggesting that the link may be unrealistic, (i.e. non-cash return of capital gain not included) (Shadbolt 1998). This idea suggests that defining cost of capital as a percentage of total assets may not be the best way to evaluate farm financial performance, especially because the owner's reasons for getting involved with on-farm business could not just reflect the return on investment, but also reasons such as lifestyle or land capital gain.

Thus, cost of capital could be estimated from the actual and future equity returns and debt costs for the farm business, as opposed to theoretical estimations (Shadbolt 1998). Cost of capital was calculated by adding debt servicing interest costs, personal drawings adjusted for post-tax managerial reward and debt repayments. Three-year averages for interest paid, personal drawings, debt repayments and reward for unpaid labour and managerial skills were used for the calculations, to avoid potential 'lumpy' payments (NZMWBES 1996a, 1996b, 1997b).

Table 4.2 Operating expenditure and cost of capital for all farm classes, season 1995-96.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Pre-tax operating expenses	147,647	291,436	193,777	146,281	136,769	130,709	150,693	121,471	234,532
1 Cost of debt *	15,470	30,328	21,363	19,946	13,542	12,426	14,627	14,067	22,120
2 Cost of equity *	25,565	19,653	37,354	32,194	26,640	23,231	27,136	9,675	42,687
3 Cost of capital (1+2)	41,035	49,981	58,717	52,140	40,182	35,657	41,763	23,742	64,807
Cost of capital (3) as percentage of total farm assets	2.7%	2.1%	3.3%	3.4%	2.5%	2.1%	3.0%	2.1%	4.1%

* post-tax figures.

The estimated cost of capital expressed as a percentage of total farm assets is also displayed in Table 4.2. It reflects the capital return required by the different sheep and beef farm classes within New Zealand to cover business' commitments to debt and equity providers. Thus, this cost of capital calculation may reflect a more realistic approach to the actual needs of primary sector businesses in New Zealand, and it can be used to include a 'truer and fairer' profit margin into the calculation of farm produce cost of production.

4.2.2 The ABC system applied to pastoral systems

The main overhead cost in pastoral systems relates to DM production. This overhead includes: costs for fertiliser, seeds, weed and pest controls, soil tests, irrigation, water supply, and other items. DM produced on the farm is generally shared between different livestock enterprises and conservation activities (i.e. hay and silage). Applying the ABC system requires the identification and definition of activities that use this resource in order to allocate costs accordingly. Figure 4.2 shows the ABC system applied to a pastoral lamb breeding production system.

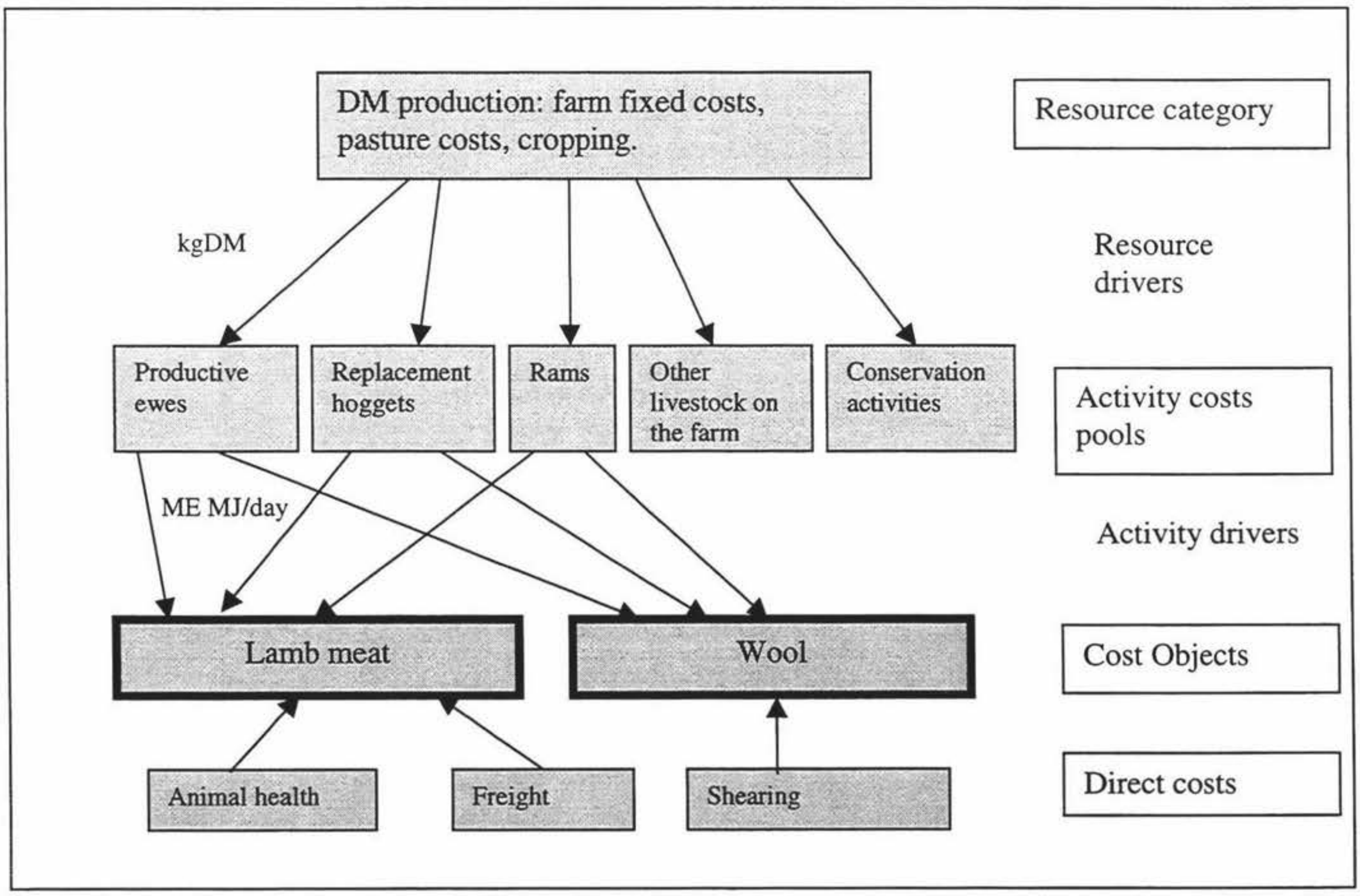

Figure 4.2 ABC system applied to a pastoral breeding lamb production system.

Resource categories

Resource categories represent the sources of costs that support activities. In a farming enterprise, typical physical resources are land, buildings and equipment. Costs associated with these resources include labour, administration, insurance, depreciation and rates. For this study, overhead costs were defined as all the cost derived from the farm operation that could not be allocated to specific enterprises (i.e. livestock, cropping). The above costs for pastoral and non-pastoral activities were allocated according to the number of effective hectares allocated to each enterprise.

First-stage resource drivers

Activities drive the cost of resources. Activity drivers are used to assign resource costs to activities. In pastoral enterprises, the main activity of land is to produce DM to sustain animal production, thus a good activity driver is the consumption of DM, measured in kgDM. Total overhead costs of DM production were allocated to every livestock enterprise in terms of their consumption, as well as conservation activities. Every stock class is considered an activity cost pool, even when they do not produce final products. For each farm class simulated, the total overhead equalled the total kgDM consumed by the different activities and the total DM used for conservation activities. For the purposes of this research, all DM utilised was assumed to have the same quality in terms of MJME/kgDM. However, in practice, grazing management can determine the quality of DM utilised by cattle and sheep by creating a complimentarily between the two enterprises rather than competition for the DM available.

Activities and activity cost pools

An activity is what an organisation does to convert inputs to outputs. These activities are "natural" identifiers. An activity cost pool is the result of assigning resource costs to an activity. The activities for a lamb production system are breeding ewes, replacement ewes and rams, other livestock classes run by the farm and conservation activities.

Second-stage activity drivers

Overhead costs allocated to the sheep enterprise were divided into those associated with wool and lamb meat. Second-stage activity drivers assign the costs in "activity cost pools" (sheep farmed) to the cost objects. Livestock obtain their energy requirements from DM, this energy is then distributed by the organism to sustain different biological processes: maintenance, growth, pregnancy, lactation and wool growth. The energy requirements to sustain these biological activities can be used as drivers to allocate costs to the cost objects. In the sheep enterprise, the only two cost objects considered were lamb meat and wool. Thus, according to ABC systems, costs should be allocated according to the rate of utilisation. Lamb meat and wool costs were determined by the energy requirements of sheep to produce meat and wool. Wool growth reflects the general level of nutrition of a sheep. Even at sub-maintenance levels, when a sheep is losing weight, its wool continues to grow. For example, the Australian Standing Committee of Agriculture has estimated the growth of clean dry wool in Merinos to be 0.5-0.9 g/MJ ME (McDonald *et al.* 1966). The ME requirements for a ewe's different metabolic activities under New Zealand conditions are shown in Table 4.3. A 50 kg sheep, producing an annual fleece of 4 kg, requires 1.3 MJ ME/day for wool growth, while its maintenance requirements are 10 MJ ME/day.

In the context of an ABC system, costs for wool should be allocated based on the resources it utilises to grow. If these resources are measured on sheep energy requirements, the third column shows the recommended allocation of costs for wool at each stage of the production calendar. To simplify calculations, the allocation cost of wool and meat for other livestock (dry ewes, rams) was set at 12%. Growing lambs (30kg, 150 g/day) required 8% of 15 ME MJ/day and replacement hoggets (35kg, 100 g/day) 8% of 16 MJ ME/day for wool growth. Breeding ewes at maintenance required 12% of their energy intake for wool growth. This reduced to 9% during pregnancy and 5% during lactation. On the basis of a simple weighted average (number of days at each activity level), the allocation for wool was 9.5 %.

Table 4.3 Metabolisable energy (ME) requirements of a 50 kg ewe for maintenance and production activities.

Activity	ME requirements (MJ ME/day)	Cost allocation for wool
Wool production	1.3	
Maintenance	10.0	12%
Liveweight gain		
50 g/day	13.0	9%
100g/day	16.5	7%
150g/day	20.0	6%
Pregnancy [1], weeks before term		
12	0.4	10%
8	1.1	9%
6	1.7	9%
4	2.6	8%
2	3.8	8%
Term	5.3	7%
Lactation [2], week		
1	24.5	5%
3	28.5	5%
6	24.5	5%
9	20.5	6%

Source: Geenty and Rattray (1987).

[1] Quantities in addition to maternal requirements. They also increase 75% for each additional foetus carried.

[2] Single sucking.

Cost objects

Cost objects are where activity costs are assigned. They are the final products of the farm: lamb meat and wool. Other farm produce like pelts are by-products of the activity of producing lamb meat; culled ewes can be considered as extra income for the sheep enterprise, since the primary purpose of the farm is not to produce cull ewes or pelts. Lambs drafted on different dates had a different cost of production because of seasonal variation in DM costs and intake levels. This issue is addressed in more detail in Chapter 5.

4.2.3 Break-even point (BEP) analysis

The break-even point (BEP) price represents the sale price per unit of lamb meat and wool at which the sheep enterprise generates no profit or loss. This analysis could also be carried out with regards to every final farm product. A BEP analysis was first conducted for wool and lamb meat for all farm classes. Then, wool income was deducted from the total sheep cost of production to calculate a BEP price for the lamb meat alone, on the basis that the first purpose of the farm is to produce lamb meat. The BEP represents the sale price per unit of lamb meat at which both sheep operation expenses and their proportion of cost of capital are met.

4.3 Results

The farm expenses (Tables 4.1 and 4.2) were allocated to the different enterprises according to land use and the DM utilisation values simulated in Chapter 3 (Figure 4.3). The composition of the cost of production for wool and lamb meat is shown in Table 4.4. These figures represent the direct sheep expenses plus the proportion of farm overhead expenses that correspond to the sheep enterprise for all farm classes.

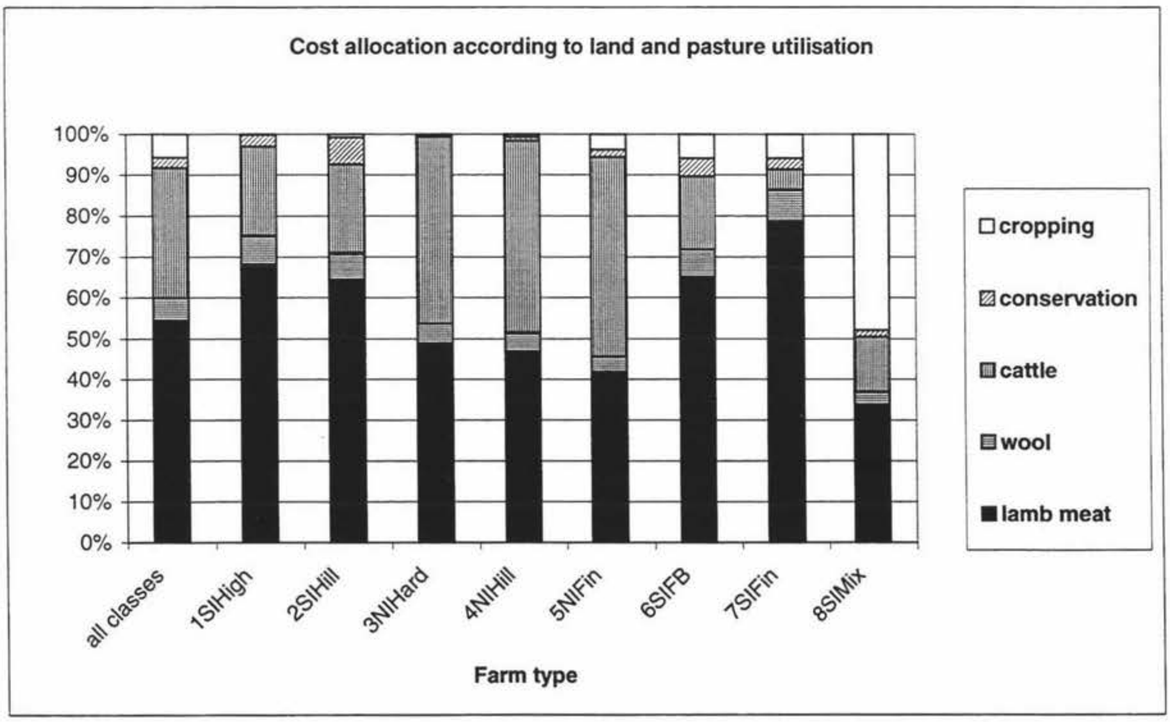

Figure 4.3 Overhead cost allocation percentages for all farm classes.

Table 4.4 Wool and meat cost of production composition for all farm classes, season 1995-96.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Lamb meat									
Pre-tax operating expenses	60,000	139,041	86,213	44,300	46,531	44,732	72,992	71,395	84,151
Cost of capital *	22,387	34,047	37,817	25,558	18,860	14,863	27,245	18,776	21,816
Wool									
Pre-tax operating expenses	14,948	45,990	24,366	16,131	13,661	9,622	16,563	15,212	12,252
Cost of capital *	2,220	3,565	3,881	2,402	1,839	1,448	2,736	1,866	2,160

* post-tax figures

The BEP prices for lamb meat and wool for all farm classes are shown in Table 4.5. BEP prices were calculated taking into account post-tax costs, however the figures presented in the table were adjusted to depict the required pre-tax sales price (market prices) to cover the cost of production allocated to lamb meat and wool. BEP prices for both products are linked to the sheep enterprise cost of production (Table 4.4). The greater variance in lamb meat BEP price and the narrower range in the wool BEP price may suggest that wool performance among farm classes is more even than lamb performance.

Table 4.5 Wool and lamb meat BEP analysis for all farm classes in the 1995-96 season.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix
Lamb production (kg)	23,510	20,725	32,656	19,826	17,851	14,779	28,455	26,822	18,477
Lambs sold (head)	1,432	1,076	1,935	1,231	1,188	917	1,851	1,807	1,244
Wool production (kg)	13,166	36,034	20,035	16,762	12,967	7,631	14,504	12,973	7,049
Lamb meat									
BEP price ($/kg)	**3.91**	**9.06**	**4.29**	**4.08**	**4.12**	**4.46**	**3.93**	**3.66**	**6.24**
Wool									
BEP price ($/kg)	**1.38**	**1.42**	**1.49**	**1.17**	**1.26**	**1.53**	**1.41**	**1.38**	**2.18**

The BEP calculations for lamb meat after deducting wool income from total sheep production expenses are depicted in Table 4.6. These BEP prices reflect the sale price per kg of lamb meat required by each farm type to cover all sheep production expenses. Wool BEP price could be calculated in a similar way by deducting lamb income from the total sheep production expenses. This analysis could be useful for those farms on which the main production focus is placed on wool (i.e. 1SIHigh farm class).

Table 4.6 Lamb meat BEP analysis for all farm classes in the 1995-96 season.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin	8SIMix[1]
Wool income ($)	42,504	175,647	71,132	50,965	38,525	23,070	47,675	42,230	22,065
Total sheep costs ($)	110,100	238,764	170,147	100,373	89,762	77,655	132,385	116,082	130,655
Lamb meat cost ($)	67,596	63,117	99,015	49,408	51,237	54,585	84,710	73,852	108,590
BEP price ($/kg)	**2.88**	**3.05**	**3.03**	**2.49**	**2.87**	**3.69**	**2.98**	**2.75**	**5.88**[2]

[1] The 8SIMix class is the only farm type that does not satisfy the condition of generating more than 70 percent of the farm revenue from sheep or beef cattle (NZMWBES 1997b, p. 6).

[2] The national average cost of production of lamb meat for the season 1995-96 was $2.88/kg, but 8SIMix class farms required more than twice that price to cover sheep cost of production. The existence of this gap may be explained by the fact that the farm financial accounts used for this study do not distinguish between overhead expenses generated by pastoral or cropping enterprises. For the season 1995-96, 8SIMix farms allocated 48% of farmland to cropping activities, while the same allocation for the rest of the farm classes do not exceed 6%, thus cropping activity could be considered as a complementary activity of these pastoral enterprises. Moreover, the total farm expenditure per effective hectare for this farm class was $842, while the same figure for the all classes average was $243 (NZMWBES 1997b, p. 45). Thus, a more detailed distinction between cropping and pastoral overhead expenditure for the 8SIMix farm class could reflect a different sheep cost of production. For these reasons, this farm class was excluded for further analysis.

4.4 Discussion

The use of the ABC system in lamb production shows that wool sales play an essential role in the profitability of the sheep enterprises under study. Wool represented 16% of the total sheep expenditure for all farm classes, generating 43% of the revenue from the sheep enterprise (Tables 4.7 and 4.8).

Table 4.7 Sheep revenue composition for all farm classes.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin
Wool	43%	76%	48%	47%	44%	40%	40%	36%
Lamb meat	57%	24%	52%	53%	56%	60%	60%	64%

Table 4.8 Sheep cost of production composition for all farm classes.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin
Wool	16%	21%	18%	19%	18%	15%	15%	15%
Lamb meat	84%	79%	82%	81%	82%	85%	85%	85%

The lamb meat BEP for 'all classes' was analysed to evaluate the impact of wool production and price variation. The net return for wool was assumed to be $3.22 kg for the 1995-96 season (NZMWBES 1997b, p 31). Wool income was deducted from sheep expenses to set the lamb meat BEP price at $2.88/kg (Table 4.6). The 1997-98 average price for wool was estimated at $3.38/kg (NZMWBES 1997a, p34). Substituting this figure in the calculation, and assuming the rest of the factors constant, the lamb meat BEP reduced to $2.79 /kg. A sensitivity analysis of the lamb meat BEP when wool production and price were modified is shown in Table 4.9.

Table 4.9 Impact of wool production and price on lamb meat BEP ($/kg), for all farm classes.

Wool production	-10%	1995-96 wool price ($3.22/kg)	+ 10%
- 10 %	**3.22**	**3.06**	**2.89**
Average 1995-96 (13,166 kg)	**3.06**	**2.88**	**2.69**
+ 10 %	**2.89**	**2.69**	**2.50**

The maximum difference was $0.72/kg in the BEP for lamb meat between the scenarios analysed. This variation can substantially impact the overall profitability of the sheep enterprise. The whole farm financial analysis and the contribution the sheep enterprise makes for all farm classes are depicted in Table 4.10. Price received for lamb meat for the season 1995-96 are also compared with the BEP price calculated on Table 4.6 for all farm classes. Financial indicators for the whole farm are presented in rows 1 and 2. A negative EFS suggests that gross revenue from farm produce was insufficient to cover operating expenses (including reward for labour and management) for the overall farming operation. The farm financial position after covering tax payments and commitments to equity holders, and banks is shown in row 2. The NZMWBES (1997b) reported a negative change in equity worth for the all farm classes average[1]. The contribution of the sheep enterprise to the overall performance of the farm is presented in rows 3 and 4. 8SIMix class farms were unable to cover sheep operating expenses before tax and the cost of capital (see Table 4.6). The average lamb price received for that season is showed in row 5 (NZMWBES 1997b). The price received for lamb meat during that season was not enough to cover the average sheep cost of production of any farm class (row 6).

Table 4.10 Lamb meat cost analysis for all farm classes, season 1995-96.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin
				Whole farm				
1 EFS ($)	10,652	(7,530)	1,336	14,197	11,868	(1,814)	8,316	12,887
2 Value added ($)	(33,533)	(62,059)	(73,681)	(43,324)	(26,850)	(37,144)	(42,693)	(12,466)
				Sheep enterprise				
3 EFS ($)	13,974	18,216	16,170	26,633	17,568	850	17,484	16,546
4 Value added ($)	(14,825)	(24,861)	(30,379)	(9,316)	(8,401)	(15,715)	(17,742)	(8,948)
				Lamb meat				
5 Price received ($/kg)	1.97	1.33	1.70	1.82	2.20	2.17	2.09	2.19
6 BEP price ($/kg)	2.88	3.05	3.03	2.49	2.87	3.69	2.98	2.75
7 Difference	**(0.90)**	**(1.71)**	**(1.33)**	**(0.67)**	**(0.67)**	**(1.52)**	**(0.89)**	**(0.56)**

The average lamb meat export price paid to farmers in 1997 was $2.33/kg, (NZMWBES 1997a, p 28). Considering this improvement on the lamb price, and assuming no change in cost of production, the negative gap between the price received and the BEP price would reduce to -$0.55/kg for all farm classes. This change, an increment of 18% in the lamb meat price, improves the financial performance of the sheep enterprise by 40% and the overall farm by 23%.

Setting a managerial reward for the labour and management skill of the owner-operator could be controversial. The NZMWBES calculated labour in 1995/96 at $24,900, adjusted in proportion to the number of working owners on the farm and the return for management skill was set at 1 % of the farm capital (NZMWBES 1997, p.58). Discussion may also arise when considering the use of the BEP cost of production shown in Table 4.10 for price setting.

[1] In making comparisons with value added it is necessary to exclude any revaluation of assets from changes in equity worth (e.g. -$9,000 value created + $12,000 revaluation of assets = $3,000 change in equity worth).

The BEP price for lamb meat when tax and cost of production is not considered was calculated (Table 4.11). This BEP price represents a null EFS from the sheep enterprise (sheep revenue - sheep operating expenses = 0). The payment received by farmers during the 1995-96 season was enough to cover sheep operating expenses and, apparently, to generate profit. However, this BEP price cannot be used as a negotiation tool because it is an insufficient profit margin to cover tax, cost of debt and cost of equity. The required profit for this price to cover all farm commitments is also showed on Table 4.11. For all farm classes, the cost of production of a kg of lamb meat in the 1995-96 season was $1.38. The price received during that season was $1.97/kg (this represents a profit margin of 30%, or a mark up of 43%), but the price required to cover all farm commitments was $2.88, which represents a required profit margin of 52% (109% mark up).

Moreover, cost accounting can provide farm managers with an excellent tool to compare the profitability of the lamb enterprise with other land uses or to compare the financial performance of the sheep enterprise under different market channel options.

Table 4.11 Lamb meat BEP before tax and cost of capital for all farm classes, season 1995-96.

	All classes	1SIHigh	2SIHill	3NIHard	4NIHill	5NIFin	6SIFB	7SIFin
BEP price ($/kg) before tax and CoC.	1.38	0.45	1.21	0.48	1.21	2.12	1.47	1.59
Price received ($/kg)	1.97	1.33	1.70	1.82	2.20	2.17	2.09	2.19
Apparent profit margin	30%	66%	29%	74%	45%	3%	29%	27%
Required profit to meet all commitments	52%	85%	60%	81%	58%	43%	51%	42%

Finally, it is important to emphasise that farmers' knowledge and decision making are decisive factors in determining the biological and economic efficiency of their farm system: production technologies, livestock policies and grazing management. There is also a seasonal cost for the production of DM: pasture, crops, conservation and supplement purchases. These costs strongly depend on weather patterns and management practice. For example, the "running costs" of one ewe (mated in

February, April or May) are different because the feed requirements for maintenance, pregnancy and lactation periods change over time (Milligan *et al.* 1987).

Cost of production also depends on the total livestock run on the farm and the utilisation of the DM produced. The cost of grazing lambs increases the longer they are on the farm, but so does the liveweight, thus the cost per kg does not necessarily follow the same trend. However, lamb returns depend not only on carcass weight, but also fat content (GR grade). Thus, a lamb that grazes more time on the farm does not necessarily return more revenue (Garrick *et al.* 1986).

Obtaining a CVP equation for lamb meat depends on the relationships between the various parameters in the drafting policies, plus the level of DM intake and costs that affect the overhead allocation percentages. The evaluation of the cost of production of lamb meat for a farm class under uncertainty is assessed in Chapter 5. Different pasture production scenarios are simulated and the effects of different livestock policies are quantified.

5 Considering risk in New Zealand lamb systems

5.1 Introduction

The cost of lamb meat production can be used to determine a BEP market price to accomplish specific levels of revenue. However, the forecasting of cost of production for planning purposes has to include variation due to uncontrollable factors such as weather conditions and purchase prices that affect lamb production systems in New Zealand. In this chapter literature on agricultural risk concepts, risk management practices in New Zealand pastoral systems and mathematical programming (MP) concepts and a description of an MP model based on a farm class considered in previous chapters are presented. The MP model was used to find an optimum cost of production for a contractual situation on an average farm.

5.2 Uncertainty and risk concepts

The effect of climatic variability is important on pastoral farms, where performance depends largely on pasture production (Cacho and Bywater 1994). When uncertainties restrict operational performance for individual organisations, one of the key success factors is the ability to respond rapidly to consumer demand. Uncertainty refers to the probability that a realisation will deviate from the expectation or estimation, assuming a decision-making environment with imperfect information regarding the future (van der Vorst *et al.* 1998).

Risk analysis is important because the main resources in any agricultural system are exposed to non-controllable variables such as weather, variable costs, product prices, and yields for the different products generated by the farm system. Gold *et al.* (1990) outlined a method to deal with uncertainty that combines information from simulation modelling with the manager's personal knowledge. Chain co-ordination can reduce uncertainties by adjusting control concepts of organisations in the supply chain and by redesigning some roles and tasks (physical, administrative and decision processes) (van der Vorst *et al.* 1998). The types of uncertainty that can be diminished through supply chain co-ordination are depicted in Table 5.1.

Table 5.1 Types of uncertainty in the food supply chain.

Type of uncertainty	Elements
Demand uncertainty	Timing, size and order composition Data accuracy on products and services required, prices, delivery
Planning and process uncertainty	Total time span of consideration Scrap, equipment failure, variable yields Administrative and decision processes
Supply uncertainty	Lead time, quantity and quality of supply Variable yields, seasonal patterns Data accuracy on supply elements, product specifications.

Source: van der Vorst *et al.* (1998, p. 379).

Martin (1996) identified the types of risk, risk control management and risk management strategies found in New Zealand pastoral farm systems (Figure 5.1). Risk can be divided into *business risk* and *financial risk* (Parton & Cumming 1990; Dake 1994; Martin 1996). Business risk is associated with the variability in production (yield) and market (input and output) prices. This risk is reflected by variation in the net operating profit of the business. On the other hand, financial risk is the probability of being unable to meet a fixed target income (i.e. debt servicing commitments) with cash generated from the operations of the firm. Martin (1996) also defined technological risk as the probability of current assets being offset by technological advances. Legal and social risk is associated with the use of contractual mechanisms (i.e. forward contracts) and the use of non-farm resources of capital. Finally, human risk involves the availability and reliability of labour and management. Cacho & Bywater (1994) and Martin (1996) agreed that the objective of risk management is to reduce the chances of a vulnerable situation for the business while at the same time trying to achieve the highest possible returns and in a manner that is consistent with management's attitude toward risk.

Martin (1996) defined '*risk exposure*' and '*risk impacts*' as the risk effects on agricultural businesses that can be controlled. According to the author, *risk exposure* can be controlled by manipulating the probability distributions facing the business in order to reduce variability by smoothing prices and yields or by cutting off troughs in these. On the other hand, managing to reduce *risk impacts* on the business does not decrease the variability of the probability distribution of prices or yields. Strategies in this category aim to enable the business to absorb negative effects of these variables. An example of this strategy is to match debt repayments to income levels. Risk management strategies can be classified into three broad categories: marketing, production and financial, with a large number of possibilities within each category.

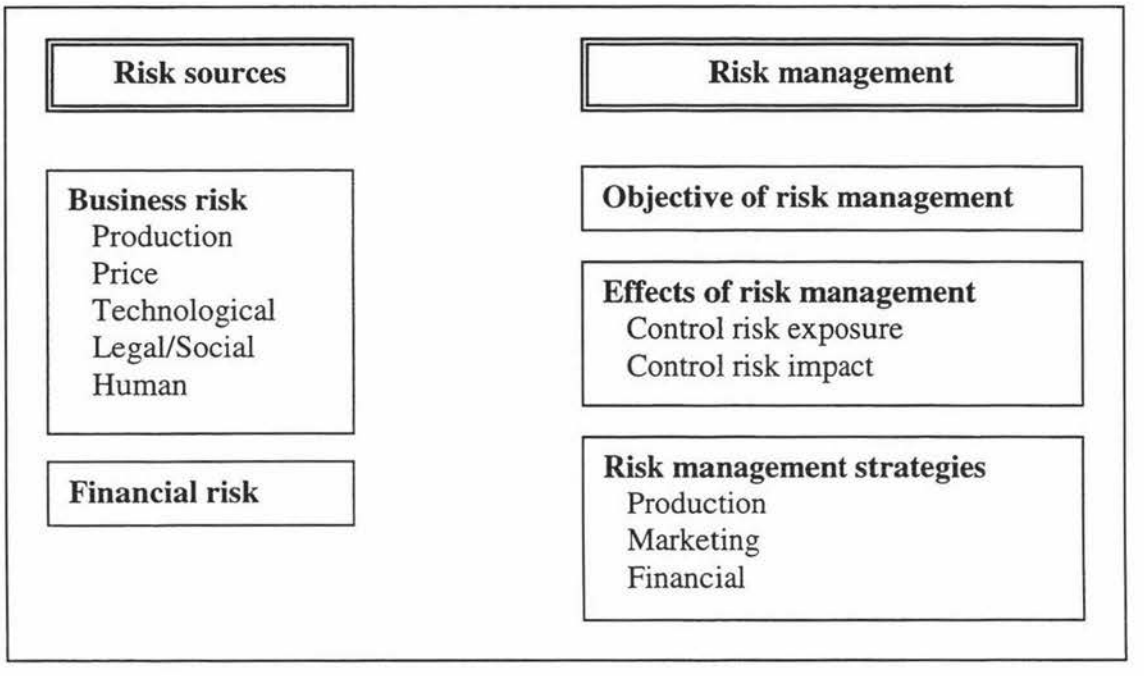

Figure 5.1 Concepts of risk and risk management.
Source: Martin (1996, p. 32).

Lawrence *et al.* (1997) identified innovative measures used by hog co-operatives in the US in order to try to minimise business risk. The producer's payment is determined by a formula of price tied to the current market price and an adjustment for the value of the resulting meat cuts of the animal delivered. The individual contract incorporates feed prices in a formula priced contract designed to: provide upper and lower bounds on prices, and share gains or losses from prices outside the price boundaries.

5.2.1 Risk management in New Zealand pastoral systems

Martin (1996) identified that the deregulation of New Zealand's economy (started in 1984) exposed farmers to more risk due to increased market uncertainty. Therefore traditional patterns of risk management have changed to re-evaluate new sources of risk and corresponding measures to protect farm businesses. The importance attached to different sources of risk by New Zealand sheep and beef cattle farmers is shown in Table 5.2, while the importance attached to different risk management responses by New Zealand sheep and beef cattle farmers is depicted in Table 5.3.

Table 5.2 Importance farmers attach to different sources of risk.

Risk source	Score *
Market risks	
Changes in product prices	4.3
Changes in world economic and political situation	3.7
Changes in New Zealand economic situation	3.7
Changes in input costs	3.7
Financial risks	
Changes in interest rates	3.3
Changes in land prices	2.7
Production risks	
Rainfall variability	3.6
Diseases or pests	3.2
Other risks	
Changes in producer board policies	3.2
Being unable to meet contracting obligations	1.7

Source: Martin (1996, p. 35).
* Ranking: 1 = not important, 5 = extremely important.

Table 5.3 The importance attached to different risk management responses and their use by sheep and beef cattle farmers in New Zealand.

Risk response	Score *	% using response
Marketing responses		
Market information	3.6	89
Spreading sales	3.6	85
More than one enterprise	3.4	79
Forward contracting	1.6	31
Future markets	0.8	6
Overall responses		
Short-term flexibility	3.4	80
Long-term flexibility	3.3	81

Source: Martin (1996, p. 37).
* Ranking: 1 = not important, 5 = extremely important.

The main concern of New Zealand pastoral farmers is market risk (price variation). Fluctuations in lamb price provoke an uncertain level of income. Thus, producers cannot plan high quality purchases to assure quality outcomes (Farrell and Tozer 1996). Marketing strategies such as forward contracting and the use of futures can reduce market risk. However, farmers do not consider these as viable risk responses, which suggest that they want to maintain the ability to enhance price performance, or bargaining power, as much as they can (Martin 1996).

5.2.2 Meat contracts in New Zealand

Blanchard (1993) and Williams (1994) suggested that meat contracts in New Zealand are a mechanism for the processor to reduce the uncertainty of supply, while farmers could benefit from them through economic advantages over the spot market. Under the spot market, farmers selling lambs for processing receive a price according to a weekly lamb schedule (for each meat carcass classification, see Table 3.2 and Figure 3.1). These schedules are based on individual meat processing company's overseas market requirements. In contrast, contract payments are a modified version of the free market payment system plus bonus payments for in-full, on-time deliveries and livestock presentation policies, among others. Meat contracts are established individually between farmers and meat processing companies. Each contract offers farmers different options in terms of financial characteristics, management advice, contract complexity, pricing, killing flexibility and stock management (Blanchard 1993).

At the beginning of each season, meat companies require the commitment of farmers to deliver a certain number of lambs per month within a specified weight range. These lambs earn bonus payments, but extra lambs delivered during the same period would not be eligible for additional payment.

The "Progressive Meats Limited 1997-98 supply commitment" contract was chosen to illustrate the characteristics of lamb meat contract in New Zealand. The payment system is a complex combination of several factors: exchange rate fluctuations, market price movements, performance bonus for meeting commitment to deliver stock in-full and on-time (Table 5.4), meat grade classification according to market destination, premium matrix (Figure 5.2), pelt characteristics, livestock presentation, drafting rebates and transport costs. Of the above-mentioned characteristics, producers have no control over exchange rate fluctuations, market price movements and transport costs. Adequate planning techniques, however, could assist lamb producers to control the rest of the payment factors for their products.

Table 5.4 Progressive Meats Limited performance bonus system – an example.

Months	O	N	D	J	F	M	A	M	J	J	A	S	Total
Lambs committed	100		200	100	100	100	100	100	100	100	100	100	1200
Changes		100	-100			100		150		100			450
Lambs delivered	110	106	121	90	60	205	105	260	100	200	95	91	1543
Eligible lambs	100	100	100	90	60	200	100	250	100	200	95	91	1486

Source Progressive Meats Limited (1997).
All figures are expressed in number of animals.

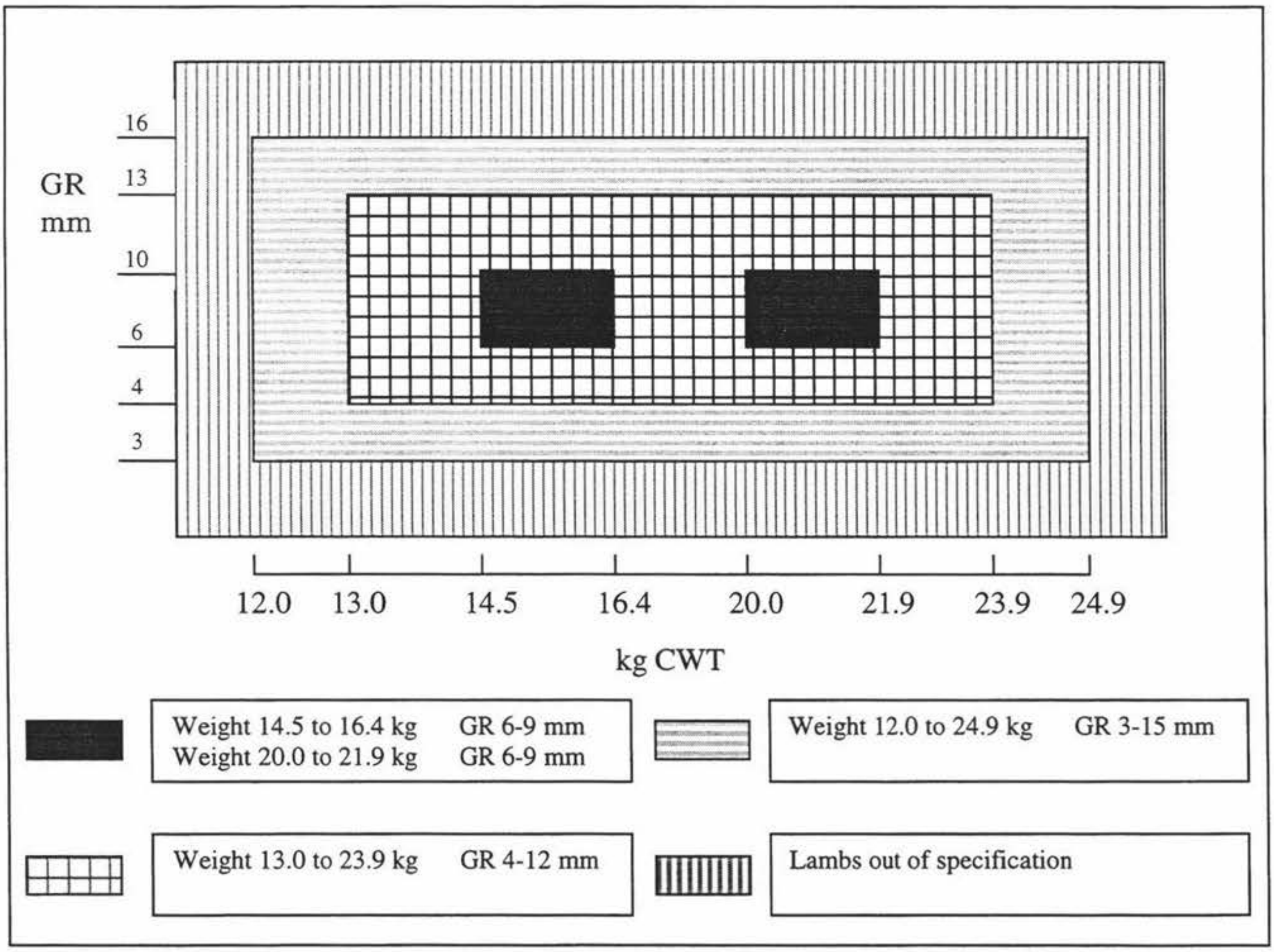

Figure 5.2 Progressive programme premium matrix.
Source Progressive Meats Limited (1997).

Lamb carcasses falling into the small squares receive higher bonus payments than those falling into the rest of the matrix. Thus, reducing the variation of lamb yield (weight and GR) could reduce the risk exposure of a lamb production system.

5.3 Discrete stochastic programming

Mathematical programming (MP) tools can be used to construct models of whole-farm systems for planning reasons (Hardaker *et al.* 1998). MP allows the analysis of decision-making and the implications of this on the whole farm context. These authors suggested that "...it is usually impossible to contemplate accounting for all sources and impacts of uncertainty. Rather, some simplification will be necessary" (p. 180). MP models can be applied in cases with embedded and non-embedded risk Embedded risk occurs when decisions depend both on earlier decisions and the outcomes of uncertain events. For example, the decision of establishing a mating date and the uncertain pasture availability at weaning date determine the final number of lambs sold to works or store, and the number of lambs bought. Non-embedded risk occurs when there is not changes to be made to the initial plan. For example, once crops are sown, no more important decisions have to be made, even when crop yield and prices are going to be known only after harvest (Hardaker *et.al.* 1998). According to the same authors, non-embedded risk models are also known as *risk programming* models (i.e. linear programming, quadratic risk programming, MOTAD programming, and utility-efficient programming). In contrast, embedded risk models can be called *stochastic programming* models (i.e. discrete stochastic programming (DSP) models).

More complex stochastic techniques can be applied to approach the problem of assessing risk over time. Examples of these techniques are deterministic dynamic programming, dynamic probabilistic simulation and Monte Carlo simulation (Barry 1984, Hardaker *et al.* 1998). However, conceptually simpler techniques such as DSP can also be considered as stochastic dynamic modelling methods. DSP models can be considered adequate for decision analysis over a short-term horizon (i.e. assessing the lamb sales policy for the 1999-2000 season), while methods such as Monte Carlo simulation are more suitable for long-term decisions (i.e. crossbreeding, farm diversification) (Hardaker *et al.* 1998).

5.3.1 DSP applied to lamb systems

For this research, a DSP model for a simple two-stage problem was formulated according to Hardaker *et al.* (1998). The decisions considered were to decide a mating date for the flock and to determine the lamb sale policy. The latter depends on the first decision and the amount of DM available on the farm to meet livestock requirements. The objective of the system is to assess the cost of production for each scenario:

$$E[U] = p_t U(z_{2t})$$
Subject to:
$$A_1 x_1 <= b_1$$
$$-L_{1t} x_1 + A_{2t} x_{2t} <= b_{2t}$$
$$C_{2t} x_{2t} - I_{2t} z_{2t} = f_{2t}$$
$$\text{And } x_1, x_{2t} >= 0, t = 1, \ldots s$$

Where subscripts 1 and 2 indicate first- and second-stages (mating date and sales policy). The subscript t indicates the state of nature (low, medium or high rainfall), p_t are 1 x s vectors of the joint probabilities of the activity cost of production outcomes given that the state of nature t has occurred. L_{1t} is a set of s matrices linking mating dates and sales policies. Thus, in this formulation it was assumed that once a mating date was decided (x_1), one of three states of nature ensued (t), a sales policy had to be adopted (x_{2t}), and that this was conditioned by both mating date and DM production. The returns from these activities were subject to further uncertainty, defined by the matrices for the activity cost of production (C_{2t}) and its associated probabilities (p_t).

The result of this model could be used to suggest the mating date and lamb selling policy for lamb production systems, given the effect of uncontrollable weather. The resulting sheep policy can be used to determine the commitments that producers can meet at the lowest cost when considering a contractual situation (see Section 5.1.3).

5.4 Materials and methods

The 7SIFin farm class was analysed in detail to illustrate the effects of uncertainty on the calculation of cost of lamb meat production. 7SIFin systems were selected because

92% of the total DM production on these farm systems was designated to the sheep enterprise. The reduced number of cattle run by these farms facilitated the identification of the effects of uncertainty and decision making on sheep performance. The 7SIFin farm class modelled in previous chapters was defined as the *status quo* system. Tables 5.5 and 5.6 show the main characteristics of this production system.

Table 5.5 Physical and financial characteristics of the status quo system.

Physical characteristics	
Location	Southland, South and West Otago
Effective hectares	220
Hectares on pasture	207
Cash crops (ha)	13
Hay & Silage (ha)	18
Normal rainfall (mm)	927
Sheep at open (hd)	2,675
Lambing %	114.4
Ewe mating date	10 Apr
Lambs sold (hd)	1,807
Wool sold (kg)	12,886
Cattle on open (hd)	25
Calving %	83.3
Cow mating date	27 Nov
Cattle sold (hd)	11
Financial characteristics	
	Whole farm
Operating expenses ($)	121,471
Cost of debt[1] ($)	14,067
Cost of equity[1] ($)	9,675
EFS ($)	12,887
Value added[2] ($)	(12,466)
	Sheep enterprise
EFS ($)	16,546
Value added[2] ($)	(8,948)
	Lamb meat
BEP ($/kg)	2.75

[1] Post-tax figures.
[2] Post-tax EFS less cost of capital.

Three possible mating dates (10-Mar, 10-Apr, 10-May) were evaluated under three different scenarios of DM production with an equal probability of occurrence. The software GROW® was used to estimate the variation in pasture production when rainfall conditions change on a month by month basis. Rainfall variation was established according to the statistics for the Gore District (Table 5.6). GROW®

results showed that total annual DM production for the status quo system was increased 2% when the rainfall pattern increased 10% and decreased 4.1% when rainfall was reduced to 90% of the normal pattern.

Table 5.6 Rainfall 1994-95 to 1997-98 for the Gore District (mm).

Normal	1994-95	1995-96	1996-97	1997-98
841	881	1045	995	995

Source NZMWBES (1997a, p. 17).

The matrix for the DSP model is shown in Appendix 2. Stockpol® was used to simulate the three mating dates under the three different scenarios for DM production. The resulting nine combinations of stock numbers and seasonal conditions determined the demand of DM for each option. Then, sheep numbers were modified in order to make the system feasible for these DM production levels, resulting in 9 possible lamb selling and purchase policies.

The criterion applied was to finish the maximum possible number of lambs at 35 kg average carcass weight (to maximise lambs falling into the premium area of the contract's premium matrix, showed in Figure 5.2), subject to DM supply (Figure 5.3). The software generated a normal distribution function for lamb meat production (weight and GR grade). These lamb production performances were used to evaluate the variation in BEP market price for the farm system.

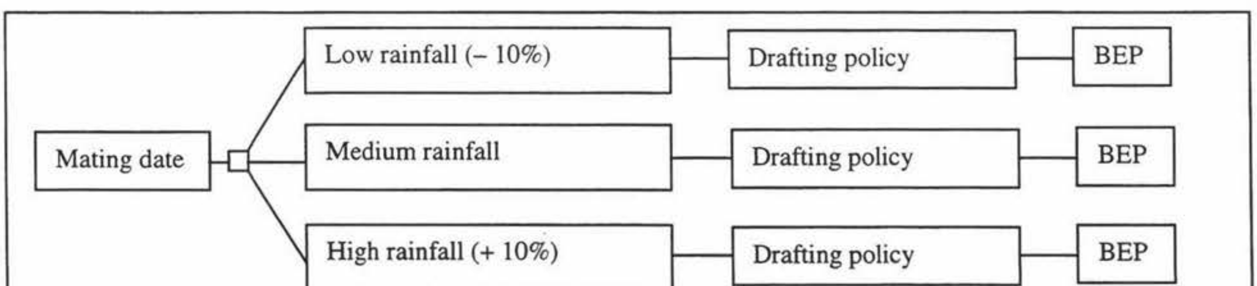

Figure 5.3 Embedded decision tree for different mating dates and lamb drafting policies for the 7SIFin farm class.

5.4.1 Stochastic variables

The DSP model also included the stochastic effects of lambing percentage, wool production, lamb purchase price and wool price. Triangular distributions for these variables were calculated based on past performance for the farm class (NZMWBES 1996a, 1996b, 1997b). Net wool revenue varied from \$3.148 to 3.251 /kg (most likely \$3.23/kg), while lamb purchase price fluctuated in the range of \$24.54 to 33.18 /hd (most likely \$26.30/hd). Lambing percentage varied from 110.3%, to 123.9%, with the most likely value being 114.4%. Finally, wool clip alternated from 4.98 kg/ssu to 5.95 kg/ssu, with a mode of 5.15 kg/ssu.

These stochastic variables were used to construct the matrices for activity cost of production (C_{2t}) and associated probabilities (p_t) (see Section 5.3.1) in the DSP model. Thus, the 9 drafting policies resulting from the simulation in Stockpol® were evaluated under the stochastic effect of these variables. For example, variation in lambing percentage determined the number of lambs weaned and those that were bought in order to accomplish the drafting policies.

The DSP model produced cumulative distribution functions (CDF) for the lamb meat BEP market price. The objective of the DSP model was to assess the lamb cost of production for each combination of mating dates and sales policies in order to assist decision-makers to forecast a cost of production that could be used to consider forward contracting (see Section 5.1.5).

5.5 Results

Stockpol® simulation results for the three mating dates under the different DM production scenarios are shown in Table 5.7. Sheep numbers were adjusted to match DM supply. The respective costs of production allocated to each option based on the DM intake of the sheep enterprise (according to the ABC system) is also displayed. The average lamb grading and the sales pattern of the three mating date options are presented in Figures 5.4 and 5.5, respectively. Stockpol® generated a normal distribution of lamb grades according to user-defined drafting policies. In each case, these drafting policies aimed to target the premium area of the contract premium matrix (Figure 5.2), subject to DM availability.

Table 5.7 Simulation results for three mating dates under three scenarios of DM production for the 7SIFin farm class.

	Mating 10 March			Mating 10 April			Mating 10 May		
	Low rainfall	Medium rainfall	high rainfall	Low rainfall	Medium rainfall	High rainfall	Low rainfall	Medium rainfall	High rainfall
Sheep intake ('000 kg/DM)	1,707	1,776	1,810	1,711	1,779	1,815	1,637	1,705	1,739
Lambs sold (head)	1,645	1,693	1,719	1,754	1,807	1,835	1,416	1,456	1,478
Lamb meat production (kg)	23,083	23,852	24,284	25,952	26,821	27,282	18,787	19,432	19,783
BEP ($/kg)[1]	**3.15**	**3.07**	**2.95**	**2.87**	**2.75**	**2.68**	**3.88**	**3.78**	**3.62**

[1] Pre-tax BEP price (market price).

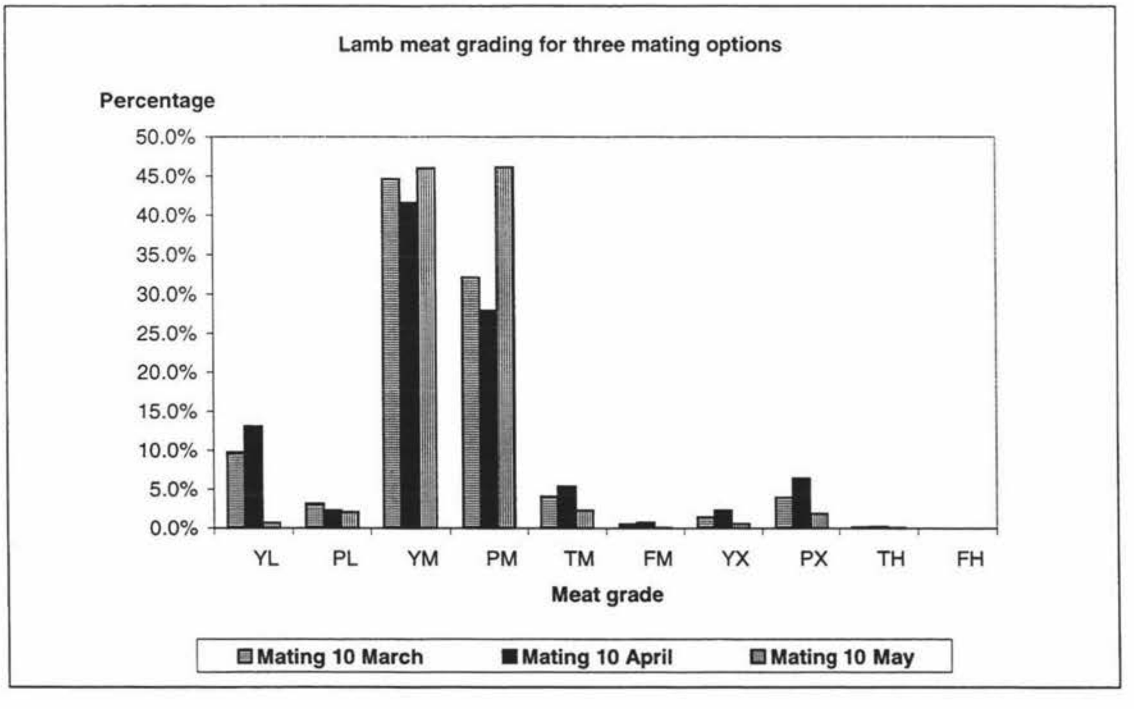

Figure 5.4 Simulated lamb meat grading for three mating dates for the 7SIFin farm class.

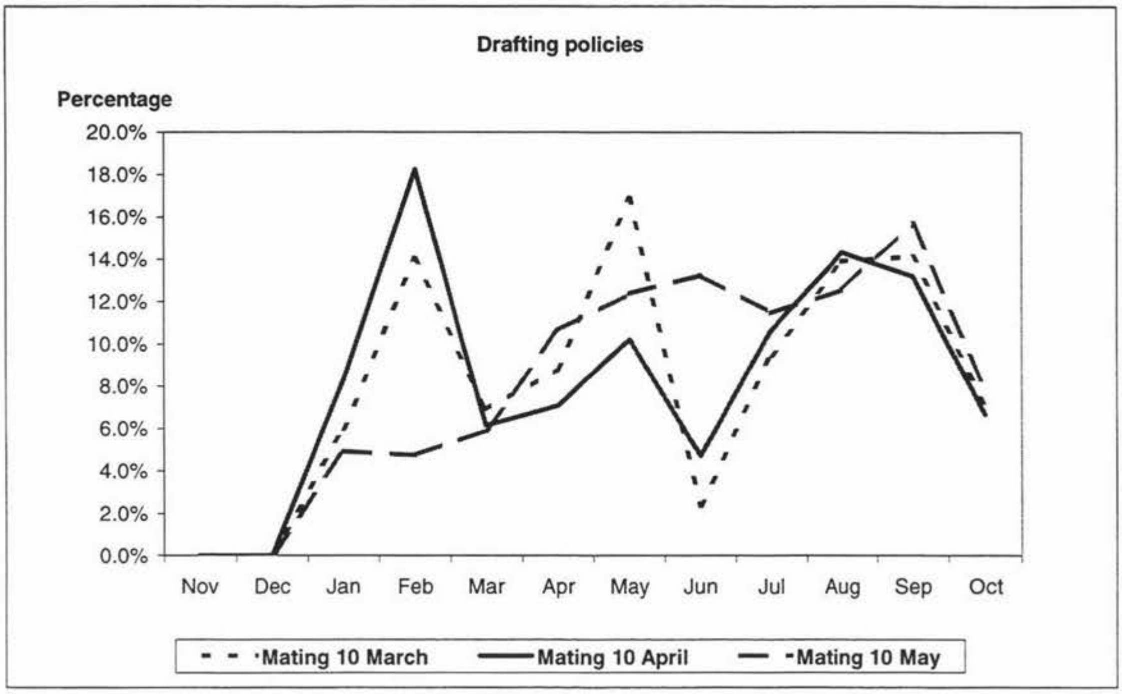

Figure 5.5 Sales pattern for three mating dates for the 7SIFin farm class.

Cumulative distribution functions (CDF) for the lamb meat BEP for the three mating dates considered were generated (Figure 5.6). The calculation of these CFDs took into account the stochastic effects of lambing percentage, wool production and wool sale prices.

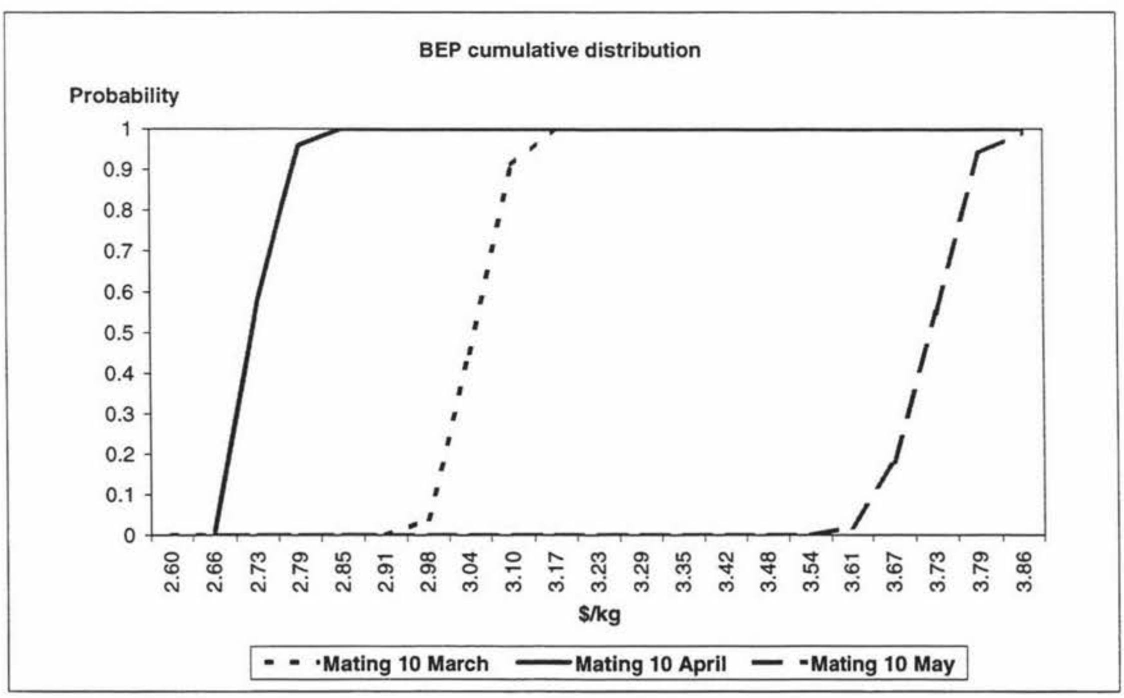

Figure 5.6 Cumulative distribution function (CDF) of the lamb meat BEP for three mating dates for the 7SIFin farm class.

The CDF represents the probability distribution of the cost of production for each mating option. The *x*-axis represents the cost of production and the *y*-axis depicts the probability of occurrence. The average cost of production for each option can be assessed when the probability of occurrence is 50%. Thus, the average cost of production for the option of mating on March 10 was \$3.05/kg, \$2.73/kg for the April 10 option and \$3.73/kg for the late mating option. The minimum cost of production for each option corresponds to the first value at the bottom of the line and the maximum value when the line reaches the top of the chart. In this case, the option of mating on April 10 presents a clear advantage over the other options in terms of lower cost of production. This is a clear example of first degree stochastic dominance, because the charts for the different options do not cross with each other. Thus, a clear differentiation between options was established and no further comparison analysis was necessary. Second or third degree stochastic dominance analyses are recommended when options are not clearly differentiated (Hardaker *et al.* 1998).

The results from the DSP model are shown in Table 5.8. The average lamb meat BEP price was \$2.87/kg under low rainfall conditions. The BEP price subject to medium rainfall was \$2.75/kg and \$2.68/kg when high rainfall conditions were considered. When equal probabilities of occurrence were assigned to each scenario for rainfall conditions, the resulting average lamb meat BEP price was \$2.73/kg. The BEP prices shown in Table 5.7 were calculated based on average figures for the 1995-96 season. The results presented in Figure 5.6 and this paragraph are slightly different due to the stochastic effects of the production and price variables discussed in Section 5.4.1.

Table 5.8 Discrete stochastic programming (DSP) model solution for an April 10 mating date and lambs committed under three rainfall scenarios.

	Stage 1
Mating date	10 April

Stage 2													
Commitment period	N	D	J	F	M	A	M	J	J	A	S	O	Total
	Number of lambs committed												
Low rainfall	0	0	141	305	104	120	172	79	177	238	219	111	1,666
Medium rainfall	0	0	143	315	106	122	176	82	184	248	228	115	1,719
High rainfall	0	0	145	320	107	123	178	83	188	253	233	117	1,747

All figures are expressed in number of animals.

5.6 Discussion

The comparison of mating dates in terms of the sheep enterprise's performance (Table 5.7) shows that livestock numbers had to be reduced to adopt late or early mating dates due to the inability of the farm system to sustain sheep intake requirements throughout the year. The low rainfall scenario for each option determined a higher BEP, due to reduced meat production. Figure 5.4 shows the Stockpol® determined normal distribution for lamb production under average conditions. In this case, the results resemble those for the New Zealand export lamb production in 1995 (Figure 3.2).

The drafting pattern for each option, assuming equal probabilities for every DM supply scenario is presented in Figure 5.5. Logically, lambs produced by a late mating production system need to be sold later in order to accomplish the targeted carcass weight. The lamb meat BEP price for mating on April 10 will always be lower than the BEP calculated for the late and early mating options, since the aim of all alternatives is to produce lamb meat with similar quality characteristics (Figure 5.6).

Drafting policies are generally conditioned by the biophysical characteristics of the farm system. Stockpol® enables the user to define these drafting policies in order to accomplish specific product requirements (i.e. sell store, sell to works, target liveweights, target carcass characteristics), so it can be used to reflect a particular farm's drafting policies. The simulation of the 7SIFin farm class was an empirical exercise in which the aim was to sell the maximum number of lambs to works, targeting specific carcass characteristics. In practice, however, more selling options are available.

The results of the modelling exercise were displayed in Table 5.8. The DSP model suggested the way in which all lambs produced by the farm system could be drafted in order to obtain the premium bonus payments offered by the meat contract considered. However, such recommendations have to be approached carefully. First, Gold's *et al.* (1990) suggested that the combination of simulation modelling and manager knowledge is the best method to deal with uncertainty. Therefore the use of systems such as Stockpol® and DSP models are useful decision-making tools when combined with a manager's personal skills. Second, Boehlje *et al.* (1998) suggested that the formation of food supply chains for agricultural products might never comprise 100% of an individual farm's output. He justified this point by indicating that the natural variation in biological components of animal production implies the inevitable existence of a residue of products that may not meet contractual specifications. This residue can be a critical component in determining the financial performance of the farm system. Therefore spot markets will remain as a viable and necessary option for farmers, as lamb meat that do not fall into the premium matrices cannot produce the same level of income as high-grade meat. Finally, the accuracy of Stockpol® and DSP models rely on the accuracy of input data and the adequacy of the probability distributions used for uncertain future events. For the example conducted in this Chapter, the rainfall pattern fluctuated only 10% above and below average figures.

Thus, a mix of contractual arrangements for the premium produce of the farm and spot market bargain power for the remaining production could be considered by farm managers as the optimum alternative. They could use the modelling tools presented in this Chapter to assess the number of lambs that are most likely to achieve premium payments to commit them into contractual arrangements, while the rest could probably be sold more profitability on the spot market.

5.6.1 Concluding remarks

Using cost of production for planning purposes can be considered as a means for a farm to control both 'risk exposure' and 'risk impacts'. As illustrated by this Chapter's example, forecasting and monitoring the cost of production may influence lamb selling policies and control product variation. On the other hand, the costs of production could be used as a negotiation tool to match income with desired profit levels.

The assessment of cost of production under possible scenarios of DM production could be used to evaluate innovative contractual arrangements between producers and processors. For example, it may be used to establish price boundaries for lamb meat, as in the case of the hog co-operatives mentioned by Lawrence *et al.* (1997). Farmers that do not finish stock also could use it to negotiate fair arrangements with finishers (McDermott and Shadbolt 1997).

6 General discussion

6.1 Introduction

This Chapter contains a brief summary of the content of previous chapters, suggestions for further research and concluding remarks arising from the study. It also illustrates how the hypothesis proposed by this research was accepted, and the objectives accomplished.

The importance of supply co-ordination in increasing the competitiveness of the New Zealand lamb industry was shown in Chapter 2. The biological components of the different lamb production systems in New Zealand, which determine their financial performance, were illustrated in Chapter 3. Chapter 4 contains a method to use the biophysical characteristics identified in Chapter 3 to determine the cost of lamb meat according to resource utilisation. In order to evaluate the cost of production of lamb systems, this research proposed a costing approach, which has been applied successfully to other industries. The outline of the sources of variability in agriculture and their effects on the cost of lamb production was presented in Chapter 5. This Chapter also contained an example of a computer mathematical programming model to illustrate how simulation of the biophysical elements of the farm system can be used to assess contractual commitments for a production season.

6.2 Evaluation of the methodology

Using cost of production as an approach to negotiating forward contracts in the New Zealand lamb industry is not well documented in the literature. This study outlines a methodology that could be used by decision-makers to encourage vertical co-ordination mechanisms in the industry. The data set used represents average figures for different farm classes in New Zealand, but the approach can be applied to individual farms.

The use of Stockpol® and GROW® for simulating DM production, animal growth and animal consumption can be compared to simple deterministic techniques such as feed budgets. The accuracy of the results in both cases relies on careful validation of the inputs to reflect the real behaviour of the farm system. The farm manager chooses to use one value or another. However, computer software can enable decision-makers to analyse and compare livestock production options faster by incorporating variability and the probability of events occurring.

The ABC system applied to lamb production can also be substituted by other costing systems. However, ABC systems enable the analysis of resource utilisation as the basis for allocating cost to different farm products. This is especially useful when the farm is diversified and the resources are shared by many production activities. The use of livestock consumption (measured in kgDM) can be improved when considering not only volume, but also the quality of DM consumed. The use of sheep energy requirements (ME MJ/day) for allocating costs to wool and lamb meat can also be debated, but it provides a straight forward and consistent way to derive the allocation of costs.

The ABC system provided a single indicator related to the cost object (lamb meat) that allowed the analysis of lamb production in New Zealand during the 1995-96 season. The analysis showed that the price obtained by producers resulted in a profit margin of 30%, while the required by the business was 52%. This approach emphasised to meat producers the importance of wool production and its revenue to sheep enterprise profitability. For example, if wool production is decreased by 10%, the additional meat revenue required to cover sheep expenses would need to increase by 6%.

Risk analysis can be conducted using different approaches and techniques. The use of a DSP model in this study achieved the objective of illustrating how risk analysis and computer simulation can be used for planning purposes. The risk analysis can be as complex as the decision-maker desires, but the final results and confidence levels depend on the accuracy of the probability distributions assigned to uncertain future events and on the decision-maker's personal skills and attitude towards risk. However, these tools, in conjunction with personal experience, could be useful for lamb producers to increase their confidence in accepting contractual commitments for lamb meat supply.

6.3 Further research opportunities

This study considered just a small number of the issues concerned with vertical co-ordination in the New Zealand lamb industry. For example, related topics that present further research opportunities in terms of lamb producers and primary processor relationships are: communication exchange, traceability systems, and production synchronisation. It is also essential to assess the impacts of vertical co-ordination from a holistic point-of-view, including the needs of producers and primary processors as well as further processors, marketers, transporters and retailers.

Further research could evaluate the cost of lamb production as a performance indicator for meat production systems or compare the different risk analysis techniques for estimating the cost of production for lamb systems.

6.4 Concluding remarks

A study conducted in the US among 600 households showed that lamb was considered the least preferred meat in terms of taste, cholesterol level, economic value, convenience/ease in cooking, and overall preference (Ward, et al. 1995). Lamb meat was compared to beef, chicken, fish, pork, turkey and veal. One of the reasons attributed to lamb's failure in the market was the greater technological development in competing meat processing industries, particularly poultry and pork (Williams & Davis 1998).

Thus, it is vital that producers, processors and retailers "understand the need to organise themselves in the form of alliances that provide the critically important co-ordination of activity that the pricing mechanism has not been able to provide" (Purcell 1998, p. 120). Alliances can help farmers reduce the level of product variability, and therefore focus product offerings to fulfil customers' needs and preferences. The level of co-operative efforts among producers will condition the lamb meat industry's long-term survival (Bastian & Whipple 1998).

New Zealand lamb meat contracts can be considered as a way to reduce risk exposure for the farm business. The use of premium matrices can encourage lamb farmers to produce specialised products. These specialised products could reduce price variability for lamb producers. On the other hand, the focus on cost of production can be used to match an individual farm's biological capabilities with the most cost efficient lamb production system.

New Zealand is recognised for being one of the cheapest producers of pastoral animal products. The cost of production approach can also be used to assess the price at which alternative lamb production systems could be economically feasible for farmers (i.e. off-season production systems, hogget mating).

Martin (1996) pointed out that in 1994 forward contracting was not a popular option for New Zealand pastoral farmers to control risk. On the other hand, McDermott and Shadbolt (1998) identified "lack of trust" as a possible reason for not considering strategic alliances in the industry. Assessing the cost of production for lamb products could assist lamb producers to consider contracts as a viable option to start building trust in the lamb supply chain.

Price negotiation can be used as an initial step to build a strategic alliance in the industry. Computer simulation techniques and risk analysis could assist lamb producers to estimate the cost of production for specific supply patterns that are essential for the success of forward contracting.

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Appendix 1. Selected tables from The New Zealand Sheep and Beef Cattle Farm Survey 1995-96.

TABLE 2.1 PHYSICAL & PRODUCTION DATA SUMMARY, 1995-96 - Per Farm

Number of Farms in Sample	1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
AREA									
1. Total Farm Area (Ha)	9,869	1,543	852	433	252	458	237	277	599
2. Effective Area (Ha)	9,867	1,449	659	397	238	425	220	275	555
STOCK NUMBERS AT OPEN									
3. Sheep	8,960	4,881	3,560	2,542	1,618	3,305	2,675	1,540	2,835
4. Cattle	339	271	432	370	269	133	25	96	234
5. Deer	81	23	19	30	32	29	23	3	27
6. Goats		21	2	8	2	7	2		6
7. Sheep per Cattle Beast	26	18	8	7	6	25	107	16	12
8. Sheep Stock Units	7,485	4,424	3,219	2,315	1,469	3,073	2,503	1,433	2,594
9. Cattle Stock Units	1,646	1,310	2,085	1,788	1,287	632	117	436	1,124
10. Deer Stock Units	149	42	36	55	58	53	43	6	50
11. Goat Stock Units		16	1	5	1	5	1		4
12. Total Stock Units	9,280	5,792	5,341	4,163	2,815	3,763	2,664	1,875	3,772
13. Stock Units Per Hectare	0.9	4.0	8.1	10.5	11.8	8.9	12.1	6.8	6.8
14. **LABOUR UNITS**	2.65	1.92	1.77	1.58	1.46	1.47	1.52	1.90	1.59
PERFORMANCE									
15. Lambing Percentage	86.4	97.1	98.5	107.1	106.8	102.4	114.4	119.8	104.9
16. Calving Percentage	84.2	82.9	79.9	84.5	85.7	84.8	83.3	100.0	83.8
17. Wool Sold Per Sheep at Open	3.90	3.98	4.67	4.88	4.83	4.15	4.82	4.09	4.50
PRODUCTION									
18. Wool Sold (Kg)	34,984	19,436	16,635	12,395	7,814	13,701	12,886	6,294	12,757
19. Lambs Sold (No)	1,076	1,935	1,231	1,188	917	1,851	1,807	1,244	1,431
20. Sheep Sold (No)	1,432	980	942	700	550	687	463	567	676
21. Cattle Sold (No)	110	88	164	180	173	69	11	40	114
22. Deer Sold (No)	27	5	6	9	9	6	7	3	8
23. Goats Sold (No)		15		1	1	3			2
24. Wool Sold (Kg Per Ha)	3.5	13.4	25.2	31.2	32.8	32.2	58.6	22.9	23.0

TABLE 2.2 SHEEP RECONCILIATION (Input), 1995-96 - Per Farm

		1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
Number of Farms in Sample										
1. START Ewes:	2 Tooth	827	791	655	473	280	628	538	179	509
2.	Mixed Age	3,192	2,547	1,754	1,302	837	1,891	1,555	1,001	1,514
3.	Total	4,019	3,338	2,409	1,775	1,117	2,519	2,093	1,180	2,023
4. Hoggets:	Ewe	1,173	945	827	589	331	617	534	190	572
5.	Wether & Ram	905	255	277	143	149	119	23	108	147
6. Wethers		2,792	292	7	6	3	20	2	49	65
7. Rams:	Down	4	8	3	4	7	8	6	6	6
8.	Romney		6	28	21	7	11	10	4	13
9.	Fine Wool	55	7				1			1
10.	Other	12	32	10	4	4	11	8	5	8
11. TOTAL SHEEP AT OPEN		8,960	4,881	3,560	2,542	1,618	3,305	2,675	1,540	2,835
12. LAMBS TAILED		3,127	3,214	2,364	1,891	1,200	2,567	2,389	1,335	2,105
13. PURCHASES:	Lambs	191	37	72	65	252	100	28	313	112
14.	Ewes	18	128	56	79	128	66	52	183	85
15.	Hoggets		2	16	19	15	4		4	10
16.	Wethers	1	29	1			1		21	3
17.	Rams	10	10	9	6	3	5	5	2	6
18.	Grazing In						6			1
19.	Total	220	207	154	170	399	182	85	523	217
20. TOTAL INPUT		12,307	8,302	6,078	4,603	3,217	6,054	5,149	3,398	5,157
21. Ewe Mating Date		10-05-95	15-04-95	26-03-95	20-03-95	10-03-95	8-04-95	10-04-95	22-03-95	29-03-95
22. Ewes Mated		3,621	3,310	2,399	1,766	1,124	2,507	2,088	1,114	2,007
23. Lambing Percentage		86.4	97.1	98.5	107.1	106.8	102.4	114.4	119.8	104.9
24. Ewes Mated % Sheep at Open		40.4	67.8	67.4	69.5	69.5	75.9	78.1	72.3	70.8
25. Purchases % Sheep at Open		2.5	4.2	4.3	6.7	24.6	5.3	3.2	33.9	7.6

TABLE 2.2 continued SHEEP RECONCILIATION (Output), 1995-96 - Per Farm

Number of Farms in Sample	1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
1. SALES: Lambs: Export	483	1,529	689	973	847	1,662	1,719	1,164	1,228
2. Live Export								11	1
3. Store	593	406	542	215	70	189	88	69	203
4. Ewes: 2 Tooth	96	33	42	36	28	44	6	26	33
5. Mixed Age	599	602	523	450	323	493	419	372	447
6. Hoggets	292	229	350	198	169	134	38	135	168
7. Live Export Sheep	65	21	16	6	23	8	1	11	11
8. Wethers	370	88	7	9	5	5		20	16
9. Rams	10	6	5	2	3	2		2	2
10. Grazing Out									
11. Total	2,508	2,915	2,173	1,888	1,467	2,538	2,270	1,811	2,108
12. LOSSES: Lambs	129	101	117	82	53	78	70	41	77
13. Sheep	598	287	194	133	80	166	113	71	146
14. FARM USE	154	71	80	56	33	46	38	13	49
15. END Ewes: 2 Tooth	847	778	659	465	270	554	511	177	484
16. Mixed Age	3,145	2,607	1,721	1,254	811	1,886	1,585	859	1,492
17. Total	3,992	3,385	2,380	1,719	1,081	2,440	2,096	1,036	1,976
18. Hoggets: Ewe	1,125	939	847	584	327	650	513	192	576
19. Wether & Ram	987	273	239	100	151	88	24	171	132
20. Wethers	2,747	278	8	11	4	18	1	50	64
21. Rams	66	53	39	29	18	31	24	14	28
22. TOTAL SHEEP AT CLOSE	8,917	4,927	3,514	2,442	1,582	3,226	2,657	1,463	2,776
23. TOTAL OUTPUT	12,306	8,301	6,078	4,601	3,215	6,054	5,148	3,399	5,156
24. Lamb Loss %	4.1	3.1	4.9	4.3	4.4	3.0	2.9	3.1	3.7
25. Sheep Loss %	6.7	5.9	5.4	5.2	4.9	5.0	4.2	4.6	5.1
26. Sales as % Sheep at Open	28.0	59.7	61.1	74.3	90.7	76.8	84.9	117.6	74.3

TABLE 2.3 CATTLE RECONCILIATION (Input), 1995-96 - Per Farm

Number of Farms in Sample	1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
1. START Cows	126	94	128	84	34	34	5	1	53
2. Heifers: 2.5 Yr	22	19	38	21	9	6	1		13
3. 1.5 Yr	38	32	59	40	23	14	1	7	25
4. Weaners	116	91	140	130	97	49	12	37	83
5. Steers	32	27	53	55	41	14	6	7	32
6. Bulls	6	6	9	31	34	8	1	13	18
7. Dairy Heifers			4	9	32	7		29	11
8. TOTAL CATTLE AT OPEN	339	271	432	370	269	133	25	96	234
9. CALVES MARKED	128	102	147	98	42	39	5	2	62
10. PURCHASES: Cows		2	3	4	3	1			2
11. Heifers: 2.5 Yr	1		2	1	3				1
12. 1.5 Yr		4	2	6	8	2			4
13. Weaner: Heifers	7	7	5	5	6	6	5	8	6
14. Steers	2	4	6	8	15	10	8	12	9
15. Bulls			9	28	42	7		10	17
16. Steers: 1.5 Yr	3	2	5	9	16	6	1		7
17. 2.0 Yr+			1	2	9	5		2	3
18. Bulls	1	1	2	18	17	3		1	8
19. Grazing In		1	6	9	28	4		48	11
20. Total	14	20	41	89	148	44	14	82	68
21. TOTAL INPUT	481	393	620	557	459	216	44	180	364
22. Cow Mating Date	2-12-94	21-11-94	18-11-94	16-11-94	3-11-94	12-11-94	27-11-94	16-11-94	15-11-94
23. Cows & Heifers Mated	152	123	184	116	49	46	6	2	74
24. Calving Percentage	84.2	82.9	79.9	84.5	85.7	84.8	83.3	100.0	83.8
25. Purchases % Cattle at Open	4.1	7.2	8.3	21.7	44.3	30.2	54.1	35.4	24.5

TABLE 2.3 continued CATTLE RECONCILIATION (Output), 1995-96 - Per Farm

Number of Farms in Sample	1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
1. SALES: Cows	16	13	32	21	13	8	1	1	13
2. Heifers: 2.5 Yr	11	9	23	18	17	6		6	12
3. 1.5 Yr	8	12	13	16	9	7	2	8	10
4. Weaner: Heifers	15	6	6	5	3	5			4
5. Steers	21	8	17	8	5	4	1		6
6. Bulls	1		2	2	4	1			2
7. Steers: 1.5 Yr	19	11	20	17	11	10	5	2	12
8. 2.0 Yr+	18	22	40	45	43	17	2	9	28
9. Bulls	1	8	11	48	68	13	1	14	28
10. Grazing Out			5	8	23	8		29	9
11. Total	110	88	169	188	196	77	11	69	124
12. LOSSES: Calves	3	1	3	2	1	1	1		1
13. Other	11	10	12	8	4	3		1	5
14. FARM USE	1	1	1	1	1	1			1
15. END Cows	126	96	130	84	31	31	5		52
16. Heifers: 2.5 Yr	25	20	37	22	9	8	1	2	14
17. 1.5 Yr	46	37	58	38	25	16	1	5	25
18. Weaners	98	98	141	122	91	52	17	33	81
19. Steers	55	35	55	54	35	18	7	15	32
20. Bulls	7	6	10	29	29	5	1	12	15
21. Dairy Heifers			6	10	38	2		43	12
22. TOTAL CATTLE AT CLOSE	356	292	436	359	256	134	31	109	232
23. TOTAL OUTPUT	481	392	621	558	458	216	43	179	363
24. Calf Loss %	2.3	1.0	2.0	2.0	2.4	2.6	20.0		1.6
25. Adult Loss %	3.2	3.7	2.8	2.2	1.5	2.3		1.0	2.1
26. Sales as % Cattle at Open	32.4	32.6	38.0	48.6	64.5	52.1	44.6	41.8	48.8

TABLE 4 FARM REVENUE ($), 1995-96 - Per Farm

		1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
	Number of Farms in Sample									
	GROSS FARM REVENUE									
1.	Wool	175,647	71,132	50,965	38,525	23,070	47,675	42,230	22,065	42,504
2.	Sheep	55,719	77,397	56,441	48,670	34,023	71,471	73,900	41,576	57,138
3.	Cattle	37,437	33,468	48,489	51,663	42,365	18,973	2,682	13,016	32,003
4.	Dairy Grazing			1,269	2,508	9,688	1,021		3,500	2,751
5.	Deer	7,961	2,836	2,006	2,787	2,786	5,094	2,996	400	3,238
6.	Velvet	1,070	149	776	1,301	1,801	536	342	34	893
7.	Goat + Fibre		61	3	55	38	-20	-6	6	19
8.	Cash Crop	1,501	1,816	455	158	8,290	9,610	9,626	205,436	15,638
9.	Other Revenue	8,446	10,405	3,180	5,800	9,525	7,369	4,696	8,219	6,776
10.	**GROSS FARM REVENUE**	287,781	197,264	163,584	151,467	131,586	161,729	136,466	294,252	160,960
11.	**TOTAL FARM EXPENDITURE**	296,081	189,012	142,410	118,894	115,589	136,883	108,701	231,495	134,876
12.	**FARM PROFIT BEFORE TAX**	-8,300	8,252	21,174	32,573	15,997	24,846	27,765	62,757	26,084
	FARM CASH SURPLUS									
13.	Farm Profit Before Tax	-8,300	8,252	21,174	32,573	15,997	24,846	27,765	62,757	26,084
14.	+ Depreciation	20,650	15,704	9,715	9,567	9,967	13,960	9,553	16,971	11,506
15.	+ Livestock Value Change	-5,626	-6,563	1,328	7,868	5,573	638	472	2,953	2,984
16.	**= FARM CASH SURPLUS**	6,724	17,393	32,217	50,008	31,537	39,444	37,790	82,681	40,574
	SHEEP GROSS MARGINS ($ Per Sheep Stock Unit)									
17.	Net Revenue	23.58	27.66	26.38	30.73	32.77	32.19	38.94	36.75	31.63
18.	Opportunity Cost	5.62	6.17	6.24	6.10	6.18	6.03	6.28	5.62	6.10
19.	Gross Margin	17.97	21.49	20.14	24.63	26.60	26.16	32.66	31.13	25.53
	CATTLE GROSS MARGINS ($ Per Cattle Stock Unit)									
20.	Net Revenue	21.56	25.84	22.69	28.81	35.23	31.97	21.22	41.78	29.20
21.	Opportunity Cost	10.96	12.09	9.70	9.49	9.04	10.53	10.44	10.23	9.84
22.	Gross Margin	10.60	13.75	12.99	19.32	26.19	21.43	10.78	31.55	19.36

TABLE 5 FARM EXPENDITURE ($), 1995-96 - Per Farm

		1	2	3	4	5	6	7	8	
		S.I. High Country	S.I. Hill Country	N.I. Hard Hill Country	N.I. Hill Country	N.I. Intensive Finishing	S.I. Finishing Breeding	S.I. Intensive Finishing	S.I. Mixed Finishing	Weighted Average All Classes
	Number of Farms in Sample	(27)	(44)	(77)	(177)	(90)	(79)	(27)	(27)	Classes
	WORKING EXPENSES									
1.	Wages	40,126	22,119	14,434	10,012	9,617	9,273	6,024	14,405	10,842
2.	Animal Health	15,673	9,954	9,920	7,786	6,436	7,372	6,596	3,882	7,504
3.	Weed and Pest Control	14,377	5,429	1,351	1,556	2,305	3,313	1,969	24,371	3,667
4.	Shearing: Wages & Contract	28,508	14,496	11,180	8,489	4,845	8,674	7,513	3,656	8,370
5.	Shed Expenses	3,223	1,023	788	634	420	560	598	263	627
6.	Fertiliser	15,247	12,672	16,210	16,539	12,781	11,764	10,587	30,953	14,432
7.	Lime	436	954	281	331	893	844	380	1,131	619
8.	Seeds	3,730	2,680	457	706	2,314	2,781	1,514	11,444	2,236
9.	Vehicles	14,179	6,954	5,320	5,106	4,477	5,792	6,134	13,570	5,984
10.	Fuel	7,489	6,372	3,322	2,993	3,698	5,280	4,931	8,940	4,489
11.	Electricity	2,610	1,849	1,857	1,472	1,400	1,513	1,076	2,840	1,551
12.	Feed and Grazing	8,730	4,451	2,442	2,488	3,698	4,982	4,785	2,890	3,806
13.	Contract	7,896	7,355	4,058	4,142	5,090	6,274	1,893	13,872	5,165
14.	Repairs and Maintenance	22,133	16,238	7,950	7,952	7,647	11,382	8,976	16,524	9,904
15.	Cartage	7,156	4,240	2,195	2,114	2,599	3,618	2,609	6,994	3,049
16.	Administration	12,403	7,604	7,045	6,691	6,147	5,887	3,433	7,692	6,146
17.	Syndicate Charges			63	22	93				26
18.	**SUB-TOTAL WORKING EXPENSES**	203,916	124,390	88,873	79,033	74,460	89,309	69,018	163,427	88,417
	STANDING CHARGES									
19.	Insurance	5,698	2,738	2,286	2,014	1,631	2,563	2,281	3,647	2,313
20.	ACC Levies	3,476	1,924	1,678	1,628	1,434	1,666	1,381	2,247	1,646
21.	Rates	9,291	5,953	5,497	4,959	5,676	5,254	4,654	5,170	5,270
22.	Managerial Salaries	1,174	1,443	3,264	2,080	1,602	1,395	26	137	1,501
23.	Interest	47,097	34,371	28,802	17,863	16,268	20,231	21,419	37,995	21,906
24.	Rent	4,779	2,489	2,295	1,750	4,551	2,505	369	1,901	2,317
25.	**SUB-TOTAL STANDING CHARGES**	71,515	48,918	43,822	30,294	31,162	33,614	30,130	51,097	34,953
26.	**TOTAL CASH EXPENDITURE**	275,431	173,308	132,695	109,327	105,622	122,923	99,148	214,524	123,370
27.	Depreciation	20,650	15,704	9,715	9,567	9,967	13,960	9,553	16,971	11,506
28.	**TOTAL FARM EXPENDITURE**	296,081	189,012	142,410	118,894	115,589	136,883	108,701	231,495	134,876

TABLE 6 CAPITAL STRUCTURE ($), 1995-96 - Per Farm

Number of Farms in Sample	1 S.I. High Country (27)	2 S.I. Hill Country (44)	3 N.I. Hard Hill Country (77)	4 N.I. Hill Country (177)	5 N.I. Intensive Finishing (90)	6 S.I. Finishing Breeding (79)	7 S.I. Intensive Finishing (27)	8 S.I. Mixed Finishing (27)	Weighted Average All Classes
ASSETS									
1. Capital Value *	1,569,778	1,248,443	1,024,617	1,082,492	1,217,321	939,278	783,704	1,127,963	1,040,084
2. Truck and Tractor	51,963	32,087	15,694	19,335	19,872	38,968	25,622	65,925	28,054
3. Other Plant & Machinery	41,333	27,924	10,386	11,141	15,709	26,594	22,320	43,269	19,958
4. Sheep at Market Value	287,581	201,818	154,023	107,044	69,369	134,268	115,489	57,574	117,385
5. Cattle at Market Value	101,364	81,533	127,238	105,597	76,837	36,457	8,530	33,374	67,550
6. Deer at Market Value	39,102	12,450	8,483	14,247	13,732	16,516	11,370	1,116	13,353
7. Goats at Market Value		205	28	108	30	90	41	9	73
8. **FARM CAPITAL**	2,091,121	1,604,460	1,340,469	1,339,964	1,412,870	1,192,171	967,076	1,329,230	1,286,457
9. Current Assets	35,494	26,632	22,872	28,249	24,424	23,229	15,532	104,745	28,030
10. Term Deposits	6,119	4,149	11,039	25,371	28,319	26,337	2,874	29,690	20,387
11. Income Equalisation Balance		545	410	1,434	50	396			528
12. Investments Off-Farm	77,845	21,544	33,208	56,218	79,984	19,210	21,041	11,152	40,608
13. Other Assets	4,275	3,805	6,641	7,844	15,332	4,844	6,636	6,039	7,746
14. Homestead	139,037	122,045	101,117	113,684	125,600	108,127	104,074	96,296	111,736
15. Car	16,652	10,418	9,066	10,872	9,562	8,708	11,746	4,719	9,872
16. **TOTAL ASSETS AT CLOSE**	2,370,543	1,793,598	1,524,822	1,583,636	1,696,141	1,383,022	1,128,979	1,581,871	1,505,364
LIABILITIES									
17. Current Liabilities	150,741	85,796	57,840	45,301	44,774	51,119	50,544	91,976	54,352
18. Fixed Liabilities	324,592	310,275	265,232	157,323	159,706	193,217	164,210	339,969	195,916
19. Reserves		27,253	56,216	37,627	100,751	63,652	13,148	55,280	51,868
20. Net Worth	1,895,210	1,370,274	1,145,534	1,343,385	1,390,910	1,075,034	901,077	1,094,646	1,203,228
21. **TOTAL AT CLOSE**	2,370,543	1,793,598	1,524,822	1,583,636	1,696,141	1,383,022	1,128,979	1,581,871	1,505,364
22. Sheep at Open	8,960	4,881	3,560	2,542	1,618	3,305	2,675	1,540	2,835
23. Cattle at Open	339	271	432	370	269	133	25	96	234
24. Deer at Open	81	23	19	30	32	29	23	3	27
25. Goats at Open		21	2	8	2	7	2		6
26. Total Stock Units at Open	9,280	5,792	5,341	4,163	2,815	3,763	2,664	1,875	3,772
27. Effective Area (Ha)	9,867	1,449	659	397	238	425	220	275	555

* Excludes Homestead

Appendix 2 Discrete Stochastic Programming Model for the 7SIFin farm class.

DSP programming model - 7SIFin farm class

	Early mating			Normal mating			Late mating		
	low rainfall	medium rainfall	high rainfall	low rainfall	medium rainfall	high rainfall	low rainfall	medium rainfall	high rainfall
Sheep intake (kgDM)	1,707,713	1,776,458	1,810,327	1,711,132	1,779,463	1,815,120	1,637,321	1,705,033	1,739,170
Lambs sold (head)	1,645	1,693	1,719	1,754	1,807	1,835	1,416	1,456	1,478
Lamb production (kg)	23,083	23,852	24,284	25,952	26,821	27,282	18,787	19,432	19,783
Probability	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%
income from wool	42,896	42,874	44,121	41,111	42,324	43,208	42,896	42,896	44,227
operating expenses meat	71,050	71,415	71,191	71,032	71,395	71,575	70,659	71,040	71,224
operating expenses wool	15,178	15,214	15,192	15,176	15,212	15,230	15,139	15,177	15,195
total operating expenses	86,228	86,629	86,383	86,208	86,607	86,805	85,798	86,217	86,420
sheep cost before cost of capital	43,331	43,755	42,261	45,098	44,283	43,597	43,568	43,987	42,192
cost of capital meat	18,705.56	18,763.19	18,703.22	18,708.52	18,765.62	18,793.83	18,641.94	18,703.22	18,732.45
cost of capital wool	1,860.49	1,866.22	1,860.26	1,860.78	1,866.46	1,869.27	1,854.16	1,860.26	1,863.16
total	20,566.05	20,629.41	20,563.48	20,569.31	20,632.08	20,663.10	20,496.10	20,563.48	20,595.62
sheep cost after cost of capital	72,711.45	73,225.64	71,637.80	74,482.24	73,757.75	73,115.76	72,848.32	73,363.26	71,614.46
BEP ($/kg)	**3.15**	**3.07**	**2.95**	**2.87**	**2.75**	**2.68**	**3.88**	**3.78**	**3.62**

Example of BEF calculation for the 7SIFin class farm.

Mating 10-April, average rainfall conditions.

Stockpol results for 7SIFin

Ewe Lamb & Hogget Drafting for 7SIFin:Sheep1 [F]

	No.	Lwt	Lwg			BeDRAF	T	B	ENo.		ADRAF	T AB	ONo.	Hold	LSTO	RE	CwWO	RKS
															0	0	0	
Wng	722	39	0	"	*	**			0	**	**			0	0	0	0	
Dec	1195	16	150	"	*	**			0	**	**			0	0	0	0	
Jan	1188	21	67	S		17.1		7	88	W	30			66	15.5	28	12.6	38.8
Feb	1094	23	67	"	*	**			0	W	30		2	84	0	0	12.7	35.9
Mar	1071	25	67	"	*	**			0	W	32		1	78	0	0	13.5	38
Apr	1054	27	47	'	*	**			0	W	33		3	98	0	0	14	41.6
May	1016	28	47	'	*	**			0	W	35		1	77	0	0	14.8	45
Jun	1000	29	37	'	*	**			0	W	35		6	56	0	0	14.9	46.9
Jul	942	30	37	'	*	**			0	W	35		9	83	0	0	14.9	47.7
Aug	859	31	37	'	*	**			0	W	35		12	105	0	0	15	50.3
Sep	753	32	79	'	*	**			0	W	37.1		4	30	0	0	15.7	50.3
Oct	722	35	134	'	*	**			0	**	**			0	0	0	0	0

Stockpol results for 7SIFin

Ram Lamb & Hogget Drafting for 7SIFin:Sheep1 [F]

	No.	Lwt	Lwg				BeDRAF	T	B	ENo.			ADRAF	T AB	ONo.	Hold		LSTO	RE	CwWO	RKS	
Wng	135	42	0		*	*	**			0		**	**		0			0	0	0		
Dec	1195	18	195		*	*	**			0		**	**		0			0	0	0		
Jan	1189	25	87		*	*	**			0		W	30	6	77			0	0	13	39.9	
Feb	1109	27	87		*	*	**			0		W	30	21	231			0	0	13	37.2	
Mar	876	28	87		*	*	**			0		W	33.5	3	28			0	0	14	41.2	
Apr	846	30	61		*	*	**			0		W	36	3	24			0	0	15.2	45.1	
May	820	32	61		*	*	**			0		W	36.3	12	99			0	0	15.4	47.8	
Jun	719	33	48		*	*	**			0		W	38.4	4	26			0	0	16.2	51.9	
Jul	692	34	48		*	*	**			0		W	38.3	15	101			0	0	16.3	53	
Aug	591	35	48		*	*	**			0		W	38	24	143			0	0	16.3	55.7	
Sep	448	36	103		*	*	**			0		W	37.6	44	198			0	0	16.3	55.5	
Oct	250	39	174		*	*	**			0		W	39.6	46	115			0	0	17.1	58.4	

Sheep production details

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
lambs sold to works													
Ewe Lamb	83	105	30	0	0	0	66	84	78	98	77	56	
Ram Lamb	101	143	198	115	0	0	77	231	28	24	99	26	
Total	184	248	228	115	0	0	143	315	106	122	176	82	1,719
carcass weight													
ewe lamb	14.9	15	15.7	0	0	0	12.6	12.7	13.5	14	14.8	14.9	
ram lamb	16.3	16.3	16.3	17.1	0	0	13	13	14	15.2	15.4	16.2	
total kilograms sold	2883	3905.9	3698.4	1966.5	0	0	1832.6	4069.8	1445	1736.8	2664.2	1255.6	25,458

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
lambs sold store													
Ewe Lamb	0	0	0	0	0	0	88	0	0	0	0	0	
Ram Lamb	0	0	0	0	0	0	0	0	0	0	0	0	
Total	0	0	0	0	0	0	88	0	0	0	0	0	88
liveweight													
ewe lamb	0	0	0	0	0	0	15.5	0	0	0	0	0	
ram lamb	0	0	0	0	0	0	0	0	0	0	0	0	
total kilograms sold	0	0	0	0	0	0	1364	0	0	0	0	0	1,364

Cost analysis

		allocation						
		non pastoral	pastoral					
			conservation	livestock				
				non-sheep	sheep			
					wool	meat	total	
		5.91%	2.49%	4.70%	7.86%	79.04%	100.00%	
			2.65%	4.99%	8.36%	84.00%	100.00%	
				5.13%	8.58%	86.29%	100.00%	
					9.05%	90.95%	100.00%	
							lamb meat cost	wool
wages	6,024	5.91%	2.49%	4.70%	7.86%	79.04%	4,761	473.57
animal health	6,596			5.13%	8.58%	86.29%	5,692	566.11
weed and pest control	1,969		2.65%	4.99%	8.36%	84.00%	1,654	164.51
shearing: wages & contract	7,513				100.00%		-	7,513.00
shed expenses	598				100.00%		-	598.00
fertiliser	10,587	14.00%	2.28%	4.29%	7.19%	72.24%	7,648	760.72
lime	380	5.91%	2.49%	4.70%	7.86%	79.04%	300	29.87
seeds	1,514		2.65%	4.99%	8.36%	84.00%	1,272	126.50
vehicles	6,134	5.91%	2.49%	4.70%	7.86%	79.04%	4,848	482.22
fuel	4,931	5.91%	2.49%	4.70%	7.86%	79.04%	3,897	387.64
electricity	1,076	5.91%	2.49%	4.70%	7.86%	79.04%	850	84.59
feed and grazing	4,785			5.13%	8.58%	86.29%	4,129	410.68
contract	1,893	14.00%	2.28%	4.29%	7.19%	72.24%	1,368	136.02
repairs and maintenance	8,976	5.91%	2.49%	4.70%	7.86%	79.04%	7,095	705.64
cartage	2,609			5.13%	8.58%	86.29%	2,251	223.92
administration	3,433	5.91%	2.49%	4.70%	7.86%	79.04%	2,713	269.88
syndicate charges	-	5.91%	2.49%	4.70%	7.86%	79.04%	-	-
sub-total working expenses	69,018						48,480	12,933
standing charges								
insurance	2,281	5.91%	2.49%	4.70%	7.86%	79.04%	1,803	179.32
ACC levies	1,381	5.91%	2.49%	4.70%	7.86%	79.04%	1,092	108.57
rates	4,654	5.91%	2.49%	4.70%	7.86%	79.04%	3,678	365.87
sub-total standing charges	8,316						6,573	654
total cash expenditure	77,334						55,052	13,587
depreciation	9,553	5.91%	2.49%	4.70%	7.86%	79.04%	7,551	751.00
Reward labour and mgmt	34,584	5.91%	2.49%	4.70%	7.86%	79.04%	27,335	2,718.78
total farm expenditure	**121,471**						**89,938**	**17,056**
less other income	**8,028**	5.91%	2.49%	4.70%	7.86%	79.04%	6,345	631.11

Sheep Income

wool	12886 @	3.28	42230							
export lambs	1719 @	33.49	57569.31							
store lambs	88 @	33.18	2919.84							
other			13,410.85		9.05%	90.95%		12,197.65		1,213.20
				Operating costs (pre-tax)			$	71,395.10	$	15,212.09
cost of capital	**23,742**	5.91%	2.49%	4.70%	7.86%	79.04%		18,766		1,866.46
cost of equity										
debt cost	14,067									
debt repayments	3,189									
personal drawings	33,884									
=- post-tax reward lab. & mgmt	24,209									
				Total cost (after tax and cost of capital)			$	68,742.19	$	12,514.93

Total lamb meat cost of production Deducting wool income, adjusted for post tax cost of capital	**$ 73,851.88**	
Total lamb meat production	**26,821.80**	**kg**
Market value of lamb meat (BEP)	**2.75**	**$/kg**