Agriculture Cooperatives and the Theory of the Firm: Case Studies of New Zealand and Chinese Dairy Industries

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ABSTRACT

In 2008, two exogenous shocks changed the way milk was transacted in New Zealand and China: the launch of Global Dairy Trade (GDT) in New Zealand, and the China melamine milk crisis. These two events provide a good opportunity to undertake an event-study analysis on how governance models evolve in response to structural changes in the market of raw milk. This research capitalises on such an opportunity.

Prior to this research, empirical studies of the efficiency of agriculture cooperatives relative to investor-owned firms (IOFs) have been largely focused on which one of these competing governance models is superior in terms of economic efficiency. This research uses the theory of the firm, an event-study approach and data from the New Zealand and Chinese dairy industries to examine how market participants migrate from one preferred governance model to another and the associated efficiency changes in response to changes in the milk market structure brought about by these two exogenous events.

TABLE OF CONTENT

CHAPTER THREE: Theory of the Firm: A Case Study of the China Melamine Milk Crisis

LIST OF TABLES

CHAPTER ONE

CHAPTER TWO

CHAPTER THREE

LIST OF FIGURES

INTRODUCTION AND RESEARCH MOTIVATION

In my two decades of executive and consulting experience with the New Zealand and Chinese dairy industries, I have often come across the following question asked by industry experts and commentators at various New Zealand and Chinese dairy industry conferences and forums: is cooperative ownership/governance the most efficient way of delivering value for the industry? This is a simple question but it does not have an easy answer.

In New Zealand, cooperative governance has been a dominant form of ownership/governance structure that delivers value and secures growth for its dairy industry, whilst in China, the dairy industry has been able to achieve exponential growth through market governance, in which farmers supply milk to investor-owned dairy firms (IOFs) using contracts. Both seem to be able to achieve rapid growth over a long period of time through these alternative governance models.

In my literature review of the empirical studies that look into the relative efficiencies of two competing governance models, agriculture cooperatives and contract supply to IOFs using market governance, I find that there is no compelling evidence that one governance model is superior to the other. Instead, the evidence seems to suggest that contracting parties engage alternative models that deliver them the most value in response to the market conditions in which they operate. I have therefore come to the view that a better way to understand the efficiency of agriculture cooperatives is not by asking whether one governance model is better than the other, but by answering the question: given the market structure of a particular agriculture industry, what is the optimal governance model?

That is, why is milk not transacted like most other goods and services using the market price mechanism? What are the market conditions that incentivise dairy farmers and dairy processors to transact through cooperatives? New Zealand adopts a cooperative governance model because cooperatives maximise both dairy farmers and dairy processors' interests under a set of market conditions that incentivise them to do so. The question is not merely about whether one governance model is better than the other but whether one model is more suitable than the other under a given set of market conditions.

This question is very similar to what prompted Coase's (1937) Nobel Prize winning work on why firms exist. What are the factors that incentivise contracting parties to transact through integrated firm governance instead of transacting directly using the market price mechanism? Since Coase (1937), much theoretical and empirical research has been undertaken to answer this question. This research has been collectively referred to as "the theory of the firm."

In 2008, there were two events that had a profound impact on the market conditions under which milk was transacted in New Zealand and China. In New Zealand, its largest dairy cooperative, Fonterra, launched the world's first online dairy commodity trading platform, Global Dairy Trade (GDT) in July 2008. The GDT prices were subsequently adopted into determining the milk price dairy processors pay to dairy farmers for their milk using contracts. This provided a milk price discovery that was not available before GDT, and enabled New Zealand dairy farmers to move from a predominantly cooperative governance model to a hybrid of cooperative and contract supply model.

In the same year, in China, we observed the world's largest milk market failure because of Chinese dairy farmers and milk traders adding melamine to increase their supplied milk

volumes, therefore increasing their milk revenue received through contracts. The melamine milk crisis has led some to the conclusion that contract supply of milk using the market price mechanism, which enabled China to achieve remarkable growth in its milk supply, was no longer the most efficient way of transacting milk. This raises the question of whether China should adopt an integrated governance model such as cooperatives to transact the milk supplied by Chinese dairy farmers.

These two events provide good opportunities for research that seeks to understand whether contracting parties involved in transacting raw milk supply do migrate from one governance model to an alternative model when there are significant changes in the prevailing market conditions as predicted by the theory of the firm. Did the New Zealand dairy industry move from an almost 100% cooperative-only supply model to contract supply in response to the milk price discovery enabled by GDT? Did China's dairy industry move from a predominantly contract supply model to an alternative integrated model, such as dairy cooperatives, in response to its milk market failure?

Accordingly, this thesis seeks to: (1) use the theory of the firm to hypothesise how the New Zealand and Chinese dairy industries responded to the two significant events that took place in 2008 by migrating from one governance model to another; and (2) use New Zealand's and China's dairy industry data to empirically examine and test the hypotheses developed. This thesis is therefore structured as follows.

Chapter One provides an overview of the theory of the firm and demonstrates, in the context of the New Zealand dairy industry, how the theory of the firm can be applied to understand why agriculture cooperatives exist. The hypotheses developed based on the theory of the firm

are then tested by examining the New Zealand dairy industry's response to the milk price discovery enabled by the implementation of GDT in August 2008.

Chapter Two provides an empirical analysis of the efficiency changes at an industry level associated with New Zealand dairy farmers migrating from cooperatives to a hybrid of the cooperative and contract supply model.

Chapter Three adopts the theoretical framework developed in Chapter One to understand: (1) how the Chinese dairy industry started from local government-facilitated cooperatives and evolved to a contract supply model using IOFs to support the phenomenal growth in milk required to meet China's rapidly increasing dairy consumption; (2) how the contract supply model failed to deliver milk that was safe for human consumption; and (3) how the Chinese dairy industry responded to the world's largest milk market failure by making changes to its governance model.

CHAPTER ONE

Agriculture Cooperatives and the Theory of the Firm: A Case Study of the New Zealand Dairy Industry

1 Introduction

In 2019, the New Zealand dairy and kiwi fruit industries generated a combined revenue of NZD$24 billion through cooperative ownership, which was around 42% of New Zealand's total goods exported and 64% of New Zealand's agriculture products exported in the same year.[1] These statistics reveal the importance of agriculture cooperatives to the New Zealand economy.

The importance of the cooperative governance model implies that individual farmers are highly dependant on the performance of the New Zealand dairy industry. That is, to be a farmer, you need to invest in farm land, cows and milking equipment to produce and supply milk to the dairy cooperative. Moreover, the farmers need to invest in the dairy cooperative that produces, sells and markets dairy commodity products around the world. Compared to other developed economies where most of their exports are transacted through investor-owned companies, in which the investors have the flexibility of investing in any part of the value chain as independent equity investors, the cooperative ownership plays a much more important role in the New Zealand economy.

The key difference between investor-owned company ownership and cooperative ownership is that the ownership rights in cooperatives are redeemed by cooperatives upon entry and exit and are not transferable to other non-supplier-shareholders. In contrast, in investor-owned companies, the ownership rights/shares are transferable to other investors but cannot be redeemed by the company. This means that when farmer-suppliers want to become members

[1] The dairy and kiwi fruit revenue figures are based on 2019 figures reported in the annual reports of Fonterra, Westland, Tatua and Zespri. The goods exported figures are extracted from Statistics New Zealand's Infoshare database. Note that the 64% of New Zealand agriculture export is made up of 57% dairy and 7% Kiwi fruit.

of cooperatives, they have to subscribe to ownership rights issued directly by cooperatives, and when farmer-suppliers leave they have to sell the rights previously purchased back to the cooperatives, and the cooperatives can then sell these rights to other suppliers. This is different to investor-owned companies where shares are issued by a company to shareholders and when shareholders exit, their shares are not sold back to the company but transferred to new shareholders who are not necessarily suppliers.

As one can see, ownership rights are defined and transacted very differently between investor-owned companies and cooperatives and, at the same time, cooperative ownership plays a critical role in New Zealand agriculture industries. This prompts one to ask the following questions: (1) why would market participants adopt one ownership model over the other? (2) does it make sense to have 64% of New Zealand's total agriculture exports transacting through cooperatives instead of investor-owned companies? and (3) if it does not make sense for the observed cooperative dominance, then could value be created by migrating from cooperatives to investor-owned companies?

These questions motivate my research into the economics of agriculture cooperatives. I achieve this research objective through theoretical and empirical analysis that seeks to answer the following research questions:

1. What is agriculture cooperative ownership? What are the key characteristics of agriculture cooperatives' ownership rights that make them unique relative to the more common ownership rights vested in investor-owned companies? How do these unique ownership rights influence the economics of agriculture cooperatives?

2. Why is agriculture cooperative ownership preferred by market participants to the more commonly adopted equity ownership in investor-owned companies? Based on cooperatives' unique ownership rights, what are the conditions that incentivise market participants towards agriculture cooperative ownership?

3. Does agriculture cooperative ownership produce economically efficient outcomes? What does the data tell us about the performance of agriculture cooperative ownership in terms of efficiency?

This chapter addresses the first two questions ("what" and "why") by firstly reviewing the literature to understand why firms exist, which is commonly understood as the "theory of the firm." This helps us to identify and understand the economic reasons that motivate market participants to integrate transactions through a firm as opposed to transacting through contracts via the market. The theory of the firm is then applied in the context of agriculture cooperatives to help understand the economic reasons for internalising transactions through agriculture cooperative ownership as opposed to contracting directly using the market.

Based on the understanding of the economics of agriculture cooperatives developed from the theory of the firm, I then seek to understand the market conditions that contribute to the formation of agriculture cooperatives. I also demonstrate how changes in these conditions could significantly impact the economics of agriculture cooperatives and lead to changes in the way agriculture cooperatives' ownership rights are defined.

The third question ("do cooperatives actually work?") on the relative efficiency of cooperatives compared to comparable investor-owned companies is beyond the scope of this

chapter. I address this question in more detail in Chapter Two of this thesis: "The Impact of Global Dairy Trade (GDT) Auction on the Efficiency of the New Zealand Dairy industry." Instead, this chapter adopts New Zealand dairy industry data from the period 2002 to 2015 to examine whether the market participants reveal their preference for one ownership model to another when conditions that have led to the formation of a particular ownership model have changed.[2] This data set has been adopted because in July 2008 the New Zealand dairy industry launched an online global dairy commodity auction platform, GDT, which provides dairy commodity price and milk price discoveries that are critical enablers to contract supply of milk to investor-owned firms (IOFs).

Such revealed preference helps us to better understand whether the market does engage alternative ownership models as an optimal solution in response to a set of conditions as hypothesised by the theory of the firm. This helps us gain an understanding of whether: (1) the theory of the firm works in explaining the economics of agriculture cooperatives; and (2) a particular type of ownership model is preferred under a specific set of market conditions, which implies that it is not about whether one ownership model is superior than the other, but whether one model is more suitable than the other under certain market conditions.

The recent changes to New Zealand dairy market conditions (more transparent and reliable prices for both dairy commodity products and raw milk) provide a good research opportunity to examine how market participants respond with their preferred ownership models. The empirical analysis therefore uses relevant data to examine how alternative ownership models

[2] The 2002 data is selected as the first year as this is the first year after the implementation of a significant restructure in the New Zealand dairy regulations leading to: (1) the formation of Fonterra (New Zealand's largest dairy cooperative), and (2) the formation of investor-owned dairy companies. The data beyond 2015 is not included in the analysis due to major changes in Fonterra's capital investment plan in the 2015 financial year leading to, in addition to the exposure to the international dairy commodity prices, a significant increase in Fonterra's exposure to the Chinese raw milk market and the Chinese consumer dairy market.

are adopted in response to the implementation of GDT and GDT-based farmgate milk prices (FMP).

This chapter is structured as follows. The next section is a literature review of research on the theory of the firm. The third section provides an institutional overview of the New Zealand dairy industry, with emphasis on some of the recent changes in the way dairy products and raw milk are priced, to provide the relevant background for the empirical analysis. The fourth section documents the empirical analysis using New Zealand dairy industry data. The fifth section concludes.

2 Literature Review – Theory of the Firm and Application to Agriculture Cooperatives

2.1 Theory of the Firm: Why Firms Exist and How the Boundary is Set

2.1.1 Coase: Why do firms exist?

"An economist thinks of the economic system as being co-ordinated by the price mechanism and society becomes not an organisation but an organism. The economic system 'works itself'."[3] This was the prevailing thought underpinning how a firm operates, quoted directly from Coase's (1937) seminal work on why firms exist.

This prevailing thought at the time regarded the firm as a "black box" that transacts through the price mechanism to procure the factors of production required to produce products desired by the market. This is described by Coase (1937): "this theory assumes that direction of resources is dependent directly on the price mechanism."[4] However, as Coase (1937) points out, this view fails to explain the observed activities undertaken voluntarily within a firm on a planning basis, as opposed to based solely and directly on the price mechanism. Coase (1937) uses a simple illustration of a worker from one division of the firm moving to another division of the same firm, which is not a direct result of changes to the price of the work the worker contributes but instead, the worker is directed by his manager to move to the new division.

If everything is determined by the price mechanism, then it is difficult to understand why large firms internalise business activities. This could have been achieved by engaging directly through the price mechanism on the inputs of the production required. If this were true, then one would not expect a firm to increase its size by internalising the inputs instead of acquiring them through the price mechanism.

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[3] Coase (1937), 387.
[4] Coase (1937), 387.

Coase (1937) argues that the reason that we observe firms internalising business activities is that there are costs of using the price mechanism that the economic theory at the time failed to recognise. The costs according to Coase (1937) are:

1. "The most obvious cost of 'organising' production through the price mechanism is that of discovering what the relevant prices are."[5] and

2. "The cost of negotiating and concluding a separate contract for each exchange which takes place on a market must also be taken into account."[6]

These costs of using the price mechanism as suggested by Coase (1937) are commonly referred to as the transaction costs of engaging the market, and such costs make a case for internalising factors of production within the firm.

2.1.2 Williamson: Transaction costs theory

Williamson (1971) further refines Coase's idea and proposes that integration is a result of "contractual incompleteness." He demonstrates his argument using a case of a bilateral monopoly where there is a single seller in the upstream product market and a single buyer in the downstream market with ex-ante uncertainty. It would be difficult for both parties to reach an efficient production decision given the ex-post opportunistic behaviour that could lead to endless costs and efforts in the ex-post bargaining of who should get the highest share of the profit. Williamson (1971) describes that such failure to reach an efficient outcome is due to "contractual incompleteness." That is, in the case of the bilateral monopoly, both parties are

[5] Coase (1937), 390.
[6] Coase (1937), 390-391.

unable to enter into a contract that captures the agreed payoff in all contingencies, and the contract is therefore regarded as "incomplete."

Williamson (1979) further refines the "incomplete contract" notion of transaction costs by characterising commercial transactions that engage the underlying assets through "buying" or "making" based on the following dimensions. The underlying asset of a commercial transaction engaged in an intermediate product market is regarded as "buying" if it buys directly from the market. Otherwise, the underlying asset is regarded as "making" if the required product is made internally through integrating ownership of the underlying assets.

Table 2-1: Transaction Costs Grouping[7]

	Investment Characteristics		
Frequency	**Nonspecific**	**Mixed**	**Idiosyncratic**
Occasional	Purchasing Standard Equipment	Purchasing Customised Equipment	Constructing a Plant
Recurrent	Purchasing Standard Material	Purchasing Customised Material	Site-Specific transfer of intermediate products through successive stages

In Table 2-1, a transaction is regarded as non-specific if the assets involved in the transaction are not unique to the transaction engaged. On the other hand, a transaction is regarded as idiosyncratic if the underlying asset involved in the transaction is unique to the transaction engaged. A transaction is regarded as mixed if the underlying asset is somewhere in between non-specific and idiosyncratic. The frequency in Table 2-1 is a dimension that measures how frequently similar transactions take place. "Recurrent" means similar transactions take place many times, whereas "occasional" means similar transactions take place less frequently.

[7] Williamson (1979), 247.

Williamson (1979) illustrates that transactions that fall more towards the category of "idiosyncratic" and "recurrent" are harder to buy directly from the market using contracts because the underlying assets are unique and there are limited or no alternative applications for the assets engaged, and, at the same time, the assets need to be used frequently. As shown in Table 2-1, Williamson (1979) uses the example of a site specific transfer of intermediate products which have limited alternative deployment as the products are works in progress and made specifically for further processing. The intermediate products are also manufactured on a frequent basis to enable continuous supply of finished products. If such intermediate products were supplied on a contract basis and the bilateral parties engaged always had to "haggle" over the fair price of the intermediate product, then such "haggling costs" could lead to internalising production of the intermediate products.

On the other end of the spectrum, Williamson (1979) gives an example of a transaction involving purchasing standard material as "nonspecific" and "recurrent." The material purchased is generic and has many alternative deployment options and can be easily re-sold to other parties in the market. The transaction is repeated frequently when the material is used up and additional material is required to sustain production activity. Such transactions are likely to be bought directly from the market on a contract basis as there are unlikely to be any costs to haggling as the prices of such generic material are transparent and observable.

The above leads to the following hypothesis: if a transaction engaged (1) has investment in assets that are idiosyncratic (transaction-specific), (2) reoccurs with high frequency, and (3) has a payoff profile that is highly uncertain, then it is more likely that the transaction has greater exposure to contractual incompleteness. Such transaction costs of contractual incompleteness would lead the parties engaged towards integration.

In an example of dairy production where there is only one dairy processing plant in a local village that can only process raw milk supplied by the village into longer shelf life milk powder products, an investment would only be made to build the processor if investors in the processor are able to secure all the milk supplied by the farms in the village. The processing facility has no value with no milk going through it. The farmers can "hold up the processor" by not supplying milk to the processing facility.

Conversely, the farmers in the local village would want to make sure that the milk produced by their farms that is not consumed by local consumers is processed by the milk processing plant because fresh milk is perishable if not collected and processed immediately. The milk that is not consumed by the village has no value if it is not processed into a form with a longer shelf life that can then be sold to consumers outside the village. The processor can therefore "hold up the farmers" by refusing to collect and process the milk supplied.

The above hold-up behaviour can be costly if it cannot be eliminated through a contract that sets out a payoff profile that is deemed to be fair and covers all contingencies (that is, the contract is complete). If we allow for uncertainty in the prices the processor receives for the milk powder products manufactured, then the potential costs associated with the hold-up behaviour in this example could be more substantial as the inherent pricing uncertainty makes it more difficult to contract the processor and farmers on a complete basis.

2.1.3 Alchian and Demsetz: Production and information costs

Alchian and Demsetz (1972) suggest that there are costs involved in monitoring individuals' marginal input into a team production process that could incentivise firms to internalise transactions. Alchian and Demsetz describe such costs of transacting as the "metering

problem": which can make transactions costly when team production is preferred and it is difficult to accurately measure the marginal input contributed by each team member and reward them fairly.

Suppose we have a dairy farm where we need a person to work on feeding and looking after the cows, a person to maintain the milking machines, and a person to liaise with the dairy processor so the milk produced is picked up by the dairy processing company close by. All three people work collectively to achieve a production outcome that cannot be achieved by working on each of the different tasks independently. However, each of their marginal efforts contribute to achieving a collectively optimal outcome that cannot be easily determined. If we reward each person by their hourly input, which is what they would be paid if they were contracted directly through the market, then the issue is who should capture the team production surplus of their joined effort. This issue is regarded by Alchian and Demsetz (1972) as the metering problem as there are information asymmetries that prevent the market to be able to reward all three persons involved in the team production fairly of the total output generated by their combined effort.

In the above example, Alchian and Demsetz (1972) argue that an optimal solution can be achieved by making one of the three persons who has the ability to measure and direct the team the residual claimant. That is, one of the three persons who has more complete information than the market with regards to the marginal effort contributed by each of the three team members should own the dairy farm business by becoming the residual claimant of the value of the combined team production. Internalising the team production by making the person who has the information advantage the owner of the integrated team's business helps minimise the transaction costs associated with the metering problem.

2.1.4 Jensen and Meckling: Agency cost theory

Contrary to viewing the firm as an alternative way to address the issue of incomplete contracts through integration, Jensen and Meckling (1976) argue that firms and any other organisations are simply "legal fictions which serve as a nexus for a set of contracting relationships among individuals."[8] That is, the "firm" is just another way of contracting instead of an alternative governance to contracting.

Jensen and Meckling (1976) give an example of a private firm as a way of contracting suppliers, customers and employees such that the contractual rights to residual cash flow can be transferred to another individual through allocating the different stakeholders' shares of the residual cash flow to the shareholders in the firm. As Jensen and Meckling (1976) put it:[9]

> "The private corporate or firm is simply one form of legal fiction which serves as a nexus for contracting relationships which is also characterised by the existence of divisible residual claims on the assets and cash flow of the organisation which can be generally sold without permission of the other contracting individuals."

Jensen and Meckling (1976) further argue that: [10]

> "The firm is not an individual. It is a legal fiction which serves as a focus for a purpose of complex processes in which the conflicting objectives of individuals (some of whom 'represent' other organisations) are brought into equilibrium within a framework of contractual relations. In this sense, the 'behaviour' of the firm is like the behaviour of the market, that is, the outcome of a complex equilibrium process."

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[8] Jensen and Meckling (1976), 310.
[9] Jensen and Meckling (1976), 311.
[10] Jensen and Meckling (1976), 311.

The way Jensen and Meckling (1976) view the governance of a firm can be understood as a complex way of contracting different parties involved such that the incomplete contract issue suggested by Williamson (1979) is addressed. However, unlike a conventional contract, the "firm" is a complex way of contracting multiple parities and the contract of the firm is shaped by balancing a set of conflicting interests of the different individuals engaged. That is, a firm is not established to achieve a purpose or a set of objectives, but instead it is an outcome generated by a group of individuals that contract through the firm's governance to achieve their own objectives.

This is a big step forward in understanding the behaviour of the firm. In addition to Coase and Williamson's work, Jensen and Meckling (1976) looks into how the boundary of the firm is determined, viewing the firm as a complex way of contracting individuals who have common interests in working together but who, at the same time, have conflicting objectives, helps us better understand how firms behave within their boundaries. As more transactions are contracted internally through the firm to minimise the transaction costs of using the market, the "agency costs" related to balancing individuals' conflicting objectives within the firm start to emerge. As defined by Jensen and Meckling (1976):[11]

> "We define an agency relationship as a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some authority to the agent. If both parties to the relationship are utility maximizers there is a good reason to believe that they will not always act in the best interest of the principal."

[11] Jensen and Meckling (1976), 308.

With more transactions internalised in a firm, the scale of the firm is likely to increase, which makes it more likely for the firm to engage more agents to act on behalf of the principals to manage the assets and business activities of the firm. Jensen and Meckling (1976) define these agency costs as the sum of:

1. Monitoring costs: the costs in designing contracts that help align the interests of the agents to that of the principal ("ex-ante monitoring cost") and the costs of monitoring the service delivered by the agents ("ex-post monitoring costs"). Employee stock option schemes are an example of ex-ante monitoring costs where employees as agents have the potential to share gains or losses in the residual cash flow of the firm. Costs incurred in engaging qualified auditors independent of management to audit the financial statements produced by management are an example of ex-post monitoring costs.

2. Bonding costs: the costs incurred by an agent to restrict the extent to which the individual can engage in opportunistic behaviour for profit at the expense of the principal. For example, an agent may enter into a non-compete contractual agreement such that if the agent no longer works for the firm, then they will not undertake similar business activities for another competing firm for an agreed period of time.

3. Residual loss: any reduction in the residual cash flow of the firm as a result of self-interested agency behaviour that cannot be eliminated by monitoring and bonding the agents engaged.

Based on the above definition of agency costs, Jensen and Meckling (1976) develop a theoretical model that hypothesises how firm value can be maximised by minimising agency

costs through: (1) changing its capital structure even without the tax advantage of using debt, (2) issuing contingent claims such as employment stock options that give the agent a potential share of the residual cash flow, (3) engaging independent qualified accounting professionals to audit the financial statements, and (4) independent security analysts providing commentary on the performance of the firm.

The work by Jensen and Meckling (1976) helps us understand how various contractual relationships are shaped, arranged and governed to minimise agency costs within a firm, whereas Williamson's work focuses on how firms are engaged in an integrated firm governance instead of contracting directly through the market to minimise transaction costs. Another way of putting it is that Williamson's work helps to define the boundary of the firm ("transaction costs"), whereas Jensen and Meckling define how the value of a firm could be optimised by minimising costs incurred within this boundary ("agency costs").

It is also reasonable to expect that the transaction costs and agency costs are not exogenous to one another. The boundary of a firm could be determined by: (1) the transaction costs of contracting using the market; and (2) the agency costs incurred by internalising transactions into a firm. The implication is that the relationship between the boundary of a firm and how it is structured and financed is endogenous. One cannot simply consider the costs and benefits of different governance models without taking into consideration how the firm is financed and structured within a particular governance model.

2.1.5 Grossman, Hart and Moore: Property rights theory of the firm

Grossman and Hart (1986) argue that while Williamson's transaction cost theory helps us understand that when the cost of writing a complete contract between two separately owned firms is high, then firms are likely to integrate, but the theory does not help us understand

how exactly such integration is structured and implemented to address the issue of incomplete contracting.

Grossman and Hart (1986) put it as follows: [12]

> "In particular, given that it is difficult to write a complete contract between a buyer and seller and this creates room for opportunistic behavior, the transactions cost-based arguments for integration do not explain how the scope of such behavior changes when one of the self-interested owners becomes an equally self-interested employee of the other owner. Furthermore, if vertical integration always reduces transaction costs, any buyer A and seller B that have a contractual relationship should be able to make themselves better off as follows: (i) A buys B and makes the previous owner B the manager of a new subsidiary; (ii) A sets a transfer price between the subsidiary and itself equal to the contract price that existed when the firms were separate enterprises; and (iii) A gives the manager of B a compensation package equal to the profit of the subsidiary. Given this, however, how can integration be strictly worse than non-integration: that is, what limits the size of the firm?"

The above argues for a clear and sharper definition of integration. Accordingly, Grossman and Hart (1986) claim integration takes place when:

1. Contracts are incomplete:

Similar to Williamson (1971), Grossman and Hart (1986) agree that integration needs to take place when it is difficult to draw up a contract that sets out the payoff for all contingencies. Grossman and Hart (1986) demonstrate that the ex-post hold-up behaviour caused by an

[12] Grossman and Hart (1986), 692-693.

incomplete contract will lead to the parties engaged unwillingly making an investment in the transaction-specific assets needed for the transaction to take place. Grossman and Hart (1986) further state that there are two types of rights inherent in a contract: specific rights and residual rights. The issue with an incomplete contract arises when it is difficult for both parties engaged to list out all the specific rights in the contract, which gives room for ex-post hold-up behaviour;

2. The acquirer of the transaction-specific asset is able to capture most of the economic surplus:

In response to the inability to enter into a complete contract that sets out a full list of specific rights, one of the two parties may be willing to acquire the residual rights that cannot be specified in the contract through securing ownership of the transaction-specific assets. The acquirer is able to extract most of the economic surplus in the transaction through ownership of the transaction-specific assets. Such integration of the transaction-specific assets gives incentive to the acquirer to invest fully as ownership enables the acquirer to capture most of the economic benefits of the transaction.

Based on the integration of one party acquiring the property rights of the transaction-specific assets from another party in a bilateral transaction, Grossman and Hart (1986) conclude that: [13]

> "The literature on transactions costs has emphasized that incomplete contracts can cause nonintegrated relationships to yield outcomes that are inferior to those that would be achieved with complete contracts. It is implicitly assumed that integration yields the outcome that would arise under complete contracts. We argue that the relevant

[13] Grossman and Hart (1986), 716.

> comparison is not between the nonintegrated outcome and the complete contract outcome but instead between a contract that allocates residual rights to one party and a contract that allocates them to another. We have emphasized the symmetry of control - namely, that when residual rights are purchased by one party they are lost by a second party - and this inevitably creates distortions. That is, integration shifts the incentives for opportunistic and distortionary behavior, but it does not remove these incentives."

This property rights theory of the firm formally modelled by Grossman and Hart (1986) is a big step forward in linking the entitlement to residual cash flow to ownership of residual rights through control of transaction-specific assets. This linkage incentivises the acquirer to invest in transaction-specific assets to minimise ex-ante investment inefficiencies. As Grossman and Hart (1986) point out, integration helps minimise ex-ante investment inefficiencies by allocating ownership of the transaction-specific assets to the bilateral party where the transaction generates more surplus to the acquirer, whereas the integration defined by Williamson (1979) does not specify such a linkage but instead more broadly suggests the conditions under which integration is more likely to take place.

Hart and Moore (1990) further extend the Grossman and Hart analysis by allowing agents of the integrated firm, such as employees, to acquire the firm's ownership. The model developed, based on similar assumptions to Grossman and Hart (1986), enables one to analyse changes in an employee's behaviour when they move from being an agent to being one of the owners of the integrated organisation. The model illustrates that some of the employees have a stronger interest in owning the integrated firm when they are able to extract relatively more ex-post economic surplus compared to other employees who are content to remain as employees of the integrated organisation.

Hart and Moore (1990) also demonstrate in their model that in a situation where one of the key trading partners of the integrated firm is able to extract the most ex-post economic surplus, the trading partner would become the owner of the integrated firm. They show in their analysis that a trading partner, such as a key customer who is indispensable in a transaction, is incentivised to acquire ownership of the transaction-specific assets to ensure they are able to continue to capture the economic benefits without the risk of being held-up by independent investors of the transaction-specific assets. This result can be applied to understand the formation of consumer cooperatives where the key customers of the services of the products of the integrated firm are incentivised to secure ownership of the integrated firm.

The above model developed by Grossman and Hart (1986) and Hart and Moore (1990) (referred to as the Grossman, Hart and Moore (GHM) property rights theory of the firm from this point onward) can be illustrated in the context of dairy cooperatives. Due to incomplete contracts, dairy farmers have a strong incentive to integrate dairy powder processing assets if doing so captures relatively more economic surplus by owning the transaction-specific assets to avoid hold-up behaviour by the processor. The investment therefore helps minimise ex-ante investment inefficiencies by allocating ownership rights to the local dairy farmers in the village. Such forward integration by dairy farmers takes place when the share of the economic surplus of the integrated processing and farming entity is worth more to the dairy farmers than to the independent owners of the processing facility.

The GHM model is also capable of explaining backward integration where the owner of the processing assets acquires ownership of the farming assets. Such backward integration can

take place when the owner of the processing assets is able to capture more economic surplus than dairy farmers.

The GHM model helps us to understand that, in addition to how the transaction costs of incomplete contracting motivate contracting parties towards integration, the ownership of integrated assets is determined by the relative value of the ownership rights to the parties involved in the integrated organisation. This is very useful in helping us understand ownership rights in the context of agriculture cooperatives - a form of integration that is always forwardly integrated and owned by farmers.

2.1.6 Social Capital Theory of Agriculture Cooperatives

Although the focus of this thesis is on applying the theory of the firm to understand how cooperatives are owned and transacted, it is important to highlight that there is another theoretical framework that seeks to explain the reasons why cooperatives are created. Apparao, Garnevska and Shadbolt (2019) suggest that there are non-conventional (non-economic) reasons for farmers to opt for cooperative ownership. That is, cooperatives are created so that farmer-shareholders are able to invest in "social capital" such that they could retain their investment in social capital through cooperative ownership.

As defined by Apparao, Garnevska and Shadbolt (2019):[14]

"According to Lyda Hanifan social capital can be defined as those tangible assets that count for most in daily lives of people: namely goodwill, fellowship, sympathy, and social intercourse among the individuals and families who make up a social unit."

[14] Apparao, Garnevska and Shadbolt (2019), 45.

In this framework, in addition to farmers transacting through cooperative ownership such that they are able to secure their financial investments in the farms, they also invest through cooperatives so that their investment in trust and relationships with fellow farmers can be internalised. However, in this research, we are focusing on how the theory of the firm can be applied to the understanding of agriculture cooperatives and examining the theoretical hypotheses developed using New Zealand dairy industry data. The application of social capital theory is not in the scope of this thesis.

2.2 The Economics of Agriculture Cooperatives

2.2.1 Defining agriculture cooperatives

Before applying the theory of the firm to understand the economics of agriculture cooperatives, it is important to first define the agriculture cooperative that I seek to analyse as there is a myriad of different types of cooperatives. The following is a more general definition of cooperatives by the International Co-operative Alliance: "a co-operative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly and democratically controlled enterprise."[15]

Evans and Meade (2006) offer an economics definition of cooperatives: "a cooperative is an organisation in which those who transact with (i.e., 'patronise') the organisation also own and formally control the organisation, and derive significant benefits from those transactions over and above any financial returns they derive from their investment in the organisation".[16] Under this definition, the following are some examples of different types of cooperatives:

[15] https://www.ica.coop/en/cooperatives/cooperative-identity
[16] Evans and Meade (2006), 1.

1. Consumer cooperatives that are jointly owned by the consumers/customers of the services and products provided by the cooperatives. For example, Rabobank is a customer-owned global bank specialising in agriculture financing with investments of EUR€590 billion;[17]

2. Producer cooperatives that are jointly owned by producers of raw materials purchased by the cooperatives. For example, Fonterra, one of the largest dairy cooperatives in the world, is owned by its farmer-suppliers and has an annual revenue of NZD$20 billion;[18] and

3. Marketing cooperatives that are jointly owned by the customers of the marketing services provided by the cooperatives. For example, Zespri is one of the world's largest fruit marketing service providers generated an annual revenue of NZD 2.6 billion; it is owned by New Zealand kiwi fruit suppliers through cooperative ownership.[19]

The above list is a subset of the different types of cooperatives. There are other forms of cooperatives such as local rugby or golf clubs where members of the organisation jointly own the assets of the clubs and the members receive benefits through using club facilities and other types of benefits, such as profits generated by the clubs. Accordingly, it is important to adopt a more precise definition of the type of cooperatives that I am examining in this analysis.

The agriculture cooperatives (Agri Co-ops) referred to in this analysis are defined as cooperatives that:

[17] Rabobank 2019 Annual Report
[18] Fonterra 2019 Annual Report
[19] Zespri 2019 Annual Report

1. Collect and process perishable agriculture produce from owner-suppliers to manufacture agriculture food products that have a finite shelf life;

2. Provide sales and marketing services required by their owner-suppliers to optimise: (1) the prices paid for the agriculture produce supplied, and (2) the profit generated by the cooperatives;

3. Are jointly owned by the owner-suppliers and decisions are made on a democratic "one-member-one-vote" basis.

The function of collecting and processing perishable products is an important one as this makes farmer-suppliers vulnerable to hold-up behaviour from the owners of the processing assets. The risk of hold-up is high when the prices of the perishable produce cannot be easily observed and are highly volatile, which makes it difficult for suppliers and buyers to contract. Such inability to contract directly using the price mechanism incentivises suppliers to integrate the processing and marketing assets.

To better understand the economics of agriculture cooperatives, we need to define an alternative ownership structure: investor-owned firm (IOF). The IOF is a conventional limited liability shareholding company in which shareholder rights and governance are more commonly understood. The IOF processing and marketing assets are owned by outside investors who do not have any roles in the firm other than being investors. A comparison between the key attributes of Agri Co-ops and IOFs is summarised in the table below.

Table 2-2: Agri Co-ops and IOFs Defined

	Agri Co-ops	IOFs
Integration	Yes (Forward)	No
Entry and Exit	Nominal value	Market value
Governance and Control	Democratic	Proportional
Prices Paid to Suppliers	Payout	Arm's length pricing
Reward to Investors	Payout	Residual cash flow
Additional Capital	Restrictive	Unrestrictive

As shown in the above table, the Agri Co-ops are forwardly integrated by farmer-suppliers whereas IOFs are owned by independent investors who own the processing and marketing assets but do not backward integrate the farming assets.

In Agri Co-ops, residual rights are valued differently from IOFs. In an Agri Co-op, the owner-suppliers acquire ownership on a "nominal entry and exit" basis. Farmer-suppliers join and leave the company on a nominal value (sometimes referred to as "standard value") that is usually set when the co-op is first initiated. This is in contrast to IOFs where investors join and leave the company by transferring their shares to other shareholders at the market value of the company.

The way governance and control are exercised is also very different between the two ownership models. In IOFs, the extent of control shareholders have is exercised in proportion to share ownership, whereas in Agri Co-ops, control is exercised on a democratic one-member-one-vote basis.

The pricing and payoff to owners also vary between Agri Co-ops and IOFs. The total payoff to investors of IOFs is the residual cash flow, whereas the payoff to owner-suppliers of Agri Co-ops is the price paid for the perishable produce as well as residual cash flow. The

combination of the price paid for perishable produce and cash flow is sometimes referred to as "payout."

The way to contract for additional capital is also very different in the context of Agri Co-ops. For owner-suppliers to retain total control, Agri Co-ops can only issue new shares for additional capital from its owner-suppliers. This is more restrictive and limited compared to IOFs, which can issue shares to any investors.

The above comparison between Agri Co-ops and IOFs shows that the ownership rights held by owner-suppliers and investors are very different. The following is my analysis of the economic implications of these differences and I carry it out by applying the theory of the firm literature reviewed earlier.

2.2.2 Application of the theory of the firm on agriculture cooperatives

The transaction costs theory of the firm championed by Williamson (1971) helps us understand the boundary of Agri Co-ops. The suppliers of perishable agriculture products are vulnerable to opportunistic behaviour by owners of processing and marketing assets when: (1) there is a lack of transparent and objective pricing mechanisms, and (2) there are no alternative competing processing and marketing facilities. Accordingly, it is difficult for suppliers to contract owners of the processing and marketing assets in such a way that the prices received for their perishable products are not subject to ex-post hold-up manipulation.

From the IOF's perspective, the investors of the processing and marketing assets would also be reluctant to invest when: (1) the processing and marketing assets have limited alternative deployment options (i.e., the assets invested are transaction-specific); and (2) the suppliers have other supplying options, for example, selling their perishable produce in a local market.

For investors to be willing to invest in transaction-specific processing and marketing assets, they need to have a way to contract the owners of the farming assets such that they are not held up by farmers not supplying the milk required. The transaction costs related to the inability to contract therefore warrant integrating of the processing and marketing assets with the underlying farming assets.

The transaction costs theory, however, does not stipulate whether the integration should be forward (the owners of the farming assets integrate the downstream processing and marketing assets) or backward (the owners of the processing and marketing assets integrate the upstream farming assets). Agri Co-ops are a product of suppliers wanting to forwardly integrate downstream processing and marketing assets. The GHM property rights theory of the firm model helps explain forward integration.

In the GHM bilateral monopoly model involving two parties, Party A has a strong incentive to integrate non-human assets by buying out Party B when Party A is able to extract relatively more economic surplus than Party B through integration. In the context of Agri Co-ops, the owner-suppliers have strong incentives to internalise the marketing and processing assets as they are able to extract more economic surplus with integration. The suppliers of perishable products would only be willing to invest more effort in farming if they are able to internalise the residual control rights of the integrated entity. The incomplete contract issue is therefore addressed by suppliers internalising control of the downstream processing and marketing assets through cooperative ownership that entitles them to residual cash flow generated by the integrated cooperatives.

Notwithstanding that the GHM model is quite helpful for understanding the underpinning economic forces that incentivise farmer-suppliers integrate forward through Agri Co-op ownership, there are two key limitations to the application of GHM to Agri Co-ops:

1. The rights to residual control defined by GHM are based on a conventional company set-up where shareholders are entitled to the value of the integrated entity through their ownership of the integrated entity, whereas the farmer-suppliers are entitled to residual cash flow while they are owners of Agri Co-ops but do not necessarily get their fair share of the value of the integrated entity when they exit and redeem their shares at nominal value (in most cases, at the same value as what they initially contributed when joining the cooperative).

2. The GHM model assumes that there are no ex-post inefficiencies once the entity is integrated; the model allocates the property rights of ownership to the shareholders who are able to extract the most economic surplus by integrating the transaction-specific assets. However, the supplier-shareholders of the Agri Co-ops who have gained ownership of the processing and marketing assets through forward integration may not have the expertise or knowledge in managing the downstream assets acquired. The supplier-owners are required to rely on professional managers (agents) to manage these downstream assets on their behalf. Agri Co-ops are more vulnerable to the agency issue compared to IOFs because cooperative ownership rights are restricted only to supplier-shareholders, which eliminates the possibility of: (1) aligning the professional managers' interests through a form of executive stock options scheme; (2) institutional investors who have more knowledge of the downstream assets investing in the cooperative to help improve monitoring the performance of the downstream assets; and (3) institutional investors investing in the cooperative to gain control and drive out inefficiencies.

These limitations imply that, ceteris paribus, Agri Co-ops are more likely to be exposed to the agency costs suggested by Jensen and Meckling (1976) than IOFs. Cook (1995) suggests that "these costs are generated by a vaguely defined 'user versus investor' set of property rights. These vaguely defined property rights lead to conflicts over residual claims and decision control."[20]

Cook (1995) has categorised the costs associated with these vaguely defined property rights into the following five categories:

1. Free rider problem: when ownership rights of an organisation are untradeable, insecure or not specifically assigned, the owners of these rights are vulnerable to the free rider problem. In the context of Agri Co-ops where new members can join by investing at a nominal value proportional to their supply, which implies that the existing shareholders could have their value diluted if the co-op's nominal entry value is lower than the market value when new suppliers join.

2. Horizon problem: "The horizon problem occurs when a member's residual claim on the net income generated by an asset is shorter than the productive life of the asset."[21] This could be an issue in the Agri Co-op context when the existing owner-suppliers cease to be shareholders and the nominal value on exit is very different from the market value of the Agri Co-op at the time of exiting. This problem discourages owner-suppliers from undertaking investment decisions that generate returns longer than their intended investment period as

[20] Cook (1995), 1156.
[21] Cook (1995), 1157.

they are unable to reap the rewards upon exiting.

3. Portfolio problem: to become supplier-shareholders, the suppliers not only have to invest in the productive farming assets that produce the perishable agriculture products, they also have to invest in the processing and marketing assets downstream. To remain in the Agri Co-op, they have to be both the suppliers and shareholders at the same time with their capital tied up in both farming assets and downstream assets, which limits the extent to which they are able to diversify their exposure through portfolio investment in non-farming assets.

4. Control problem: "The agency costs associated with trying to prevent divergence of interests between the membership and their representative board of directors (principal) and management (agent) in a co-operative introduces a control problem."[22] Because investors in Agri Co-ops are required to be both suppliers and owners at the same time, it is difficult for other investors to undertake acquisition and gain control of an underperforming Agri Co-op, change its underperforming agents and drive out inefficiencies.

5. Influence cost problem: this is a cost incurred when the underlying objectives of the owner-suppliers of an Agri Co-op are no longer aligned. That is, the interests of the owner-suppliers are heterogeneous. This cost is more apparent when the average interests of the owner-suppliers are different from the decisions made by the owner-suppliers on a one-member-one-vote basis.

The following table links the above five agency issues to the ownership rights of Agri Co-ops and IOFs.

[22] Cook (1995), 1157.

Table 2-3: Issues with Agri Co-op Ownership Rights

Ownership Rights Characteristics[23]	IOFs	Agri Co-ops	Potential Problems for Co-ops
Assignment of Residual Claims	To investors	To supplier-shareholders	Portfolio and control problems
Separation of Ownership	No	Yes	Portfolio and control problems
Control Rights	Voting rights proportional to shareholding	Voting rights not proportional but on an one-member-one-vote basis	Influence cost problem
Horizon of Residual Claims	Unlimited	As long as the supplier is a shareholder	Free rider and horizon problems
Transferability of Residual Claims to Independent Investors	Yes	No	Free rider and horizon problems
Redeem-ability of Residual Claims	No	At nominal value	Free rider and horizon problems

2.2.3 Alternative agriculture cooperative models

The above links between the agency problems and characteristics of Agri Co-op ownership rights highlight how particular characteristics of ownership rights expose co-ops to specific agency problems. This provides an opportunity to address some of these issues by modifying certain Agri Co-op characteristics to minimise the suggested problems. For example:

1. Making Agri Co-op ownership rights transferable at fair market value upon exiting among supplier-shareholders instead of redeemable at nominal value upon exiting. Such fair market value entry and exit helps minimise the free rider and horizon problems as long as the value at which the ownership rights are transferred fully reflects its true underlying market value.

2. Making the supplier-shareholders' equity capital contributions in proportion to the volume

[23] The ownership rights characteristics are developed based on Chaddad and Cook (2004).

of perishable products supplied and having voting rights attached in proportion to the capital invested. This helps minimise influence cost problems as the decisions are now made in proportion to supply (not on a one-member-one-vote basis).

The following table lists a number of possible alternative cooperative governance models by making changes to some of the key characteristics of cooperative ownership rights.[24]

Table 2-4: Modification to Agri Co-ops Ownership Rights

Ownership Rights Characteristics	Agri Co-op	Proportional Investment Co-op	Member-Investor Co-op	New Generation Co-op	IOF
Restricted to Supplier-Shareholders	✓	✓	✓	✓	×
Redeemable	✓	✓	✓	×	×
Not Transferable	✓	✓	✓	×	×
Residual Cash Flow Distributed through Supply	✓	✓	×	×	×
Decision Rights on One-Member-One-Vote basis	✓	×	×	×	×

As shown in the table above, an Agri Co-op has ownership rights that: (1) are restricted to suppliers only; (2) are not transferable but only redeemable back to the co-op at nominal value upon exiting; (3) benefit suppliers through a combination of prices paid for the perishable agriculture products and the residual cash flow generated by the co-op; and (4) have decisions made based on a one-member-one-vote basis.

A proportional investment co-op shares all the same ownership rights characteristics of Agri Co-ops except that the decisions are made in proportion to investment in the co-ops, and are

[24] This table is put together based on the alternative cooperatives defined in Chaddad and Cook (2004).

no longer made on a one-member-one-vote basis. This modification helps warrant against the influence cost problem.

Member-investor co-ops share the same characteristics of Agri Co-ops apart from: (1) the residual cash flow is no longer bundled up with the price paid for the perishable products supplied, but is distributed back in proportion to the equity capital contributed; and (2) decisions are made in proportion to the equity capital contributed.

A new generation co-op is defined by modifying the following characteristics of Agri Co-op ownership rights: (1) the equity capital contributed is transferable to fellow suppliers at market value and cannot be redeemed back to the cooperative; (2) the residual cash flow generated is distributed in proportion to equity capital contributed; and (3) decisions are made by votes in proportion to the equity capital contributed. These modifications enable supplier-shareholders of a new generation co-op to become less vulnerable to free rider, horizon, and influence cost problems. The only remaining problem is that the new generation cooperative model is unable to mitigate control and portfolio agency issues as the ownership rights are still restricted to suppliers only.

The table also shows that modifications to some key ownership rights characteristics of cooperatives helps minimise the potential agency problems associated with "vaguely defined" property rights vested in Agri Co-ops by incentivising supplier-shareholders to undertake investment decisions that are more beneficial to the co-ops. However, the interesting issue is that while these desirable outcomes are achieved, these changes make Agri Co-ops more like IOFs. As shown in the table, the only difference between a new generation co-op and an IOF is that the ownership rights in IOFs are not restricted to supplier-shareholders only. If this is

the case, then does it make sense to make further modifications to the new generation co-op so it becomes an IOF?

Chaddad and Cook (2004) suggest that: [25]

> "Investment constraints arise in agricultural cooperatives as a result of free rider, horizon, and portfolio problems, which in turn emerge because ownership rights are restricted to members, are non-transferable, redeemable, and have benefit distribution proportional to usage rather than member investment. As a result, cooperative members lack the necessary incentives to invest in traditional cooperatives because their investment is illiquid and does not receive adequate returns. Risk-bearing costs are simply too high. We argue that by relaxing some of these restrictions on ownership rights, non-traditional cooperatives may provide incentives for members and non-members in investment in organisation-specific assets, thereby ameliorating perceived financial constraints."

Accordingly, an Agri Co-op is more likely to evolve into a form of modified co-op as it is presented with more growth opportunities that require capital contributions from its shareholder-suppliers. In an event where a co-op has fully exhausted all the capital possible from its supplier base but still intends to grow further, then a process of demutualisation that converts a co-op into an IOF could take place as it starts to seek capital from non-supplier investors.

Chaddad and Cook (2004) suggest that before a co-op fully demutualises to an IOF, there are two types of hybrid IOF Co-op governance models that can be considered:

[25] Chaddad and Cook (2004), 358.

(1) Cooperatives with capital seeking entities: [26]

> "This model attenuates the restriction that cooperative ownership rights be restricted to member-patrons. The cooperative, however, does not convert to an IOF because outside equity capital is acquired by a separate legal entity. This entity may be a strategic alliance, a trust company, or a publicly held subsidiary."

(2) Investor-share cooperatives: [27]

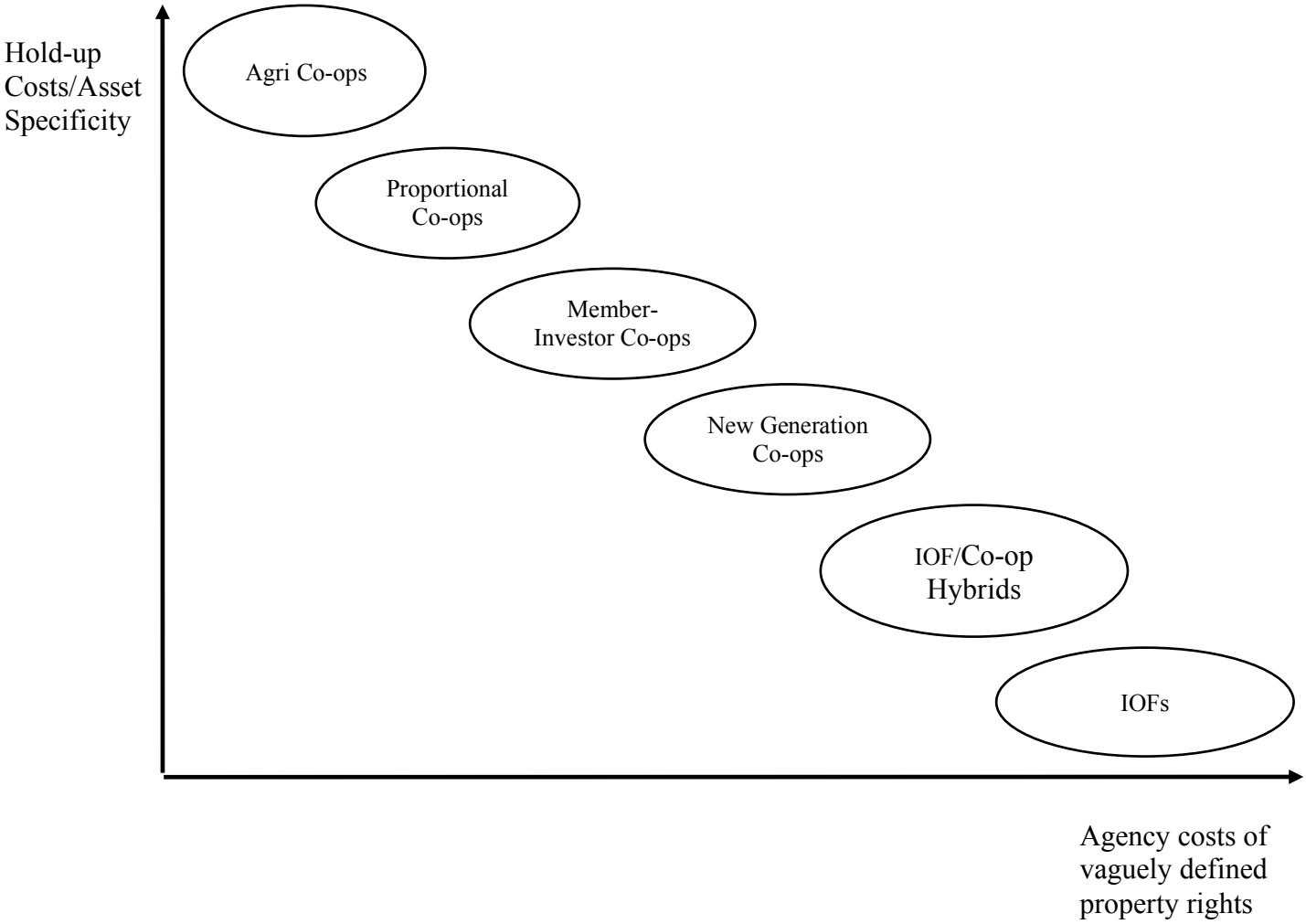
> "In this model, the cooperative acquires non-member equity capital without converting to an IOF. Contrasting to the previous model, the investor-share cooperative issues separate classes of equity shares in addition to the traditional cooperative ownership rights held by member-patrons. Investor shares may bundle different ownership rights in terms of returns, risk bearing, control, redeem-ability, and transferability. Investor shares include preferred stock, nonvoting common stock, and participation certificates."

Chaddad and Cook (2004) demonstrate that co-ops could evolve to become more IOF-like in response to their need to have access to capital to fund growth. However, moving toward IOF-like ownership happens at the expense of disabling additional suppliers who want to have access to Agri Co-ops. These additional suppliers may want to mitigate hold-up costs but lack the capital available to invest into larger, more diverse, capital-intensive and increasingly IOF-like co-ops. Moving toward IOF-like ownership also lets independent non-supplier investors to gain more control over the IOF-like co-ops.

[26] Chaddad and Cook (2004), 355.
[27] Chaddad and Cook (2004), 357.

For Agri Co-ops, there is a cost and a benefit trade-off between the agency costs associated with vaguely defined cooperative ownership rights and the benefit associated with hold-up inefficiencies minimised through cooperative ownership. The following chart maps out such trade-offs.

Figure 2-1: Evolution of Agri Co-ops



As shown in the chart above, in a situation where there is a high-level of transaction-specific (high asset specificity) investment required to process perishable agriculture supplies with low agency costs, Agri Co-ops are more likely to be the preferred ownership model. On the other hand, if there is a low level of transaction-specific (low asset specificity) investment with

substantial agency costs (for example, cooperatives that need substantial capital for growth), then the preferred ownership model will lean towards IOFs. Different forms of modified co-ops as per Chaddad and Cook (2004) are placed in between Agri Co-ops and IOFs to illustrate the trade-off between the level of asset-specific investment and agency costs of vaguely defined ownership rights.

This chart shows that there is no one optimal co-op model that is most efficient under all scenarios, but instead shows how different forms of cooperative ownership are in place in response to: (1) the extent to which the investment is specific to the transaction; and (2) the agency costs attached to the vaguely defined property rights. One cannot conclude that one form of ownership model is better than another without carefully evaluating how well a particular ownership model is able to address the market conditions supplier-shareholders face at the time.

Accordingly, different forms of cooperative ownership exist for good reasons. I therefore suggest an empirical approach to understanding how the market adopts different models of cooperatives in response to different market conditions by addressing the following: (1) understand whether the market adopts a particular form of cooperative based on the economic reasoning set out above; and (2) understand whether a particular form of cooperative governance structure is more efficient given a certain set of market conditions.

The second issue regarding the relative efficiency of a particular form of ownership model can be addressed by empirical studies that measure the changes in the efficiency of a cooperative when it migrates from one ownership model to another. For example, if an Agri

Co-op migrates to a Proportional Co-op, the efficiency change related to the migration can be assessed and captured. If the market is always looking for the most efficient ownership model in response to a set of prevailing market conditions, then we would expect, on average, efficiency gains after each migration.

3 New Zealand Dairy Industry Institutional Overview

The New Zealand dairy industry has gone through substantial changes over the last thirty years. In 1996, the industry consisted of 13 cooperatives. These cooperatives ultimately consolidated into three by 2001, with Fonterra being the largest, processing up to 96% of the milk supplied by New Zealand dairy farmers at the time.[28] The following table provides an overview of the consolidation of New Zealand dairy cooperatives between 1996 and 2001.

Table 3-1: New Zealand Dairy Industry Consolidation[29]

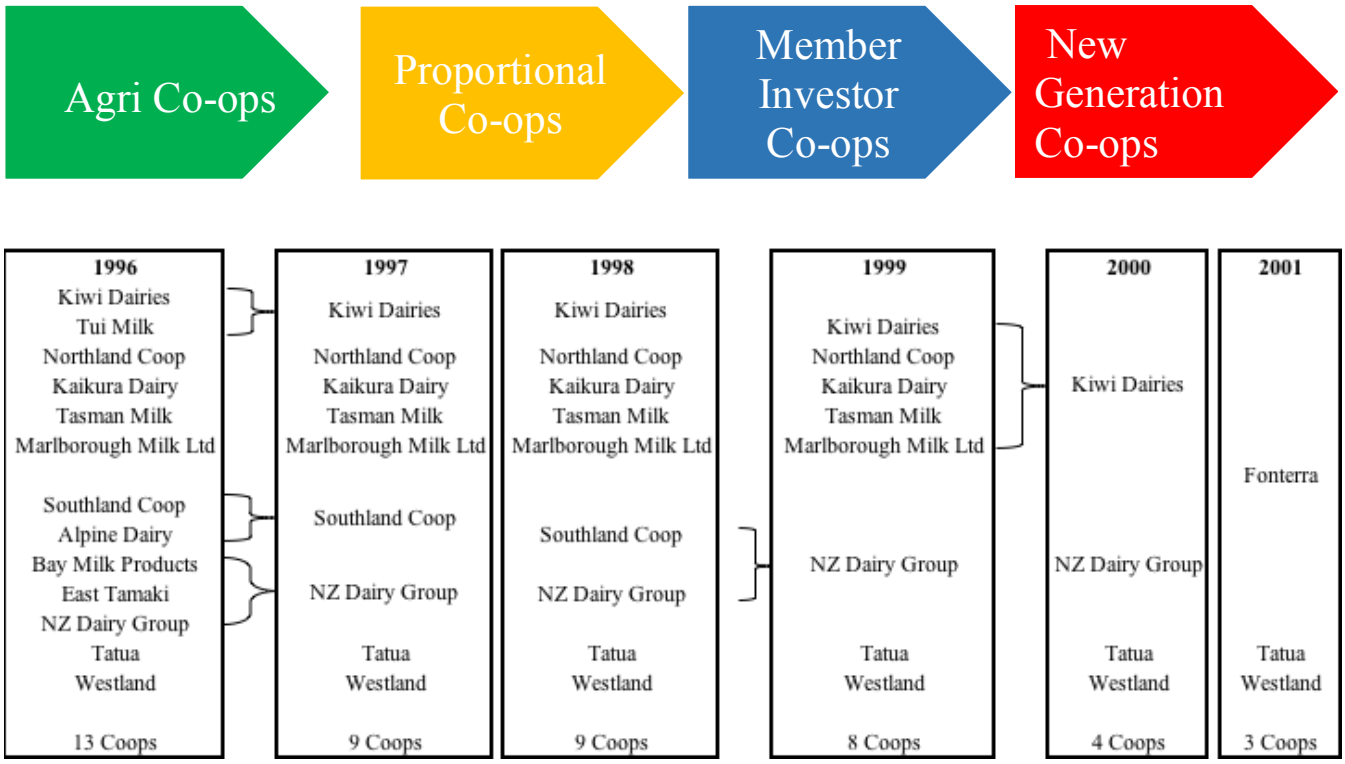


Table 3-1 also reveals the evolution of the different forms of cooperative governance models discussed earlier. In 1996, most cooperatives operated in a form of cooperative governance that leaned towards conventional Agri Co-ops. The consolidation led to bigger and more

[28] New Zealand Dairy Statistics 2014/15, Fonterra 2002 annual report, and Trecher, McGregor and Murray-Prior (2003), 5.

[29] Note that the arrows in the chart are an illustration of the evolution of how the different regional cooperatives are consolidated to form New Zealand's largest dairy cooperative, Fonterra. The arrows in the chart do not correspond to the exact way each of the different cooperatives' rights is defined and changed over the years.

diversified agriculture cooperatives that adopted a governance model that had ownership rights similar to the New Generation Co-ops.

The consolidation that formed Fonterra was motivated by two objectives: (1) to establish a dairy company that is able to compete internationally to ensure that New Zealand farmers are able to achieve the best price for their milk; and (2) to achieve cost efficiency through economies of scale. At the time of Fonterra's formation, Fonterra accounted for around 20% of New Zealand's total exports, 7% of New Zealand's GDP and was the fourth largest international dairy company.[30]

To ensure that Fonterra did not use its near monopoly position to deter entry of competing independent dairy processors, the New Zealand regulator introduced the Dairy Industry Restructuring Act (DIRA) in 2001. Under DIRA, there are two key provisions that Fonterra has to comply with at all times to "promote the efficient operation of the New Zealand dairy market."[31] These two provisions are: (1) free entry and exit of Fonterra by New Zealand farmer-suppliers so they are free to choose who will process their milk such that they are not locked up in the cooperative; and (2) supply of raw milk by Fonterra to competing independent dairy processors such that independent processors are able to compete in the domestic New Zealand dairy market.[32] The following is a more detailed description of these two regulatory requirements.

3.1 Free Entry and Exit of Supplier-Shareholders

When Fonterra was first established, it was governed through a type of cooperative governance leaning towards the new generation cooperative ownership structure defined by

[30] Trecher, McGregor and Murray-Prior (2003), 4.
[31] DIRA (2001), 43.
[32] The provisions are detailed in DIRA (2001), 43.

Chaddad and Cook (2004). The following table sets out the key features of Fonterra's ownership rights and a comparison of these rights to the ownership rights of Agri Co-ops and IOFs.

Table 3-2: Fonterra Ownership Rights Compared to Agri Co-ops and IOFs

Ownership Rights Characteristics	Agri Co-op	Fonterra	IOF
Restricted to Supplier-Shareholders	✓	✓	✗
Redeemable	✓	✓	✗
Not Transferable	✓	✓	✗
Residual Cash Flow Distributed through Supply	✓	✗	✗
Decision Rights on One-Member-One-Vote basis	✓	✗	✗

As shown in the above table, Fonterra shareholder-supplier ownership rights are redeemable but not transferable. Upon exiting (or joining), the ownership rights are redeemed (or acquired) at fair market value. The fair market value is determined by a credible and independent valuer engaged by the board of Fonterra. The valuation is completed based on the valuer's financial analysis of the cooperative's financial projections using contemporary valuation techniques such as the discounted free cash flow model.

As long as the fair market value set by the valuer accurately reflects the market value of the ownership rights, the fair value entry and exit approach helps minimise agency costs related to the free riding and horizon problems suggested by Cook (1995). The fact that the rights are redeemable but not transferable helps ensure that the ownership rights will always be in the hands of farmer-suppliers, thus allowing Fonterra to retain the advantage cooperatives have in minimising exposure to hold-up costs.

The table also shows that the voting rights of Fonterra's members are proportional to shareholding. Fonterra also distributes its residual cash flow in proportion to shareholding. As suggested by Chaddad and Cook (2004), these two features help minimise the issue of influencing costs.

These ownership rights features are required to facilitate the DIRA regulatory requirement of "free entry and exit by New Zealand dairy farmers." In other words, Fonterra is obligated to take any milk that New Zealand farmers are willing to supply through the cooperative and also let them withdraw their milk and supply it to alternative processors as they see fit. This fair value entry and exit ensures the fairness of the terms upon which any additional milk is supplied through the cooperative and any milk that is switched away from the cooperative to competing processors.

However, the free entry and exit on fair market value only works if the value determined by the valuer accurately reflects the market value of the ownership rights of the cooperative. If the value set is different from its market value, then this approach could lead to an inefficient outcome. For example, if the value set by the valuer is higher than the intrinsic market value of the shares owned by farmer-shareholders, then some suppliers could be induced to leave the cooperative so they could capitalise on the over-valued shares in the cooperative. On the other hand, if the value set is under the intrinsic market value, then farmer-suppliers are induced to increase their shareholding by supplying more to the cooperative. Both cases lead to an inefficient supply of milk to the cooperative.

3.2 Supply of Milk to Competing Independent Processors

DIRA regulations require Fonterra to supply milk to competing independent processors at a formulaic milk price that promotes entry of competing independent dairy processors. Under the regulatory requirements, Fonterra must:

1. sell up to 400 million litres of raw milk collected by Fonterra (around 2% of total 2015 raw milk supplied) to independent processors in New Zealand;[33] and

2. sell the milk at a formulaic milk price called the Default Milk Price estimated using the following formula:

Default Milk Price = Total Payout + Retention – Annualised Share Value

Total Payout is defined as the total payment to supplier-shareholders that includes both payment for milk supplied by the supplier-shareholders and dividends to supplier-shareholders. Retention is the portion of the net profit available to be distributed to shareholders that is retained in the business. The Annualised Share Value is the dollar value capital charge estimated by Fonterra's cost of capital multiplied by the market value of Fonterra shares estimated by the independent valuer at the beginning of each season.

As illustrated in the pricing formula, this milk price is inherently inefficient if:

1. Fonterra's total payout including retention is not a good proxy for selling prices and earnings that could be achieved by competing efficient independent dairy processors; and

[33] Total raw milk of around 21 billion litres is taken from New Zealand Dairy Statistics (2015).

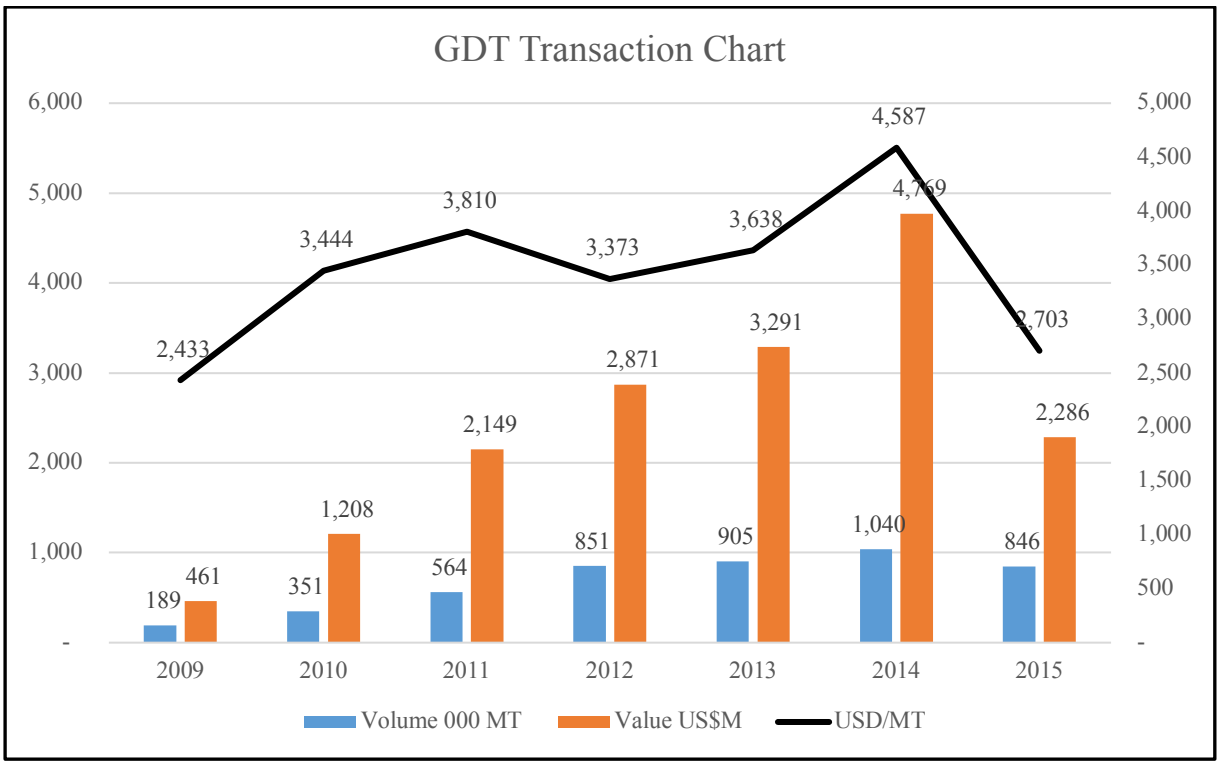
2. The capital charge estimated is not a good proxy for the cost of capital required by an efficient independent processor due to: (a) the cost of the capital applied being incorrectly estimated by the valuer; and/or (b) the share price of Fonterra being incorrectly estimated by the valuer.

The inherent weakness of this formulaic milk price is that most of the inputs in the calculation are derived estimates using Fonterra's costs and revenues and are not extracted directly from the market, making the market price of milk highly theoretical. This calculation could be improved by adopting a total payout based on market-observed dairy commodity prices that a competing independent processor could achieve in the international dairy commodity market, as well as the capital charge based on the cost of capital and capital investment required by an efficient competing independent processor to produce dairy commodity products.

3.3 The Introduction of Global Dairy Trade

In July 2008, Fonterra introduced and implemented the Global Dairy Trade (GDT) online dairy commodity auction. The key objective of GDT is to provide an online auction platform where key dairy commodity products such as whole milk powder (WMP) and skim milk powder (SMP) can be sold at prices that are set by qualified dairy commodity buyers through an online auction process. The auction event took place once a month in the first two years (2009 to 2010) and subsequently once every fortnight. Figure 3-1 details the annual volumes, values and prices transacted between August 2008 and July 2015.

Figure 3-1: GDT Transactions 2009 - 2015[34]



The 2009 year in Figure 3-1 is based on New Zealand's dairy production season, starting from 1 August 2008 and ending 31 July 2009. All the years in Figure 3-1 adopt the same definition. The annual transaction volumes include eight commodity product types transacted on the platform: SMP, WMP, anhydrous milk fat (AMF), butter, butter milk powder (BMP), milk protein concentrate (MPC), cheddar cheese (cheese), rennet casein (casein), and lactose.

As illustrated in Figure 3-1, the GDT volume grew from 189,000 metric tonnes (MT) in 2009 to a peak of 1 million MT in 2014, and total transaction value grew from USD$461m in 2009 to USD$4.8b in 2014. The average price peaked at USD$4,587 per MT in 2014. The 2014 value transacted on GDT was around 40% of the total New Zealand dairy export value.[35]

[34] The data beyond 2015 is not included in the analysis due to major changes in Fonterra's capital investment plan in the 2015 financial year leading to, in addition to the exposure to the international dairy commodity prices, a significant increase in Fonterra's exposure to the Chinese raw milk market and the Chinese consumer dairy market.

[35] Figures extracted from Quick Stats about Dairying 2013-14, Dairy NZ.

The observed rapid growth of dairy commodity products transacted on GDT means there was increasing transparency in the prices of dairy commodity products. This enabled New Zealand and other international dairy producers to contract by referencing the prices set in the online auction. For the much smaller scale independent New Zealand dairy processors, this presented an opportunity to achieve similar price levels to GDT prices for their dairy commodity products. Prior to the introduction of GDT, it was difficult for independent processors, who did not have access to the international commodity trading network of Fonterra, to achieve similar price levels realised by Fonterra. The fact that 40% of the value of dairy exports transacted on GDT in 2014 means that it is very likely that independent New Zealand processors were able to contract by referencing the prices set by GDT, which substantially lowered the barriers to entry.

Notwithstanding that GDT does not directly provide a price for milk, GDT does provide a more transparent way of estimating a price for milk based on what can be achieved in the international dairy commodity market. This enables market participants to derive value for milk on the commodity prices achieved on an open and transparent dairy commodity auction platform. This means that farmers, dairy processors, and international purchasers of dairy commodity products are able to contract based on a set of dairy commodity prices that are relevant, transparent and up to date. Accordingly, GDT vastly enhances the possibility of contracting among the market participants.

Post-GDT, farmer-suppliers and independent dairy processors can now enter into a form of pre-agreed contract pricing arrangement similar to the Default Milk Price calculation set out above. That is, independent processors have the ability to set a milk price paid to farmer-

suppliers by: (1) referencing GDT commodity prices as revenue input; and (2) having pre-agreed processing costs, capital charge, and the capital required to put in place the dairy commodity processing assets as the cost base for the milk price calculation. Under this contractual arrangement, an independent processor is able to make a return higher than its cost of capital if: (i) it is able to sell its commodity products higher than the GDT prices achieved in the global auction; and/or (ii) it produces the agreed set of commodity products incurring costs and engages a capital base that are more efficient compared to the cost and capital base agreed in the contractual pricing model. In other words, farmer-suppliers would be paid milk prices based on a contract milk price determined by GDT commodity prices that are transparent, verifiable and set by global international dairy demand and supply, and pre-agreed processing costs and capital base that are deemed to be reasonable and acceptable to both the sellers and buyers of milk.

As illustrated above, this contractual arrangement of buying and selling milk could be implemented by minimising ex-post opportunistic hold-up behaviour potentially engaged by both independent processors (the buyer of milk) and farmer-suppliers (the seller of milk). It is therefore hypothesised that the introduction of GDT reduces hold-up costs and it is expected that farmer-suppliers will respond by increasing their supply to IOF dairy processors on a contract basis.

3.4 The Introduction of Farmgate Milk Price

Subsequent to the introduction of GDT in 2008, the DIRA regulation was amended in April 2010 to require Fonterra to replace the Default Milk Price with the Farmgate Milk Price (FMP).[36] Although both pricing models are based on a similar approach in estimating milk

[36] The amended regulations came into force in June 2010, with the first Farmgate Milk Price published and applied in the 2010/2011 season.

price by deducting a capital charge from the total payment to shareholder-suppliers, the ways in which the capital charge and total payment to shareholder-suppliers are defined are different in the two milk pricing models. The differences are:

1. In the FMP model, the total payment to suppliers is estimated using commodity prices that a competing independent efficient dairy processor can achieve through selling its dairy commodity products on GDT, whereas in the Default Milk Price model, the total payout is based on Fonterra's actual revenue, which includes all products sold through Fonterra, of which only a proportion of the total products sold is through GDT.

2. In the FMP model, the costs that are deducted from the GDT pricing revenues are based on the costs that a competing independent efficient processor would incur in realising the GDT-based dairy commodity revenues. In the Default Milk Pricing model, Fonterra's actual costs are used in estimating total payout to supplier-shareholders.

3. In the FMP model, the capital charge is estimated based on the capital required by a competing independent dairy processor to process the commodity products sold through GDT and the cost of capital required by an investor to invest the capital so required. In the Default Milk Price model, Fonterra's total capital is used and a capital charge is adopted by an independent valuer to determine the fair market value of the capital base in Fonterra.

As illustrated above, the key differences between the two models are: (1) adoption of GDT commodity pricing series; and (2) adoption of a notional efficient independent dairy processor that produces only commodity products sold through GDT. These differences theoretically make the FMP a better model than the Default Milk Price model because FMP moves away

from estimating the milk price based on Fonterra's total revenues and total costs (which reflect not only the underlying commodity business, but also other value added businesses such as consumer products and foodservices) to using more market-based inputs into the milk pricing calculation. The Default Milk Price is therefore more reflective of what Fonterra is able to pay its own shareholder-suppliers as opposed to what a new independent competing dairy processor is able to pay for milk based on the prices they can actually achieve in the international dairy commodity market. However, it is worth noting that the FMP model only works well when the following conditions are met:

1. That a newly set up independent processor that does milk collection, processing and selling of dairy commodity products is able to achieve commodity prices set by GDT auctions; and

2. That the benchmark independent efficient manufacturer's asset base and cost of capital adopted in the calculation are realistic. Accordingly, the milk price set would enable a newly set up independent processor to earn at least its cost of capital, which makes independent dairy processing commercially viable.

It is also understood from Fonterra that it is in the cooperative's and the dairy industry's best interest to implement FMP for the following reasons:[37]

1. Allocating return and setting share price: FMP provides the market with visibility on milk returns and on equity investment returns. This enables Fonterra to issue shares to public shareholders who do not supply milk, and the value Fonterra's shares can be determined by

[37] Fonterra Milk Price – The Facts (2011), 6.

valuing the return to its equity investors. This is particularly important should Fonterra choose to issue equity to non-supplier-shareholders.

2. Performance and investment decisions: FMP helps each of Fonterra's different business units to have visibility of the earnings generated in addition to the milk price. This enables Fonterra to benchmark the profitability of the different business units. This helps facilitate better performance management and investment decisions for the different business units.

3. Milk production decisions: if the milk price is not accurately set then this could lead to inefficient on-farm investment decisions by farmer-suppliers. If the milk price is lower than what it should be then this could lead to potential underinvestment in farming assets. If the milk price is higher than what it should be then this could lead to overinvestment in farming assets.

The FMP was published in the Fonterra 2011 Annual Report for the first time for the 2010/2011 dairy season.[38] The FMP has been adopted as the price upon which Fonterra is required to sell its compulsory volume of raw milk to other independent processors. Since 2012, Fonterra is also required to publish a detailed calculation of how the FMP is calculated in the Farmgate Milk Pricing Manual, and the manual is reviewed by the New Zealand Commerce Commission each season. This price is also adopted by independent processors as an important reference price for determining the milk price paid to contract milk suppliers.[39]

The following table sets out the key dates for when GDT and FMP were introduced to the New Zealand dairy industry.

[38] The New Zealand dairy season runs from 1 August to 31 July of the following year.
[39] Dry Run Review of Fonterra's Farmgate Milk Price (2011/12), New Zealand Commerce Commission.

Table 3-3: GDT and FMP Event Dates

Date	Event
Jul-08	First GDT Trading Event launched on 2 July 2008
Apr-10	Farmgate Milk Price replaced Default Milk Price
Nov-11	First Farmgate Milk Price applied to 10/11 season

As discussed earlier, the introduction of GDT in July 2008 helped provide price discovery (transparency) and price maximisation (optimisation) of dairy commodity products sold in the international market. The transparency and optimisation of dairy commodity prices made purchasing and supplying dairy commodity products less costly. This means that smaller and newly established dairy companies that did not have any international dairy sales and marketing capabilities now had the ability to contract directly with international customers. In addition to GDT, the introduction of FMP further increased the transparency and credibility of the milk prices that can be used as a basis for contract milk supply.

It is important to note, however, that the key change that encourages contract milk supply is the introduction of GDT. As illustrated earlier, the formulaic milk prices had been in place since the introduction of the Dairy Industry Restructuring Act in 2001. The FMP is Fonterra and the regulator's best attempt at improving the regulated milk pricing formula and could not have taken place without the input of the GDT commodity pricing series. That is, if the market and regulator thought that they could improve the market credibility of the formulaic raw milk prices to improve the efficiency of the New Zealand dairy industry before the introduction of GDT, they could have revised the raw milk pricing formula before 2010. However, the introduction of FMP milk prices based on the GDT pricing series only came into being after GDT was implemented, as illustrated in the discussion on the FMP pricing formula above, the FMP price would have not had much impact without the input of a credible GDT commodity pricing series.

4 The Impact of GDT and FMP on New Zealand Dairy Ownership

The theory of the firm suggests that firms internalise transactions that could take place in the market because of the difficulty of entering into a complete contract. This difficulty happens because buyers and sellers struggle to define prices for all contingencies. Accordingly, any changes in market conditions that lead to increased price transparency and reduced pricing uncertainty have the potential to switch the market away from integration towards contracting.

As illustrated above, GDT provides a commodity pricing series that is transparent and is set to reflect international demand and supply of dairy commodities. As such, this price is expected to substantially reduce the transaction costs of contracting dairy commodity products. In addition, the linkage of GDT prices to New Zealand domestic milk prices through a form of formulaic farmgate milk prices (FMP) provides increasing transparency for domestic raw milk pricing.

The introduction of GDT provides an excellent opportunity to empirically examine whether IOF-owned dairy processing capacity increased post-GDT, which is what is expected given the decrease in contracting costs with IOF processors post-GDT.

In addition to GDT and FMP, I have also included two independent variables to control for the potential impact of switching due to underperformance by the cooperative in delivering returns to shareholders. The two independent variables are defined as follows:

1. Return on Investment (ROI) of the cooperative. As there is only one cooperative (Fonterra) in the area where there are both cooperative and IOF processing facilities, ROI is approximated by the annual changes in Fonterra's share value set by the independent valuer

as required by DIRA. This allows for the possibility that farmer-suppliers are switching due to the underperformance of the cooperative in delivering returns to shareholder-suppliers. Note that profit is not included in the calculation as most of the profits were distributed back to shareholders through payouts in the time period of my analysis; and

2. Payout Premium: the cooperative's relative payout (both payment for milk and dividends for the season on the volume of milk solid supplied) compared to the other competing cooperatives allows for the possibility that the switch could be due to Fonterra underperforming relative to other New Zealand cooperatives. This is estimated by dividing Fonterra's annual cash payout to its farmer-suppliers by the cash payout of the second largest cooperative in New Zealand, Westland Dairy Cooperative.

Accordingly, the following empirical model is used to examine whether the market has adopted an alternative ownership model in response to the introduction of GDT and GDT-based FMP.

$$\textbf{\%Milk Supplied to Co-op}_t = \alpha + \beta_1 GDT_t + \beta_2 FMP_t + \beta_3 ROI_t + \beta_4 \textbf{Payout Premium}_t + \varepsilon_t$$ [40]

Where, t = 2002, 2003 to 2015 seasons;

GDT_t = 1 where t > 2008 (GDT was introduced and implemented throughout the 2009 season);

FMP_t = 1 where t > 2010 (FMP was introduced and implemented in the 2011 season);

[40] The potential omitted variable bias in the regression model is addressed by matching the IOFs and cooperative processing facilities operating in the similar geographical areas as shown in Table A1.4 on P.115.

%Milk Supplied to Co-op$_t$ is the percentage of total milk solids supplied to the cooperative facilities by the famers operating in the areas where there are competing IOF and cooperative processing facilities.

ROI$_t$ is the return on investment estimated by the percentage change of Fonterra's share determined by its Fair Value Share valuation process; and

Payout Premium$_t$ is estimated by dividing Fonterra's total payout by the payout of Westland, the second largest New Zealand dairy cooperative.

In the above model, if the famers respond to GDT and the GDT-based FMP by switching their supply from the cooperative to competing IOFs, then the estimated coefficients β_1 and β_2 are expected to be significantly greater than zero.

Note that the above analysis is undertaken in all dairying areas in New Zealand excluding the milk supplied to Westland and Tatua as there are no competing independent dairy processors in these areas. This is required as the analysis looks into farmer-suppliers' decisions on alternative competing processing facilities.

The data for the empirical analysis is extracted from the following sources:

1. The total annual milk solids supplied in New Zealand from the 2002 to 2015 seasons are taken from statistics published jointly by Dairy NZ Limited and Livestock Improvement Corporation Limited;

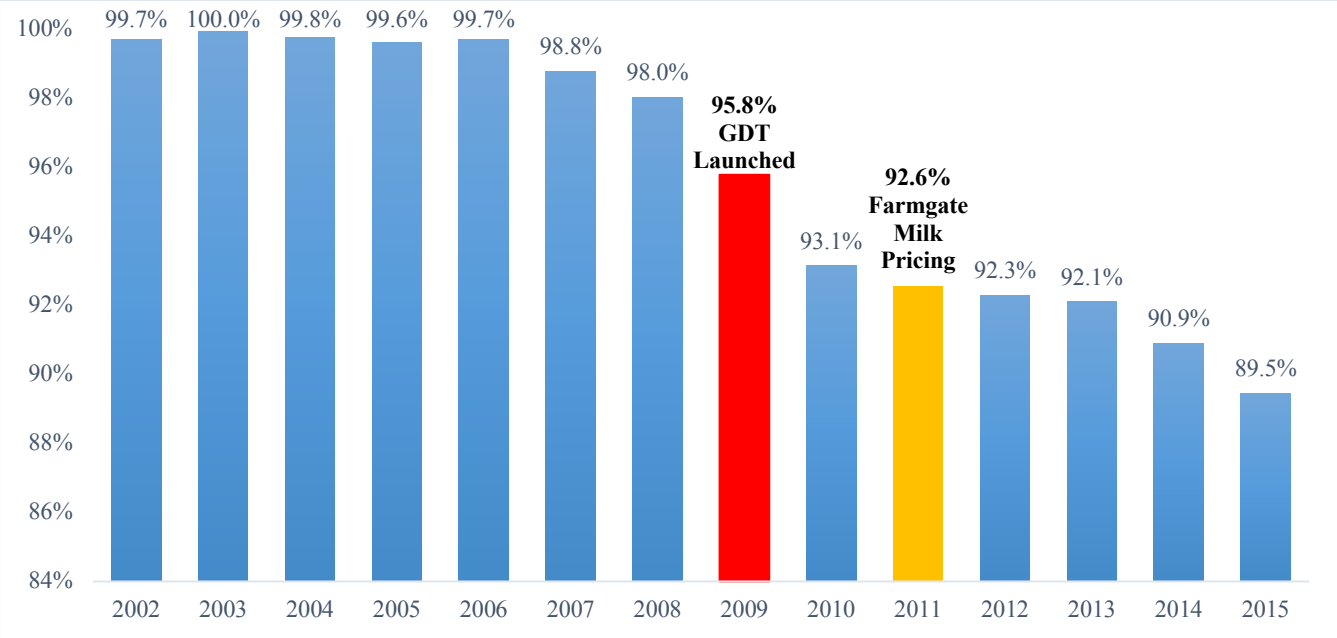
2. The milk volumes supplied to each of the New Zealand dairy cooperatives are extracted from their respective annual reports;

3. The annual milk solids supplied to independent processors are extracted by deducting total milk solids supplied to cooperatives from total annual milk solids produced in New Zealand; and

4. The payout, profit and return on investment financial information are extracted from the respective New Zealand cooperatives' annual reports.

Based on the above data set, the following chart shows the changes in the annual percentage of milk supplied to cooperative processing facilities in all New Zealand dairy land except Westland and Tatua as defined above. This is approximated by dividing annual milk solids supplied to cooperative facilities by total milk solids supplied in the areas where there are competing IOF and cooperative processing facilities.

Figure 4-1: Cooperative and IOF Milk Supply Share % 2002 -2015



The red bar in 2009 is the percentage of total milk supplied to cooperative-owned facilities after GDT launched in July 2008 and the yellow bar is the first season when GDT-based FMP was implemented.[41] The chart shows that there have been significant reductions in the percentage of milk supplied to cooperative-owned facilities, which supports the hypothesis that farmer-suppliers are responding to better dairy commodity price transparency brought by GDT. The reduction also seems to be further reinforced by the introduction of FMP introduced in 2011.

However, it is also observed in the chart that, prior to the launch of GDT in the 2009 dairy season, there is a reduction of around two percentage points from 2006 to 2008. This likely happened because IOFs began ramping up production capacities one or two years before the official launch of GDT in July 2008 in response to: (1) the concept of the GDT trading platform and its impact on milk pricing were nurtured and discussed among Fonterra's dairy farmers during early reviews of Fonterra's capital structure after its formation in 2002; and (2) the GDP platform was introduced and promoted within Fonterra and its international customers in the year prior to its official launch in July 2008. That is, the idea was socialised among key stakeholders before its implementation and it is reasonable to expect that there could be an earlier market response before its official launch.

Table 4-1 reports the results of the regression analysis undertaken based on the data and the regression model defined above. The results are reported for three models where Model 1

[41] Note that the year above is not a calendar year but a dairy season year, which starts on 1 August the prior year to 31 July the following year.

does not include the control variables, Model 2 includes ROI, and Model 3 includes all the control variables.

Table 4-1: GDT and FMP Regression Results

	Model 1	Model 2	Model 3
Intercept	99.30%	98.93%	99.08%
	(244.43)**	(213.35)**	(237.44)**
GDT	-4.84%	-4.18%	-5.05%
	(-5.61)**	(-4.53)**	(-5.39)**
FMP	-3.00%	-3.51%	-3.26%
	(-3.33)**	(-3.80)**	(-3.94)**
ROI		2.28%	2.74%
		(1.62)	(2.16)*
Payout Premium			9.02%
			(1.88)
Adjusted R^2	0.9234	0.9281	0.9439
Sample Size	14	13	13

The dependent variable is the share of total milk supply captured by the cooperative processing facility. GDT is a dummy independent variable that has a value of 0 if the year in which the milk is supplied is before or equal to 2008 and a value of 1 if the milk is supplied after 2008. FMP is a dummy independent variable that has a value of 0 if the year the milk is supplied is before or equal to 2010 and has a value of 1 if the milk is supplied after 2010. ROI is an independent variable that is estimated by the percentage change in the value of Fonterra's shares determined by its Fair Value Share valuation process. Payout premium is Fonterra's payout divided by the payout of Westland, the second largest New Zealand dairy cooperative. The t-statistics are in parentheses. * and ** mean the coefficients are significant at 5% and 1% levels, respectively.

As shown in the table, the estimated coefficients of GDT are significant at the 1% level in all three models. The estimated coefficient of GDT of -4.84% in Model 1 suggests that, after the

introduction of GDT, around 5% of annual milk supply switched from cooperative-owned processing facilities to IOFs.

The results also show that FMP further reinforces the switching to IOFs. The estimated coefficient is significant at a 1% level across all three models. The estimated coefficient of -3% in Model 1 implies that there is a further 3% switch from cooperative-owned processing facilities to IOF processing facilities after the introduction of FMP.

Both estimated coefficients for ROI and Payout Premium are positive, which implies that strong ROI and relative payout performance help to retain milk supply in the cooperative. However, the estimated coefficients of ROI and Payout Premium are not statistically significant, with the exception of ROI, which is significant at the 5% level in Model 3.

The overall results support the hypothesis that GDT and GDT-based FMP encouraged farmers to contract with IOFs as GDT and FMP provide prices where contracts can be put in place. This finding is consistent with the theory of the firm for the reasons set out below:

1. As per Williamson's (1979) transactions costs theory, farmer-suppliers and owners of processing assets have strong incentives to engage in integration through cooperative ownership where the processing assets engaged are highly specific to the transaction of collecting and processing raw milk supply. This transaction-specific investment becomes an issue as it attracts hold-up costs because parties are unable to enter into contracts based on prices that can be discovered and agreed on. The observed empirical results suggest that GDT and GDT-based FMP help provide dairy commodity and milk prices that encourage

processors and farmer-suppliers to contract as both prices can be efficiently determined and agreed in the contracts, and are less exposed to ex-post hold-up behaviour.

2. The GHM property rights theory suggests that in a bilateral monopoly situation, the party to whom the value of the transaction-specific asset is the highest would be willing to internalise the transaction-specific asset by taking ownership of the asset. Under this theory, dairy farmer-suppliers are incentivised to internalise processing assets as this enables them to optimise the value of their on-farm investment. Similar to the transaction cost model, such integration takes place due to the inability to put in place a complete contract that sets up ex-ante payoffs that are free from potential hold-up behaviours. The observed results suggest that farmers are now willing to become contract suppliers of dairy processing assets as GDT and GDT-based FMP provide prices that enable more complete contracting.

3. The results also support the idea that in a situation where the hold-up costs have been substantially reduced through contracting, market participants are willing to switch from relatively vaguely defined cooperative ownership rights towards IOFs to minimise the agency costs associated with vaguely defined cooperative ownership rights.

5 Concluding Remarks

This chapter began by applying the theory of the firm in the context of agriculture cooperatives to gain a better understanding of the economic forces that motivate the formation of agriculture cooperatives. This theoretical analysis shows that cooperative ownership is adopted when suppliers of perishable agriculture products are unable to enter into a contract with the owners of the processing assets because of difficulty in determining complete, pre-agreed prices for their perishable supply. Such costs of incomplete contracts lead to an inefficient production outcome and motivate the formation of agriculture cooperatives by: (1) suppliers of agriculture products forwardly internalising ownership of the processing assets; and (2) internalising through cooperative ownership rights that are redeemable and not transferrable.

In the theoretical analysis, I demonstrated that whilst the issue of incomplete contracts is addressed through cooperative ownership, it also comes with unwanted agency costs. For example, the redeemable and not transferrable feature of cooperative ownership rights makes cooperatives more vulnerable to agency issues of: (1) free riding by new entrants that erodes the value of existing members, (2) lack of incentives to participate in investment that creates value in the longer term that does not benefit members beyond their intended investment horizon, and (3) members having less capacity to diversify their risk as they are required to own both farming and processing assets.

I then demonstrated how some of these agency costs can be reduced by modifying the redeem-ability and non-transferability of cooperatives' ownership rights. For example, modifying the ownership rights from redemption at nominal value to a market-based valuation of the cooperative ownership rights upon exiting helps minimise the horizon

problem. However, the analysis also shows that such modification helps minimise agency issues of cooperative ownership but is unable to eliminate agency costs completely.

Towards the end of my theoretical analysis, I show that the actual choice of agriculture ownership model is determined by the trade-off between hold-up and agency costs. That is, the trade-off that determines a particular form of governance model depends on the prevailing market structure, and the prevailing market structure determines the extent of the potential hold-up and agency problems. The objective is not to design and set up a particular type of cooperative governance model that is always superior to others but, instead, to design and set up the most fit-for-purpose cooperative model minimising overall inefficiencies inherent in the prevailing market conditions.

I then demonstrated that the introduction of Global Dairy Trade (GDT) and subsequently the Farmgate Milk Price (FMP) in the New Zealand dairy industry have provided market participants with much more reliable and credible dairy commodity prices and raw milk prices, making contract supply to IOF processors a commercially viable option. This provides an opportunity to empirically examine whether market participants switch from cooperative ownership towards IOF ownership when there is a significant reduction in hold-up costs, as hypothesised in my theoretical analysis.

I undertook a regression analysis using New Zealand dairy industry data from 2002 to 2015 to examine whether, in an area where there are both cooperative and IOF dairy processing facilities, farmers switched their milk supply from cooperative processors to IOF processors after the implementation of GDT and GDT-based FMP.[42] The results of my analysis support

[42] The 2002 to 2015 data is selected as per the reasons detailed in Footnote 2 above.

the hypothesis that some New Zealand dairy farmers switched to IOF processors in response to a substantial reduction in hold-up costs because of the availability of credible dairy commodity and milk prices enabled by the implementation of GDT and GDT-based FMP.

Notwithstanding the empirical support for the theoretical hypothesis, the small sample size and New Zealand dairy industry-only data restrict the extent to which we can generally apply the observed results to other agriculture industries internationally. Despite this caveat, this is the first empirical study on how the market responds to changes in one-off step-wise reductions in hold-up costs.

It is also worth noting that while this research was conducted, the second largest New Zealand dairy cooperative – Westland Dairy was in the process of being sold to Yili, one of the largest IOF-owned dairy companies in China. This observation further reinforces the theoretical prediction of how the market responds to a substantial reduction in hold-up costs due to improvement in price discovery by moving away from integration and moving towards contracting.

CHAPTER TWO

The Impact of Global Dairy Trade (GDT) Auction on the Efficiency of the New Zealand Dairy Industry

1 Introduction

In Chapter One, we observed contract supply of milk to investor-owned firm processors (IOF or independent processors) in New Zealand gaining momentum after the online dairy commodity products trading platform Global Dairy Trade (GDT), was introduced in July 2008. This momentum was further reinforced by the changes made to the Farmgate Milk Pricing (FMP) in 2010, which links GDT prices to the calculation of raw milk prices paid by the largest New Zealand milk processor, Fonterra. The regression analysis using New Zealand dairy industry data reveals that controlling for the difference in payout and shareholder return, independent processors gained 8.3% of New Zealand's total milk supply from dairy cooperatives post-GDT. In 2015, the independent processors processed 190 million kg milk solids, which was around 10% of New Zealand's total milk supply, compared to 24 million kg milk solids in 2008 (around 2% of New Zealand's total milk supply), just before the introduction of GDT.

The observed results are consistent with the "theory of the firm" which stipulates that market participants voluntarily transact through an integrated firm instead of contracting using the market price mechanism when contracting through the market is more costly than transacting through an integrated firm. The New Zealand dairy industry's evidence reveals that when purchasers and suppliers of milk are able to enter into contracts based on ex-ante prices that are deemed to be fair and reasonable by both parties and are less vulnerable to ex-post opportunistic hold-up behaviour, then contract supply to IOFs is preferred over supply through vertically integrated cooperatives. Contract supply is preferred as: (1) it enables farmer-suppliers to receive milk prices that fully reflect the market value of milk without requiring them to invest further in downstream processing assets; and (2) it enables the processors to be owned through IOF ownership, which is inherently more efficient than

cooperative governance in terms of agency costs attributed to relatively vaguely defined cooperative ownership rights.

However, the empirical results documented in Chapter One only reveal farmers' preferences to contract supply; they do not estimate the efficiency impact of GDT on the New Zealand dairy industry. All we can conclude from the empirical results in Chapter One is that contract supply reduces the total capital investments required of dairy farmers because under contract supply: (1) farmers no longer have to stretch their balance sheet to invest in downstream processing assets; and (2) processing assets can be funded by investors who are able to hold more diversified portfolios of investments than New Zealand dairy farmers, which implies a lower cost of capital on the funds provided by investors through IOF ownership. The analysis in Chapter One does not directly compare the changes in the efficiency of converting key inputs required (for example, operating costs and capital investment required to put in place dairy processing assets) to the desired outputs (for example, milk prices and dividends paid to supplier-shareholders) before and after the introduction of GDT.

This chapter therefore provides an empirical assessment of the impact of contract supply of milk to IOFs enabled by GDT on the efficiency of the New Zealand dairy industry. This objective is achieved by:

(1) reviewing contemporary empirical literature that examines economic efficiencies of agriculture cooperatives and comparable IOF-owned processors;

(2) defining and developing empirical models and hypotheses to assess the efficiency impact of GDT using New Zealand dairy industry data based on the contemporary empirical studies

reviewed; and

(3) documenting the results of my empirical models and comparing the results of the analysis to the results documented in the literature.

This chapter is structured as follows. The next section reviews contemporary empirical studies examining the economic efficiency of agriculture cooperatives and their comparable IOF processors. The third section details the empirical models and hypotheses adopted in assessing the efficiency impact of GDT on the New Zealand dairy industry. The fourth section reports the results of the empirical analysis. The fifth section concludes.

2 Literature Review and Empirical Research Motivation

2.1 Empirical Analysis of Relative Governance Efficiencies

Soboh, Lansink, Giesen and Dijk (2009) (SLGD (2009)) put together a comprehensive review of empirical studies undertaken between 1987 and 2007 using data from the United States, Canada, Japan, India and Greece to examine the performance of agriculture cooperatives relative to IOFs. The objective was to document the wealth of studies of the relative efficiency of the two alternative ownership models.

SLGD (2009) suggest that cooperative ownership, due to its vaguely defined property rights as suggested by Cook (1995), is less efficient than IOF ownership. This hypothesis can be empirically tested by: (1) comparing the financial ratios of agriculture cooperatives to their IOF peers; and (2) using efficiency measurement methods such as data envelopment analysis (DEA) to examine the relative efficiencies of alternative governance models.

Accordingly, in this section, I firstly review the empirical studies put together to examine the relative efficiency between agriculture cooperatives and comparable IOFs using the ratio analysis approach, followed by a review of similar studies undertaken using the efficiency measurement approach, and then make comparisons of the reported results using the different approaches.

2.1.1 Empirical studies of cooperative efficiency based on financial ratio analysis

The empirical studies that examine the efficiency of cooperative governance by benchmarking its financial ratios to that of comparable IOFs test the following hypotheses:

1. Cooperatives are likely to be less efficient and profitable than IOFs as cooperative governance is adopted not only to maximise profit to shareholders but also attempts to

maximise total payoff of both profit and prices paid to supplier-shareholders. For example, a dairy cooperative may opt to pay for higher milk prices to its shareholder-suppliers instead of paying dividends on its profit. This implies that cooperatives are more likely to have lower efficiency and profitability financial ratios than their IOF counterparts; and

2. Cooperatives are likely to have relatively higher gearing than IOFs because cooperatives are restricted to capital provided by supplier-shareholders, retained earnings and bank borrowing, whereas IOFs can always raise additional funding through issuing shares to independent investors. This implies that cooperatives are more likely to have leverage ratios that are higher than their IOF counterparts.

The following table provides an overview of the empirical studies undertaken to test the above two hypotheses.

Table 2-1: Agri Co-op and IOF Financial Ratio Empirical Studies[43]

Empirical Study	Sample Size	Period	Country	Sector	Profitability/Efficiency Ratios	Leverage Ratios
Chen, Bab and Schrader (1985)	32 coops and 34 IOFs	1975-80	USA	Dairy and other food industries	Consistent	Consistent
Venieris (1989)	17 coops and 9 IOFs	1981-83	Greece	Wine	Consistent	Consistent
Parliament, Lerman and Fulton (1990)	9 coops and comparable IOFs from RMA	1976-87	USA	Dairy	Inconsistent	Inconsistent
Gentzoglanis (1997)	6 coops and 6 IOFs	1986-91	Canada	Dairy	Inconsistent	Inconsistent
Hardesty and Salgia (2004)	41 coops and comparable IOFs of RMA	1991-2002	USA	Dairy, FarmSupplies, Fruit and Vege, Grain	Inconsistent	Inconsistent

[43] Note that, in my research, I have not been able to find any empirical studies that examine the relative efficiency between Agri-coops and IOFs using ratio analysis since 2004. The more recent relative efficiency studies are largely based on efficiency measurement techniques such as DEA and stochastic frontier analysis, as summarised in Table 2-2.

As shown in Table 2-1, Chen, Bab and Schrader (1985) looked into how larger cooperatives performed in comparison to their IOF counterparts in the US food sector between 1975 and 1980. Their study found that the 32 larger US food cooperatives were less profitable and more highly geared than the 34 US food IOFs. These results are consistent with the hypotheses.

Venieris (1989) used data from the Greek wine industry in the period 1981 to 1983, and found that cooperatives were less profitable and more highly geared than their IOF counterparts, which is again consistent with the hypotheses. However, Venieris suggests that the observed results largely reflect the Greek government's policy that gives cooperatives a lower tax rate and interest free bank borrowings such that the inefficient cooperatives can compete with their more efficient IOF counterparts.

Parliament, Lerman and Fulton (1990) used US dairy cooperatives data and comparable dairy IOF data from Robert Morris Annual Statement Studies (RMA) in the period 1971 to 1987, and found that there were no observed significant differences in profitability measures between dairy cooperatives and their IOF counterparts and, contrary to expectations, the dairy cooperatives were more efficient and used less debt than their IOF counterparts. This observed result is inconsistent with the theoretical hypothesis that cooperatives are inherently less efficient in terms of profitability and more highly geared due to a relatively restrictive capital base.

Gentzoglanis (1997) used Canadian data on six dairy cooperatives and six comparable dairy IOFs in the period 1986 to 1991, and found that the cooperatives were as profitable as their IOF counterparts and had a lower debt to equity leverage measure than their IOF counterparts. Gentzoglanis concludes that these results are similar to that of Parliament, Lerman and Fulton

(1990) and do not support the hypothesis that cooperatives are less profitable, efficient, and more highly leveraged compared to IOFs. This result requires further development in the theoretical understanding of cooperatives as one would not expect cooperative governance, which is designed to maximise both profits and payments of key agriculture ingredients to supplier-shareholders, to deliver similar levels of profitability and efficiency ratios with lower gearing in comparison to IOFs (whose primary objective is to maximise profit to shareholders).

In a more recent study, Hardesty and Salgia (2004) used 41 US agriculture cooperatives in four sectors: dairy, farm supply, fruit and vegetable, and grain, and comparable IOFs from RMA in the period 1991 to 2002. They observe that cooperatives in all four agriculture sectors were less leveraged, and the result with regards to relative profitability is not conclusive: the grain cooperatives were more profitable than their IOF counterparts, while cooperatives in the other three sectors delivered similar levels of profitability as their comparable IOFs. Hardesty and Salgia conclude that their results are similar to that of Parliament, Lerman and Fulton (1990) and do not support the prediction that cooperatives are less profitable, efficient and more highly leveraged than IOFs. They further conclude that these results "should alleviate some of the concerns expressed by producers and lenders regarding the viability of agricultural cooperatives" and "these results, when combined with the fact that cooperatives ensure secured markets for their members' products, demonstrate that cooperatives continue to promote the economic welfare of agricultural producers."[44]

The financial ratio efficiency analyses using different data from different time periods, different countries and across different agriculture sectors reveal mixed results. Chen, Bab

[44] Hardesty and Salgia (2004), 16.

and Schrader (1985) and Venieris (1989) support the hypothesis that cooperatives are less efficient and more highly geared compared to their IOF counterparts, but the three other studies reveal that cooperatives are just as efficient and have the same or lower level of gearing compared to their IOF counterparts.

2.1.2 Empirical studies of cooperative efficiency based on economic efficiency techniques

In addition to the financial ratio analysis, researchers have examined the efficiency of cooperatives using economic efficiency measurement techniques such as data envelopment analysis (DEA) and stochastic frontier analysis. "These studies basically use quantitative tools to explain the value of one output using the value of many different inputs."[45] The theoretical and technical details of how DEA efficiency studies are put together are provided in Appendix Two.

Similar to financial ratio studies, the DEA efficiency studies were undertaken to test the hypothesis that due to the various agency issues related to vaguely defined cooperative ownership rights, cooperatives are expected to be less efficient than their IOF counterparts in terms of converting key inputs to key outputs. The results of the empirical studies undertaken to examine this hypothesis over the last 30 years are summarised in the following table.

[45] Soboh, Lansink, Giesen and Dijk (2009), 463.

Table 2-2: Agri Co-op and IOF Economic Efficiency Empirical Studies

Empirical Study	Data Period	Country	Sector	Consistent with Theory
Porter and Scully (1987)	1972	USA	Dairy	Consistent
Sexton, Wilson and Wann (1989)	1980-85	USA	Cotton	Inconsistent
Akridge and Hertel (1992)	1980	USA	Grain and Farm Supplies	Inconsistent
Singh, Coelli and Fleming (2000)	1993-1997	India	Dairy	Inconsistent
Boyle (2004)	1961-87	Ireland	Dairy	Inconsistent
Soboh, Lansink and Dijk (2012)	2004	Six EU Countries	Dairy	Consistent
Monteiro and Straume (2018)	2010-12	Portugal	Wide Range of Industries	Mixed

Porter and Scully (1987) used 1972 US fluid milk processing plant data collected by the US Department of Commerce at the plant level to look into price, scale and technical efficiencies of the dairy plants that are owned and operated through cooperative ownership relative to plants owned and operated through IOF ownership. The efficiencies are defined as the relative efficiencies of each dairy plant in converting key inputs (capital and labour hours) to one key output (quantity of products manufactured). Their overall results suggest that the average cooperative dairy fluid processing firm is only 75.5% economically efficient compared to their IOF counterparts. Porter and Scully (1987) interpret their results as strong evidence for the hypothesis that cooperative ownership is inherently weaker than IOF ownership due to its vaguely defined property rights.

Contrary to the finding of Porter and Scully (1987), Sexton, Wilson and Wann (1989) tested the allocative efficiency of cooperatives using data from the US cotton ginning industry and their results do not support the hypothesis that cooperatives use their capital less efficiently than IOFs. Similarly, Akridge and Hertel (1992), using data from 301 US farm retail firms in 1980, found that cooperatives were just as efficient as IOFs and incurred similar input costs to deliver similar levels of output.

A more recent study, Singh, Coelli and Fleming (2001), used 13 Indian dairy cooperatives and 10 IOFs for the period 1993 to 1997, and found that cooperatives were more cost efficient than IOFs. Similarly, Boyle (2004), using Irish dairy processing assets data for the period 1961 to 1987, found that Irish dairy marketing cooperatives were as economically efficient as their IOF counterparts, and cooperatives behaved as if they were profit maximisers with respect to the cost of their key raw material, milk. These results are again contrary to the hypothesis that cooperatives are less efficient than their IOF counterparts and also, interestingly, do not support the idea that cooperatives maximise total payoff to farmer-suppliers, but instead behave as if they were profit maximisers.

Soboh, Lansink and Dijk (2012) (SLD) applied DEA to European dairy processer data (43 cooperatives and 90 IOFs) observed in 2004 and found that cooperatives were less efficient than IOFs. However, different results are observed when they redefine the input to output model separately for the dairy cooperatives and IOFs analysed. SLD (2012) analysed the efficiency of IOFs assuming they minimise all inputs to production to optimise profit, whereas cooperatives minimise all costs to optimise payment for milk and profit. Under this redefined model, SLD found that the dairy cooperatives' efficiency performance improved significantly and the efficiency differences between cooperatives and IOFs became insignificant. They therefore suggest that cooperatives are set up to achieve total payoff to farmers that is made up of profit and payment for milk, whereas IOFs are set up to maximise profit.

Monteiro and Straume (2018) used the data from the Portugal cooperatives and IOFs of a wide range of industries for the period 2010 to 2012 to examine relative productive efficiency.

They studied the relative efficiency of cooperatives to IOFs by comparing their efficiencies in optimising gross production output using key inputs: total employment, tangible fixed assets and real intermediate inputs. The results of their analysis reveal that the estimate coefficients using their benchmark random-effects GLS model suggest that cooperatives are less productive than their IOF counterparts. However, when they adopted an alternative System-GMM approach, the results are less conclusive: they are unable to reject the null hypothesis that the productive efficiency is significantly different between cooperatives and their IOF counterparts.

Based on the results were quite sensitive to the different efficiency models adopted, Monteiro and Straume (2018) concluded that: "the less conclusive nature of the System-GMM results indicate that we should interpret the GLS results with some caution, and we cannot conclusively state that cooperatives are generally less productive than IOFs."[46]

2.1.3 Reasons for the observed inconsistencies

To date, the empirical studies based on financial ratio analysis and economic efficiency measurement analysis do not provide consistent and conclusive evidence that supports or rejects the hypothesis that agriculture cooperative ownership is less efficient than IOF ownership. SLGD (2009) suggest the reason for this empirical observation is that the hypothesis testing undertaken by most of the empirical studies on cooperative efficiency assumes that cooperatives are viewed as independent business units and that they exist to maximise cash flow to shareholders. This assumption results in: (1) comparing the financial ratios of cooperatives to their IOF counterparts to assess relative efficiency in maximising

[46] Monteiro and Straume (2018), 404.

residual cash flow to shareholders and/or profit; and (2) comparing technical, scale and allocative efficiencies of cooperatives to IOF counterparts to examine relative efficiencies in maximising residual cash flow to shareholders and/or profit. Such assumptions may not be appropriate as cooperatives could be set up to pursue one of the following three objectives:

1. Cooperatives are viewed as vertically integrated firms. That is, the cooperative is integrated with the farming assets each supplier-shareholder has and is set up to maximise total payout to suppliers that includes both prices paid for the agriculture ingredients supplied and profit;

2. Cooperatives are viewed as independent business enterprises similar to IOFs. Similar to IOFs, the primary objective under this view of cooperatives is set up to maximise residual cash flow to shareholders; and

3. Cooperatives are viewed as a coalition of firms. Under this view, "the [cooperative] coalition can be formed between firms such as, but not limited to: heterogeneous member groups, managers, non-member customers, and non-member shareholders, in which each firm has its own objective."[47] That is, the different stakeholders engage with cooperatives as platforms and work with each other to maximise both their individual interests and the cooperative's overall objective.

If cooperatives were set up to achieve goals other than maximising cash flow to shareholders (i.e., consistent with the first or the third objective above), then undertaking comparisons between cooperatives and IOFs based on financial ratio analysis and economic efficiency analysis by assuming that cooperatives behave in the same way as IOFs could lead to a biased

[47] Soboh, Lansink, Giesen and Dijk (2009), 455.

result. Instead, SLGD (2009) suggest that empirical work should be undertaken to incorporate the possibility that cooperatives are set up not solely to maximise cash flow to shareholders, but to maximise total payment to supplier-shareholders. The empirical study done by SLD (2012) summarised above demonstrates how this can lead to a very different result: cooperatives are found to be less efficient than IOFs in maximising profit to shareholders, but cooperatives are as efficient as IOFs in maximising total payouts to supplier-shareholders.

2.1.4 Limitation of IOF cooperative cross-sectional analysis

The contemporary empirical studies reviewed above have all been undertaken to answer one question: are IOFs different from cooperatives in delivering economic efficiency for the agriculture industry? However, as detailed in Chapter One, a particular governance model is intentionally adopted by market participants in response to a set of given market conditions. A better way to define the question might be: why is a particular ownership model adopted over another model in response to a change in market conditions? This suggests that there is a need for a dynamic analysis that looks into the factors that contribute to the evolution of one governance model to another over time.

As discussed in Chapter One, there are different types of cooperatives. For example, farmers can opt to transact through conventional agriculture cooperatives where the ownership rights are redeemable at nominal value and not transferable. Alternatively, farmers can opt to transact through new generation cooperatives where the rights are redeemable at fair market value. Although they are both regarded as cooperatives, the economic forces at play in the conventional agriculture cooperatives and new generation cooperatives are quite different. The question is therefore not whether one model is better than the other but, instead, why one model is preferred to the other by farmers under a set of given market conditions.

It is also worth noting that in the cross-section comparisons undertaken in the empirical studies reviewed, the results are prone to bias where the suppliers to the incumbent cooperatives are "cherry picked" by the emergent IOFs such that the IOF relative performance is overstated.

2.2 GDT: an Opportunity for Time-series Analysis

The above limitations of prior empirical studies call for an alternative way of analysing efficiency changes brought about by the different governance models. Recent changes to the New Zealand dairy industry because of the online Global Dairy Trading (GDT) platform provide an excellent research opportunity for an empirical assessment of the changes in economic efficiency resulting from a major change in the market condition. As shown in the regression analysis in Chapter One, farmers chose to migrate from a predominately cooperative only governance model to a hybrid of IOF and cooperative co-existing model in response to the introduction of GDT in July 2008. This observed result is largely driven by GDT significantly lowering the barriers to entry for newly established dairy processors because: (a) GDT enables the new processors to gain direct access to international dairy markets, which was only available to the incumbent cooperatives prior to GDT; and (b) the subsequent introduction of GDT-based FMP facilitates newly established IOF processors to secure milk supply through contracts.

It is also important to note that FMP helps to reinforce the impact of GDT but not the other way around. Prior to GDT, Fonterra had engaged a number of different methods to estimate a milk price that best reflected market value for milk. The assumption on efficient manufactures' operating costs and the cost of capital adopted in the FMP formula is not a novelty and similar assumptions were adopted in the estimation of Fonterra milk prices prior

to GDT to help assess the value added return delivered. The key input that establishes the credibility of FMP is the commodity prices set by GDT, which were not available prior to the launch of the GDT platform in July 2008.

As also discussed in Chapter One, Fonterra opted to estimate FMP using the GDT commodity prices for its internal efficiency reasons and did not envisage that GDT would facilitate growth in competition for milk from IOF processors. Fonterra was anticipating benefits of GDT-based FMP to improve its internal efficiencies, but did not take into account the possibility that GDT-based FMP could facilitate the establishment of IOF processors.

I therefore regard the unanticipated impact of GDT establishing competing IOFs as the main exogenous shock to the New Zealand dairy industry. This exogenous shock provides an opportunity for an empirical analysis of efficiency changes brought in by farmers willingly switching from supplier-owned cooperative governance to IOF contract supply enabled by GDT. In comparison to the empirical studies to date, which focus largely on the question, "which governance model is better than the other?", assessing the changes in efficiency in response to changes in governance models enables me to directly test the impact of GDT on the efficiency of the New Zealand dairy industry.

3 Empirical Models and Hypotheses Development

In line with the empirical work that looked into the efficiency differences between cooperative and IOF ownership models, I used both financial ratio and DEA approaches to examine the impact of GDT on the efficiency of the New Zealand dairy industry. This section details the empirical models and hypotheses adopted.

Appendix One provides an overview of the relevant institutional details of the New Zealand dairy industry, which readers may find useful in understanding the context of the following empirical analysis.

3.1 Efficiency Assessment Using Financial Ratio Analysis

As suggested above, GDT provides New Zealand dairy farmers with an alternative milk processing option: contract supply to IOFs. I expect that after the introduction of GDT, the efficiency of dairy processing facilities, where alternative supply options are available, will increase in response to the emergence of IOF processors. Accordingly, I have set up the following empirical financial ratio analysis, which:

1. Compares the relative efficiencies measured by the differences between the combined financial ratios of both cooperative and IOF processing facilities in areas where milk is contested by both IOFs and cooperatives, with the financial ratios of cooperative facilities where there are no competing IOFs. I expect the overall efficiency in the areas where milk is contestable to improve as: (1) IOFs are set up more efficiently in terms of agency costs; and (2) cooperatives become more efficient in response to competitive pressure in areas where there are competing IOF processors.

2. Compares the relative efficiencies measured by comparing the key financial ratios of the cooperative processing facilities in areas where there is an alternative IOF supply option to the cooperative processing facilities where there are no competing IOFs. It is expected that the cooperative processing facilities where there are IOFs competing for milk will become more efficient than cooperative facilities where there is no competition.

The financial ratio adopted to undertake the efficiency comparison is the Total Payout before Interest and Tax Return on Assets ratio (TPROA). TPROA is estimated by dividing total payout before interest and tax by total assets employed and is obtained from the respective annual financial reports and accounts of the two cooperatives and two IOF processors in New Zealand.

The selection of TPROA is motivated by the empirical finding in Soboh, Lansink and Dijk (2012) (SLD). In their analysis, different efficiency results are observed when they redefine the output in their DEA efficiency assessment model from maximising profit to maximising the combined profit and payment for milk to cooperative shareholder-suppliers. SLD (2012) argue that this is expected as cooperatives are not set up merely to maximise return to shareholders in the form of profit, but are more likely to be set up to maximise total return to farmer-suppliers in the form of total return that includes both profit and payment for milk. Based on SLD's (2012) finding, I therefore consider TPROA an appropriate measure of return for farmer-suppliers.

The two cooperatives included in the following analysis are Westland and Fonterra, and the two IOF processors are Synlait and Open Country Dairy. These four dairy processors

processed up to 99% of the total milk produced by New Zealand dairy farmers between 2002 and 2015. Note that Tatua, the third largest New Zealand dairy cooperative, is not included for the following reasons:

1. Tatua is regarded as a "closed cooperative" as, in accordance with Tatua's constitution, Tatua shareholders are restricted to a list of shareholder-suppliers who are on its shareholder register. That is, Tatua processes milk within its existing shareholder base and is not open to new shareholder-suppliers joining, which is different to Fonterra and Westland where new shareholders are able to join by fulfilling and complying to a set of new supplier entry requirements.

2. Tatua has a very different product mix to the other New Zealand dairy processors. A significant amount of Tatua's milk is processed into milk caseinate products whereas all other dairy processors have significant exposure to milk powder commodity products.

3. Tatua processes about 1% of New Zealand's milk supply, which is much smaller in scale compared to the other dairy processors included in the analysis.

Based on the above motivations, I estimate the following time-series regression models (Model 1 and Model 2) to assess the efficiency impact of New Zealand dairy farmers switching from supplying milk to cooperatives to contract supply to IOF processors in response to the implementation of GDT.

Model 1: $(TPROA_{IOFCOOPt} - TPROA_{WESTLANDt}) = \alpha + \beta_1 GDT + \varepsilon_t$

In Model 1, $TPROA_{IOFCOOPt}$ is the combined total payout before interest and tax on combined total assets for both the cooperative and IOF processors in areas where milk is contested by both cooperatives and IOFs for period t (t = 2002 to 2015). If GDT can improve the efficiency in the areas where there are both cooperatives and competing IOFs, then the estimated coefficient β_1 is expected to be significantly greater than zero. The cooperative and IOFs included here are Fonterra, Open Country Dairy, and Synlait where the milk supply areas are contestable. For more details on the supply footprint please refer to Appendix One.

It is important to note that I have only been able to include data for the period 2008 to 2015 for Open Country and 2009 to 2015 for Synlait in Model 1, because prior to 2009, Synlait had only just commenced their operations, while Open Country was going through a series of restructures in response to unsustainable financial performance prior to 2008. Also, Open Country Dairy and Synlait jointly processed between 0.3% to 1.9% of the total New Zealand milk supply before 2008.

$TPROA_{WESTLANDt}$ is the total payout before interest and tax return on total assets of Westland dairy cooperative (Westland), which is the control because this cooperative is operating in an area where there are no competing IOFs.

All financial figures are extracted from the cooperatives' and IOFs' published annual reports and financial accounts filed on the New Zealand Companies Office website.

GDT is a dummy variable that has a value of 0 for the data observed before or in 2008, and has a value of 1 for the data observed after 2008. The GDT dummy is in place to capture the efficiency impact associated with alternative governance options enabled by the introduction of GDT in July 2008.

Model 2: $(TPROA_{FONTERRAt} - TPROA_{WESTLANDt}) = \alpha + \beta_1 GDT + \varepsilon_t$

In Model 2, $TPROA_{FONTERRAt}$ is the total payout before interest and tax return on the total assets of Fonterra.

$TPROA_{WESTLANDt}$ and GDT are defined in the same way as per Model 1 above. Similar to Model 1, if GDT improves efficiency as suggested, then the estimated coefficient β_1 is expected to be significantly greater than zero.

The validity of the results from Models 1 and 2 are highly dependent on the quality of Westland as the control. In addressing this issue, I also estimated the following regression model using New Zealand's share of global milk production as a cross-check to Model 1 and Model 2.

Model 3: $NZShare\%_t = \alpha + \beta_1 GDT + \varepsilon_t$

$NZShare\%_t$ is the New Zealand share of the total global volume of milk produced for period t = 2002 to 2015. GDT is a dummy variable that has a value of 0 for period t <= 2008 and a value of 1 for period t > 2008. The global milk production data is sourced from the United

States Department of Agriculture: Dairy World Market and Trade 2002 to 2015.[48] The GDT dummy variable is adopted to examine whether, in addition to its impact on New Zealand dairy's absolute efficiency, it has an impact on New Zealand's relative supply efficiency compared to the rest of the world.

The objective of the analysis is to test whether the introduction of GDT has led to New Zealand increasing its share of global milk production. If this is the case, then we can conclude that GDT not only helped the New Zealand dairy industry become more efficient in absolute terms, but also helped it become relatively more efficient compared to other milk supplying countries, which enabled New Zealand to increase its share of the total global milk production. In Model 3, if GDT improves New Zealand's relative efficiency in producing dairy commodity products, then it is expected the estimated coefficient β_1 to be significantly greater than zero.

In addition to the above time-series analysis that measures the changes in efficiency in response to the impact of GDT, I have also undertaken a financial efficiency analysis that examine the efficiencies of the key financial ratios of the IOF facilities relative to the cooperative facilities where there is no competition for milk. This comparison is undertaken so one can compare the results against the cross-sectional financial efficiency ratio analysis documented in the literature. Consistent with similar empirical studies examining the relative efficiency between agriculture cooperatives and IOFs using cross-sectional data, it is expected that IOF facilities are inherently more efficient as their ownership rights are better defined than that of cooperatives. This analysis is achieved by testing differences in the means of the

[48] Dairy: World Markets and Trade, United States Department of Agriculture, December 2003, July 2008, December 2013, and December 2016 (https://www.fas.usda.gov/data/dairy-world-markets-and-trade).

financial efficiency ratios achieved by IOF ($TPROA_{IOFt}$) and the control cooperative, Westland ($TPROA_{WESTLANDt}$), where I expect $TPROA_{IOFt} > TPROA_{WESTLANDt}$ (Model 4).

In this analysis, $TPROA_{IOFt}$ is the combined total payout before interest and tax return on the total assets of the two IOFs, Synlait and Open Country. Note that I have only included data for the period 2009 to 2015 (i.e., t = 2009 to 2015), because in 2009 Synlait had only just commenced their operations, while Open Country was going through a series of restructures in response to unsustainable financial performance prior to 2009.

3.2 Efficiency Assessment by Data Envelopment Analysis (DEA)

In addition to the financial ratio efficiency assessment of IOFs to cooperatives, I used data envelopment analysis (DEA) to examine the relative efficiencies between the IOFs and the controlled cooperative. This was undertaken as a cross-check to the financial analysis ratio approach for the following reasons:

1. The financial ratio analysis examines the efficiency differences using the reported financial ratio between one output (total payout before interest and tax) and one input (total assets engaged). The analysis is unable to assess the empirical relations of converting multiple inputs to multiple outputs. DEA, on the other hand, is able to assess the efficiency impact of converting multiple inputs to multiple outputs.

2. DEA can be designed to decompose efficiencies of converting multiple inputs to multiple outputs into different types of economic efficiencies. For example, total technical efficiencies of converting two inputs to one output can be separated into pure technical efficiencies and scale efficiencies to help gain a better understanding of the different sources of efficiencies.

3. The DEA analysis is adopted so we are able to compare the results of the analysis to empirical results documented in a number of empirical studies that engage similar DEA analysis reviewed.

The DEA analysis examines the efficiencies of dairy cooperatives relative to IOF dairy processors by benchmarking the different dairy processing decision making units to the most efficient set of processing units through a linear programming model that optimises input to output relations of all the processing units examined. The analysis provides estimates of efficiency scores, indicating each decision making unit's efficiency relative to the most efficient set of dairy processing units.

The form of DEA model I have adopted in the subsequent analysis is an input-oriented constant returns and variable returns to scale model suggested by Coelli, O'Donnell and Battese (2005), and Coelli (1996). The details of their models are provided in Appendix Two.[49]

Consistent with the objective of maximising payout by minimising costs and asset base as per the financial ratio analysis, I have adopted an input-oriented DEA model, as defined in Appendix Two, with two inputs and one output. The two inputs are (1) total annual operating costs incurred by each decision making unit in running and maintaining all its underpinning dairy processing assets, and (2) total processing assets used by each decision making unit. The

[49] The reason for adopting an input-oriented DEA model that maximises a given level of payout by flexing operating costs and asset base is that the production costs decisions are made in response to the international dairy commodity prices, which are determined by global demand and supply of dairy commodity products.

two inputs are approximated by the operating costs and value of total assets extracted from the annual reports of Westland, Open Country, and Synlait for the period 2002 to 2015.[50]

The output (payout before interest and tax) is extracted from the same source as the two inputs. Note that because I am pooling the data from different time periods in the DEA analysis, I have made the following adjustments:

1. Both the inputs and the output are adjusted for inflation by indexing to 2002 dollars using inflation figures extracted from the CPI index provided by the Reserve Bank of New Zealand; and

2. The output (payout before interest and tax) is scaled by the corresponding inflation-adjusted export whole milk powder commodity prices to minimise the impact of commodity price volatility on the analysis.

The DEA analysis reports two types of efficiencies: pure technical efficiency and scale efficiency. The pure technical efficiency (referred to as technical efficiency from this point onwards) is a measure of how efficient each decision making unit is relative to the most efficient set of input to output conversions, controlling for differences in scale. This is achieved by estimating the efficient frontier, which is not a straight line but a curve that connects the best set of input to output conversions at different levels of output scale.

[50] Fonterra is not included in this analysis as (1) its scale is much bigger than that of Westland, Open Country and Synlait, and (2) Fonterra has more exposure to value added dairy businesses such as consumer brands and foodservice.

Accordingly, I hypothesise ($IOF\theta_t$ - $Westland\theta_t$) > 0, where the estimated efficiency scores of the IOFs ($IOF\theta_t$) are higher than that of the estimated efficiency scores of the control, Westland ($Westland\theta_t$) (Model 5).

4 Empirical Results

4.1 Financial Ratio Efficiency Assessment

The regression results of the financial analysis regression for Models 1 and 2 are summarised in Table 4-1.

Table 4-1: Financial Ratio Efficiency Assessment of the New Zealand Dairy Industry

	Model 1	Model 2
Intercept	-36% (-14.63)**	-36% (-15.07)**
Coefficient: GDT GDT=0 t <= 2008 GDT=1 t > 2008	13% (3.62)**	11% (3.20)**
Adjusted R^2	0.48	0.42
Sample Size	14	14

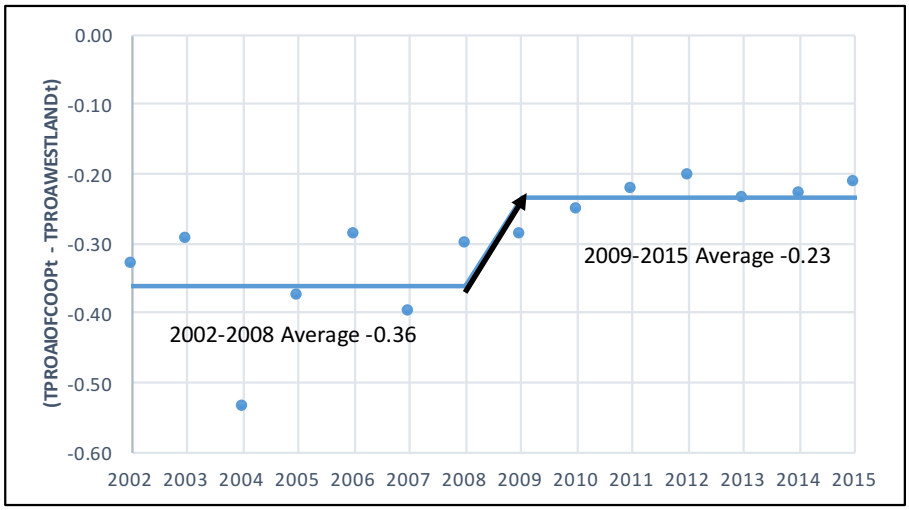
The dependent variable for Model 1 is the relative efficiency measure between the combined IOF and cooperative processing facilities and the control cooperative ($TPROA_{IOFCOOPt}$ - $TPROA_{WESTLANDt}$).
The dependent variable for Model 2 is the relative efficiency measure between Fonterra and its control (Westland) proxied by ($TPROA_{FONTERRAt}$ - $TPROA_{WESTLANDt}$).
The independent variable for Models 1 and 2 is the GDT dummy variable, which has a value of 0 for t <= 2008 and the value of 1 for t > 2008. The t-statistics are in the parentheses. ** means the coefficients are significant at the 1 percent level.

As shown in the regression results presented in Table 4-1, the estimated coefficients of GDT are 13% and 11% for Model 1 and Model 2 respectively, and both are statistically significant at the 1% level. The 13% estimated coefficient suggests that the combined efficiency of the cooperative and IOF facilities in areas where milk is contested is returning 13% more TPROA compared to the TPROA achieved before GDT. The 11% estimated coefficient suggests that the cooperative (Fonterra) where its milk is contested by IOFs has managed to generate a TPROA return that is 11% higher than the TPROA achieved prior to the introduction of GDT.

These results suggest that GDT is efficiency enhancing to the New Zealand dairy industry, as predicted by economic theory.

The efficiency impact of GDT on the combined IOF and cooperative facilities where milk supply is contested as captured in Model 1 is also visually presented in Figure 4-1.

Figure 4-1: Scatter Plot of ($TPROA_{IOFCOOPt}$ – $TPROA_{WESTLANDt}$)



As graphically presented in Figure 4-1, we can see that there is an uplift in the average relative efficiency measured by ($TPROA_{IOFCOOPt}$ – $TPROA_{WESTLANDt}$) in the seven year period 2009 to 2015 compared to the average efficiency in the seven year period 2002 to 2008 in response to the implementation of GDT in July 2008. This visual observation is consistent with the results reported in Table 4-1.

In addition to the regression analysis as per Models 1 and 2 defined above, I also re-ran Models 1 and 2 to include additional independent variables: New Zealand dollar export value per MT of milk powder (MP) products exported, relative dairy to beef prices proxied by dividing MP by New Zealand beef export value per MT (MP/Beef), and relative export dairy

to lamb prices proxied by dividing MP by New Zealand lamb export value per MT (MP/Lamb).[51]

The variables MP/Beef and MP/Lamb are included to control for any potential impact on efficiencies that are due to significant changes in the prices of dairy commodity products relative to the prices of beef and lamb. They are included as sheep and beef farming is regarded as the next best alternative to dairy farming in New Zealand, and any improvement in the relative export prices of dairy to beef and lamb is expected to attract farmers to convert from sheep and beef farming to dairy farming.

MP is included as an independent variable to control for efficiency changes that are driven by changes in international demand and supply of New Zealand dairy commodity products. It is expected that any significant changes in international demand could have a significant impact on the value of New Zealand milk powder products as total milk powder products accounted for more than 50% of New Zealand's total dairy exports.[52]

The results of Models 1 and 2 that include these additional independent variables reveal that the estimated coefficients and the degrees of significance are very similar to the ones reported in Table 4-1. The analysis including the additional independent variables therefore alleviates concerns that the results observed could be explained by changes in international dairy commodity prices or changes in relative prices between dairy and sheep and beef prices instead of the introduction of GDT.

[51] The export pricing and volume data are extracted from Statistics New Zealand's online database.
[52] Estimated using dairy export value and volume data extracted from Statistics New Zealand's online database.

As discussed in the hypothesis development section, I also examined whether the improved efficiency introduced by GDT helps to substantially increase New Zealand's share of global milk production as a cross-check to Model 1 and Model 2. The results of the regression analysis as defined in Model 3 are summarised in Table 4-2.

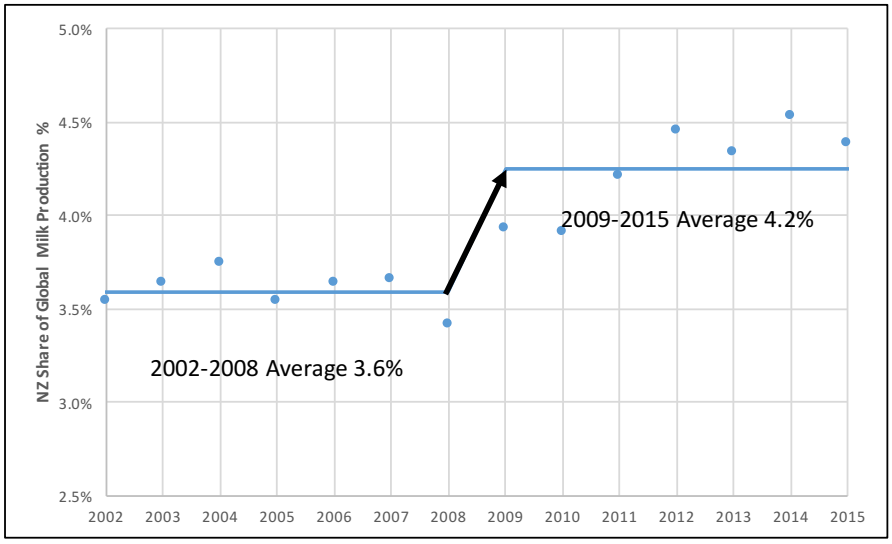
Table 4-2: New Zealand Share of Global Milk Regression

Intercept	3.6% (50.30)**
GDT	0.7% (6.47)**
Adj R^2	0.76
Sample size	14

GDT has a value of 0 for t <= 2008 and 1 for t > 2008. The t-statistics are in parentheses. ** means the coefficients are significant at the 1 percent level.

As shown in Table 4-2, New Zealand's share of global milk production is significantly enhanced by GDT by 0.7%. This result suggests that GDT not only significantly increased the absolute efficiency of the New Zealand dairy industry, but also increased its share of global milk production. Figure 4-2 provides a scatter plot of the data used in the regression analysis to visually illustrate the changes in New Zealand's share of global milk production.

Figure 4-2: Scatter Plot of New Zealand's Share of Global Milk Production 2002 - 2015



The results of the difference in the mean in the TPROA of IOFs and the TPROA of the control cooperative (Model 4) are summarised in

Table 4-3. The results show that IOFs are more efficient than the controlled cooperative at the 5% level, as predicted by the agency theory.[53]

Table 4-3: IOF and Co-op TPROA Efficiency Hypothesis Testing (Model 4)

	IOF TPROA	*Co-op TPROA*
Mean	100.33%	84.02%
Variance	0.07	0.02
Df	6	
t Stat	2.16	
P (T <= t) one-tail	0.04	
t Critical one-tail	1.94	

[53] Because of the small sample size, I also undertook the nonparametric Wilcoxon Rank Sum test. The results indicate that the IOF TPROA is more efficient than the cooperative TPROA at the 10% level.

4.2 DEA Efficiency Assessment Results

Similar to the financial ratio analysis undertaken in the previous section, I used DEA to examine whether there were any differences between IOF and cooperative processing facilities.

The following tables report the results of the technical efficiency (TE) and scale efficiency (SE) scores estimated using the DEA model based on a pooled sample of IOFs and Westland for the period 2009 to 2015 as defined in Model 5 above.

Table 4-4: Technical Efficiencies of IOF and the Control Co-op

	IOF TE	Co-op TE	TE (IOF-Co-op)
2009	100%	100%	0%
2010	92%	100%	-8%
2011	96%	100%	-4%
2012	100%	93%	7%
2013	78%	89%	-11%
2014	100%	97%	3%
2015	83%	71%	12%

Table 4-5: Scale Efficiencies IOF and the Control Co-op

	IOF SE	Co-op SE	SE (IOF-Co-op)
2009	78%	56%	22%
2010	89%	64%	25%
2011	98%	70%	29%
2012	100%	69%	31%
2013	98%	73%	25%
2014	86%	84%	2%
2015	96%	72%	24%

As shown in Table 4-4, there does not appear to be much difference in terms of technical efficiency between IOFs and the control cooperative processing facilities (Westland). However, as shown in Table 4-5, IOF-owned processing facilities have greater scale efficiency than the control cooperative processing facilities.

The hypothesis test based on Model 5 defined above and the efficiency scores estimated for IOF and Westland are summarised in Table 4-6 and

Table 4-7.

Table 4-6: IOF and Co-op Technical Efficiency Hypothesis Testing

	IOF TE	*Co-op TE*
Mean	92.7%	92.9%
Variance	0.01	0.01
Observations	7	7
df	6	
t Stat	-0.04	
P (T <=t) one-tail	0.49	
t Critical one-tail	1.94	

Table 4-7: IOF and Co-op Scale Efficiency Hypothesis Testing

	IOF SE	*Co-op SE*
Mean	92.31%	69.77%
Variance	0.01	0.01
Observations	7	7
Df	6	
t Stat	6.20	
P (T <= t) one-tail	0.00	
t Critical one-tail	1.94	

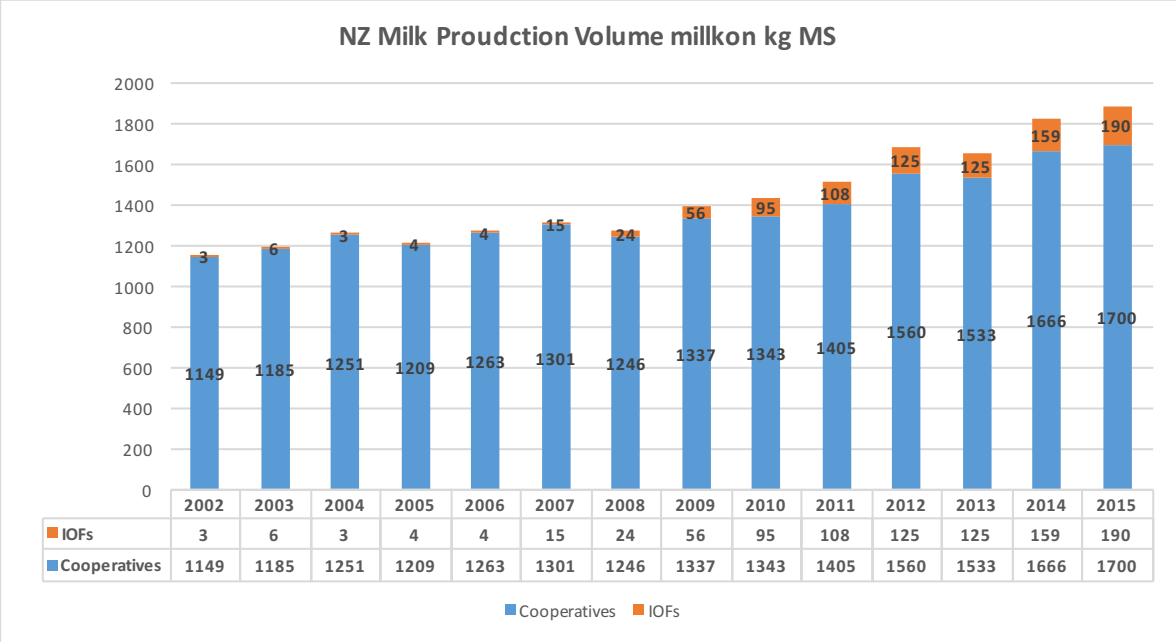
As shown in Table 4-6, there is no significant difference between the IOF and the control cooperative (Westland) processing facilities in terms of technical efficiency. That is, controlling for scale, the IOF and the cooperative facilities are just as efficient in converting two inputs (operating costs and total assets) to one output (total payout before interest and tax).

Consistent with the observation in the DEA results reported in Table 4-5, IOFs are able to achieve better scale efficiency. The estimated t-statistic of 6.2 indicates that the difference in scale efficiency is statistically significant at the 1% level. The difference in the mean scale

efficiency scores shows that, on average, IOFs use 23% less input to deliver the same scale of output as Westland.[54]

The above results show that IOF processors achieve better efficiency than the control cooperative through increasing scale. As shown in Figure 4-3, IOFs processed around 24 million kg of milk solids in 2008 (prior to GDT) and increased to a respectable milk production volume of 190 million kg of milk solids in 2015 (a growth of 166 million kg of milk solids). This spectacular growth took place while the total New Zealand milk pool grew from 1.2 billion kg of milk solids in 2008 to 1.7 billion kg of milk solids in 2015, which is substantially more compared to the growth from 1.1 billion kg in 2002 to 1.2 billion kg of milk solids in 2008.

Figure 4-3: Annual New Zealand Milk Production 2002 – 2015



[54] Similar to Model 4, I undertook the Wilcoxon Rank Sum test to check that the results are consistent using a statistical method that does not require normality assumptions with a large sample size. The Wilcoxon Rank Sum test provides consistent results to the mean differences results reported in Table 4-6 and Table 4-7.

5 Concluding Remarks

In Chapter One, we saw the emergence of IOF dairy processing facilities in response to a substantial reduction in the transaction costs of contract supply because of the introduction of Global Dairy Trade (GDT). The economic rationale underpinning this phenomenon is that farmers choose to enter into a contract with the owners of the processing assets when the contracts can be executed without the risk of the farmers and the owners holding up resources required to fulfil the terms agreed in the contracts.

It is therefore expected that the emergence of IOF processors helps improve efficiencies because:

1. IOFs/Independent processors are less capital intensive than cooperative processing facilities for dairy farmers because, with IOFs, dairy farmers are no longer required to invest in the processing facilities. This not only directly eases the total capital required from New Zealand dairy farmers but also gives farmers options to invest surplus capital in a portfolio of securities other than dairy to help better diversify their exposure;

2. IOF processors are able to be established with lower agency costs associated with less well defined cooperative ownership rights. We saw in Chapter One how the ownership rights in IOFs that are transferable and not redeemable help alleviate the free riding, horizon and control agency problems associated with cooperative ownership rights, which are redeemable and not transferable; and

3. It is expected that incumbent cooperative dairy processors operating in areas where milk is contested by emerging IOF processers will become more efficient in order to secure milk supplied in the local areas.

The contemporary empirical studies reviewed in this chapter have been undertaken to examine the differences in efficiency due to differences in agency costs between IOF and cooperative ownerships. However, these empirical studies reveal mixed results. Some studies show that IOFs are more efficient than cooperatives, while other studies show that cooperatives are just as efficient and, in some cases, more efficient than IOFs. The results vary with data from different time periods, industries and efficiencies estimated using different approaches.

In my empirical analysis, I examined a research question different from prior empirical studies. I examined whether there were any efficiency gains in response to changes from one ownership model to another after a structural change to the New Zealand dairy industry. It is expected that New Zealand dairy farmers would only be willing to voluntarily supply their milk to IOFs when it is in their best interests to do so. It is not about whether one ownership model is better than the other, but which model works better for the farmers in response to a significant change in market conditions. This research objective was achieved by examining the efficiency changes based on a financial ratio analysis approach, with the efficiency measured by total payout before interest and tax return on total assets (TPROA) before and after the introduction of GDT.

In addition to the primary objective of assessing the changes in efficiency in response to the introduction of GDT, I included an evaluation of the relative efficiency between IOFs and

cooperative governance using both the financial ratio and DEA efficiency analyses. The objective of these analyses was to see whether there is any support for the prediction that IOFs are more efficient than their cooperative counterparts, as suggested by the agency cost literature.

The results of my empirical analysis show that:

1. The introduction of GDT improved the efficiency of the combined IOF and cooperative processing facilities (cooperative processing facilities only) by a TPROA uplift of 13% (11%) in areas where milk is contested by both cooperative and IOF processors.

2. New Zealand's share of global milk production significantly increased by 0.7% post-GDT.

3. The IOFs delivered a TPROA that is 16% higher than that of the control cooperative.

4. The IOFs could achieve better scale efficiency than the control cooperative in converting two key inputs (total operating costs excluding milk payment and total assets employed) to one output (total payout before interest and tax).

These results show that the efficiency improvement is not driven solely by IOFs being more inherently efficient than cooperatives or vice versa, but is driven by changes brought in by GDT that incentivises New Zealand dairy farmers to opt for an alternative ownership model where a hybrid of cooperatives and IOFs are adopted. For example, if we believe that IOFs are inherently more efficient to New Zealand dairy farmers, then we would expect IOFs to emerge not long after the removal of the laws and regulations that established the monopoly

dairy producer board (New Zealand Dairy Board) in 2001. Instead, we observed that IOFs became a real alternative supply option only after the introduction of GDT in July 2008.

One has to be cautious with generalising the findings documented in this study. Similar analyses need to be repeated on bigger samples across different geographies and agriculture industries other than dairy. The objective of this study is not to provide an answer to whether one ownership model is better than the other, but to encourage future empirical studies to look into: (1) how changes in market conditions drive changes in alternative governance/ownership models; and (2) how efficiencies can be gained/lost through changes from one governance/ownership model to another in response to changes in market conditions.

6 APPENDIX ONE: Profiles of New Zealand Dairy Processors

This appendix provides an overview of the financial profiles and supply footprints of the New Zealand dairy processors examined in the analysis.

The following tables detail the revenue, operating costs excluding milk prices, and payout before interest and tax for the two cooperatives included in the analysis for the period 2008 to 2015. I have also included compound annual growth rates (CAGR) implied by the financial figures reported in 2008 and 2015.

Table A1.1: Fonterra Financial Overview

Fonterra NZ$ million		2008	2015	CAGR
Ownership		Cooperative	Cooperative	Cooperative
Revenue	R	16,725	18,845	2%
Opex (Excluding Milk)	C	8,457	10,852	4%
Total Payout Before Interest and Tax	P = R-C	8,267	7,993	0%
Total Assets		14,439	18,315	3%

Table A1.2: Westland Financial Overview

Westland NZ$ million		2008	2015	CAGR
Ownership		Cooperative	Cooperative	Cooperative
Revenue	R	429	639	6%
Opex (Excluding Milk)	C	154	289	9%
Total Payout Before Interest and Tax	P = R-C	276	350	3%
Total Assets		326	538	7%

As shown in the above tables, Westland grew at a faster rate than Fonterra in terms of revenue, Opex (operating costs excluding milk), total payout before interest and tax, and total

assets. I also provide a similar financial overview in the table below for the two IOFs (Open Country and Synlait) included in the analysis.

Table A1.3: Open Country and Synlait Financial Overview

NZ$ million		2008 Synlait	2008 Open Country	2008 Combined IOF		2015 Synlait	2015 Open Country	2015 Combined IOF	CAGR
Revenue			109	109		448	688	1136	40%
Opex (Excluding Milk)			19	19		110	158	268	46%
EBIT			-3	-3		26	50	77	
Total Assets			241	241		580	591	1171	25%

In Table A1.3, the information for Synlait in 2008 is not available because its manufacturing facility had just commenced operations at a small scale in 2008 and therefore the financial information before 2009 is not available on the New Zealand Companies Office website.

As shown in Table A1.3, the combined revenue of both Synlait and Open Country grew at a compound annual growth rate of 40% in revenue, and 46% in Opex (operating costs excluding milk); earnings before interest and tax (EBIT) grew from -NZ$3m to NZ$77m. Total assets also grew substantially from NZ$241m to NZ$1.2b. These growth rates are much faster than those of Fonterra and Westland as documented in Table A1.1 and Table A1.2.

In addition to the financial profiles, I also provide a comparison of the supply footprints for the cooperatives and IOFs included in the analysis. The supply footprints are defined as the regional areas of milk supply that are within reach of the respective cooperative and IOF processing facilities. The regional areas are based on the definition provided by Dairy NZ. The percentage of total supply captured in a regional area is proxied by the percentage of the total number of New Zealand dairy cows that are in the local regional area. The information is summarised in Table A1.4.

Table A1.4: Dairy Cow Distribution and Dairy Processing Footprint by Key Production Regions

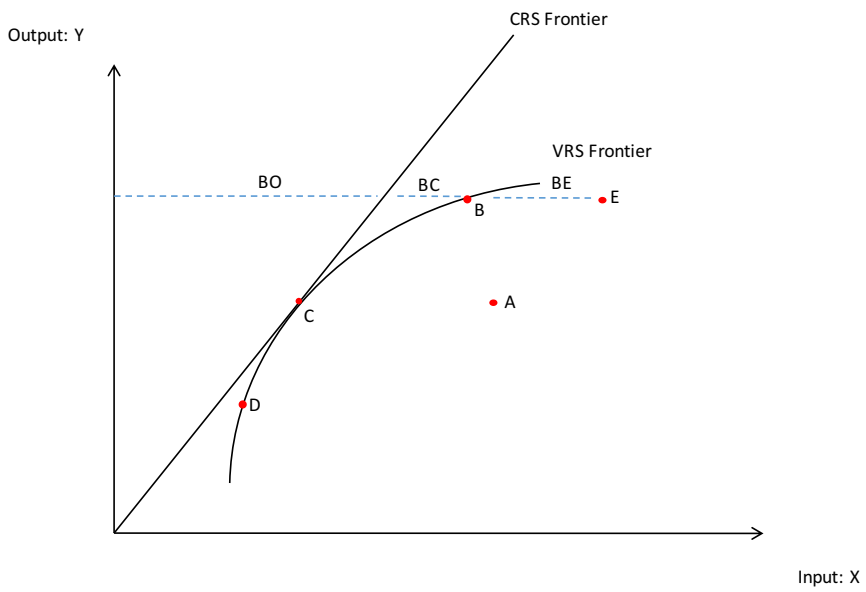
	2008	2008		2015	2015
	Dairy Cows %	Processors		Dairy Cows %	Processors
Waikato	27%	Fonterra and Open Country		23%	Fonterra and Open Country
Taranaki	12%	Fonterra		10%	Fonterra and Open Country
Rest of North Island	30%	Fonterra		27%	Fonterra
Total North Island	**69%**			**60%**	
West Coast	3%	Westland		3%	Westland
Greater Canterbury	13%	Fonterra		18%	Fonterra and Synlait
Otago and Southland	13%	Fonterra		17%	Fonterra and Open Country
Rest of South Island	2%	Fonterra		2%	Fonterra
Total South Island	**31%**			**40%**	
Total Cows million	**4.01**			**5.02**	

As shown in the table above, in 2008, the cooperatives only had one IOF (Open Country) competing for raw milk supply only in the Waikato region. In 2015, the IOFs (Open Country and Synlait) were competing for raw milk supplied in Waikato, Taranaki, greater Canterbury, Otago, and Southland. These regions where there are both IOF and cooperative processing facilities have 68% of New Zealand's total dairy cows. This implies that in 2015 IOFs were able to access 68% of milk supplied compared to 27% in 2008.

7 APPENDIX TWO: Data Envelopment Analysis (DEA) Model

Before I formally define the input orientation model adopted, it is important to first clarify the types of efficiencies that I am trying to measure and how they relate to one another.

Figure A2.1: Input Orientation DEA Model



In Figure A2.1, two efficient frontiers are estimated using input orientation DEA analysis to estimate the best possible input to output combinations for four decision making units: A, B, C and D. In the chart, there is one input "X" and one output "Y". The two frontiers estimated are the constant return to scale (CRS) frontier and the variable return to scale (VRS) frontier.

The CRS frontier assumes that all decision making units are able to adjust their scale to the most optimal conversion of input to output based on the combination of the input to output achieved by all decision making units included in the analysis. The VRS frontier, on the other hand, assumes that there are practical constraints inherent in all decision making units which

make it difficult for decision making units to achieve the best possible input to output combinations through changing scale. The VRS frontier assumes that there are different levels of best possible input to output combinations at different scales. It is therefore observed that the VRS frontier is a convex envelope shape, as illustrated in Figure A2.1.

The level of efficiency achieved by each decision making unit is measured by the relative distance between the unit of input X each decision making unit is using to the unit of X used by the efficiency unit defined by the frontier to deliver the same unit of output Y. For example, the degree of efficiency achieved by the decision making unit E is measured by the relative distance of X between E and B on the VRS efficient frontier. Accordingly, the VRS efficiency E is able to achieve is therefore (BO+BC)/(BO+BC+BE).

Similarly, decision making unit E's efficiency score relative to the efficiency unit estimated based on the CRS frontier is measured by the relative distance of BO/(BO+BC+BE).

Coelli (1996) defines the relative distance between decision making unit E to that of CRS total technical efficiency. That is, the total technical efficiency for E is estimated by BO/(BO+BC+BE). The relative distance between E and that of VRS frontier ((BO+BC)/(BO+BC+BE)) is defined by Coelli (1996) as pure technical efficiency (TE). It is regarded by Coelli (1996) as pure technical efficiency because, since there are practical constraints that prevent each decision making unit from adjusting its scale in the short run, then the relative distance between E and that of the VRS frontier is the best that the decision making unit E could achieve without the flexibility of adjusting its scale.

Coelli (1996) defines the relative distance between the input used by the decision making units on the VRS frontier and the decision making units on the CRS frontier delivering the same level of output as a measure of scale efficiency (SE). That is, for decision making unit E, SE is measured by BO/(BO+BC).

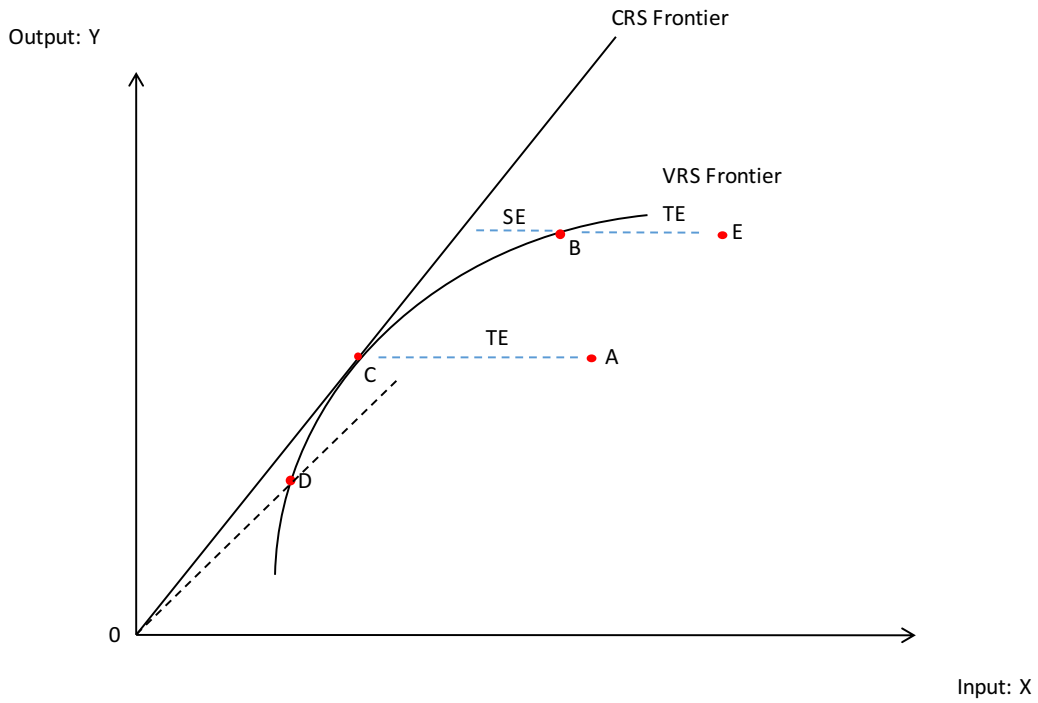
Accordingly, total technical efficiency can be decomposed into TE and SE. That is:

Total Technical Efficiency = TE x SE

- ⇨ Total Technical Efficiency of E = (BO+BC)/(BO+BC+BE) x BO/(BO+BC)
- ⇨ Total Technical Efficiency of E = BO/(BO+BC+BE)

Coelli (1996) suggests that there is scope for increasing returns or decreasing returns to scale on the VRS efficient frontier. That is, a decision making unit on the VRS frontier, operating at an efficiency level that is lower than the one implied by the CRS frontier, has the capacity to increase its efficiency by changing its scale measured in terms of output Y. This is illustrated in the following chart.

Figure A2.2: Increasing Return to Scale

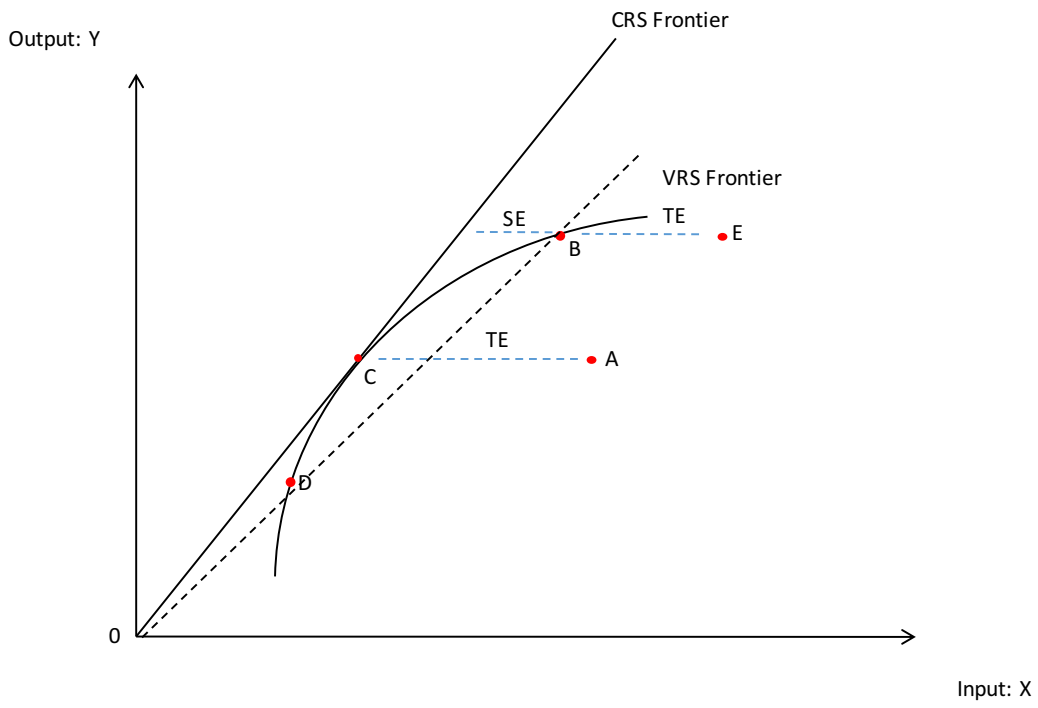


As shown in Figure A2.2, decision making unit D on the VRS frontier has the potential to increase its efficiency by increasing its scale of output Y to the output level achieved by the decision making unit C. The slope of the line 0D can be increased to 0C through changing the output level towards that of C. Accordingly, the decision maker D is operating at lower scale efficiency compared to the scale efficiency achieved by C.

Likewise, the decision making units operating on the VRS frontier at output levels that are higher than the output achieved by C are operating with decreasing returns to scale. This definition of decreasing returns to scale is visually presented in the chart below.[55]

[55] For example, in the context of the New Zealand dairy industry, the increasing return to scale can be achieved by growth in milk solids processed by IOFs investing in more technologically advanced milk processing facilities.

Figure A2.3: Decreasing Return to Scale



As shown in the chart, decision making unit B is operating at a lower scale efficiency to C. That is, the slope of 0B is lower than that of 0C. B is able to achieve improved scale efficiency by reducing its output level towards that of C. This observed difference in scale efficiency between B and C is defined by Coelli (1996) as decreasing return to scale efficiency.

Based on the above definition of total technical efficiency, pure technical efficiency and scale efficiency, the following is the formal CRS linear programming model developed by Coelli (1996).[56]

Minimising $_{\theta,\lambda}$,θ

such that $-y_i+Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$\lambda \geq 0$,

$\theta \geq 0$,

where the notations are defined as:

1. There is data on K inputs and M outputs on each of N decision making units (DMUs);
2. For the i-th DMU these are represented by the vectors x_i and y_i;
3. Y is M x N output matrix and X is K x N input matrix;
4. θ is a scalar and λ is a Nx1 vectors of constants and the value of θ is the efficiency score for the i-th DMU.

For the VRS model, the above CRS model is modified by adding the convexity constraint: $N1'\lambda=1$ to provide:

Minimising $_{\theta,\lambda}$,θ

Such that $-y_i+Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

[56] For example, in the context of the New Zealand dairy industry, the decreasing return to scale is a result of milk solids processed by the incumbent cooperative's outdated processing facilities. Improved efficiencies can be achieved by reducing milk volumes processed by the outdated processing facilities.

$N1'\lambda=1$

$\lambda \geq 0,$

$\theta \geq 0,$

where all the notations adopt the same definition of the CRS frontier model.

The constant return to scale (CRS) model adopted is largely based on the seminal DEA work by Charnes, Cooper, and Rhodes (1978), who were the first to introduce data envelopment analysis by capturing the input to output relationship through estimating the best performing unit frontier.

The variable return to scale (VRS) model adopted has been developed based on the work of Banker, Charnes, and Cooper (1984). The model has been developed by modifying the constant return scale model developed by Charnes, Cooper, and Rhodes (1978).

I have adopted the above CRS and VRS models defined by Coelli (1996) in the empirical efficiency analysis of the impact of GDT on the New Zealand dairy industry. The mathematical computation of the models adopted were undertaken using the DEA computer software developed and provided by Coelli (1996).[57]

[57] DEAP Version 2.1 developed by Coelli (1996).

CHAPTER THREE

Theory of the Firm: A Case Study of the China Melamine Milk Crisis

PREFACE

On a hot Shanghai Saturday morning on the 2nd of August 2008, I got up early, planning how I would spend my weekend relaxing after weeks of busy business travel. My plan was immediately interrupted by many missed calls and text messages from Mr. Liu, the vice chairman of Shijiazhuang San Lu Dairy Limited (Sanlu). I called back promptly, and, over the phone, Mr. Liu told me that they had learnt from their laboratory that a substance called melamine had been found in the raw milk Sanlu collected from local dairy farmers, and the substance was causing health issues to the babies drinking Sanlu infant formula milk. I grabbed a taxi to my boss Bob Major's residence in Shanghai and updated him on the conversation I had with Mr. Liu. This sets the beginning of my first-hand experience of the China melamine milk crisis: I was on the Fonterra crisis management team based in Beijing and Hong Kong, which was an interim leadership team responsible for managing the various on-the-ground public relations, product quality, regulatory, and financial issues associated with Fonterra's 43% investment in Sanlu, as well as capturing and documenting Fonterra's learnings from the crisis. This research is my best attempt at using the theory of the firm to explain changes in the ownership/governance structure of dairy assets through which the milk transacted in China brought about the melamine milk crisis.

1 Introduction

In the three decades prior to August 2008, the Chinese dairy industry managed spectacular growth in milk production, enabled by a rapidly growing domestic raw milk market. The growth in domestic milk supply was facilitated by dairy companies migrating from a local government-facilitated integrated cooperative supply model to milk supply that was secured using contracts. China's milk production grew from just slightly less than 1 million MT in 1978 to 35 million MT in 2007, and, at the same time, dairy livestock grew from 475 thousand cows in 1978 to 12 million in 2007. This phenomenal growth in milk supply secured through contract was required to support the exponential growth in China's dairy demand, which led to the creation of one of the world's largest raw milk markets. The Chinese raw milk market was generally perceived to be functioning well until August 2008 when it was discovered that it had failed to deliver milk that was safe for human consumption.

The milk quality failure was the result of dairy farmers and milk traders adding a substance called melamine, which helps boost the percentage of protein in the milk, when the milk is collected and tested. In a way, melamine in the milk can be regarded as a "fake protein" and it enabled the dairy farmers and milk traders to increase the volumes of their milk sold at a very low cost. The dairy farmers and milk traders were able to convert their raw milk into larger volumes by adding water and melamine to their milk, therefore increasing their revenues and profitability. However, this was achieved at a significant cost of the health of 300,000 children and the lives of six babies in China.[58]

[58] "China dairy products found tainted with melamine", BBC News, 9 July 2010.

Since the crisis, there have been many studies that have sought to understand the reasons for the crisis from: (1) a food safety and regulatory perspective; (2) a business ethics perspective; and (3) a supply chain economics perspective. However, none of these studies analyse the issue from a theory of the firm perspective: (1) why did Chinese dairy companies voluntarily migrate from integrated local government-facilitated dairy cooperatives to investor-owned dairy firms (IOF) that secure milk using contracts?; and (2) why did contract supply of milk work well for a long period of time but fail in 2008? The observed failures in securing milk using contracts are also seemingly in conflict to the findings of Chapter One and Chapter Two of this thesis, which document significant efficiencies gained on the emergence of the contract supply model enabled by the introduction of Global Dairy Trade (GDT). Does the melamine milk crisis imply that contract supply of milk to IOF dairy companies using the market price mechanism is not an efficient way of securing milk?

In response to: (1) the observed lack of understanding of the crisis from the theory of the firm perspective; (2) my personal interest in documenting the learnings from the crisis, given my hands-on involvement; and (3) my research interest in the relative efficiencies between securing milk through integrated cooperative governance, and through contract supply using the market price mechanism, I analyse the factors leading up to the world's largest milk market failure, and the impact of the observed market failure on the dairy market governance model that evolved in response to the crisis. More specifically, in this chapter, I aim to address the following questions:

(1) What factors contributed towards the Chinese dairy industry shifting voluntarily to a model of market governance using contract supply instead of a model of integrated

cooperative governance?

(2) Did the contract supply model of milk production work properly before milk quality was compromised by the addition of melamine? If it worked in the past, then what were the factors contributing to its failure?

(3) Did the Chinese dairy industry abandon contract supply to IOFs and migrate towards a vertically integrated supply model, such as cooperative ownership, as a solution to the milk market failure? If it did not, then what changes were made so that the milk market is functioning again?

This chapter is structured as follows. The second section reviews studies that have been undertaken to understand the China melamine milk crisis from food safety, regulatory, business ethics, and supply chain perspectives. The third section provides an overview of: (1) the factors contributing to the creation of one of the world's largest raw milk markets, and (2) the factors contributing to the melamine milk crisis that undermined the efficiency of China's raw milk market. The fourth section provides an analysis of how the Chinese dairy industry responded to the melamine crisis using the theory of the firm framework. The fifth section concludes.

2 Review of Studies on the China Melamine Milk Crisis and Research Implications

In this section, I provide a literature review of the contemporary studies on the impact of the China melamine milk crisis from food safety, regulatory, business ethics, and supply chain perspectives and follow with an assessment of the gaps in the literature that need to be filled, which motivate the remaining parts of this research.

2.1 Review of Studies on the China Melamine Milk Crisis

Chan and Lai (2009) examined the China melamine milk crisis from a food technology ethics perspective. They suggest that ethics underpinning food production helps to ensure socially acceptable outcomes through a norm of "social contracts." They define social contracts as "unwritten agreements between members in a community, having a binding effect on legal governance, community order and social cooperation."[59]

Chan and Lai (2009) ascribe the observed China melamine milk crisis to a lack of education on food technology used in milk production, as most of the dairy farms involved in the crisis were small-scale, labour intensive, and lacked capital in their operations. "Small-scale farmers have usually received little education on formal farming and husbandry practices; they might have thought that mixing certain 'magic' chemicals (e.g., melamine) and preservatives could make it more nutritious and longer lasting, thus rendering it more profitable, with little understanding of the severity of the problem caused by their actions."[60] Such lack of understanding compromises the ethics underpinning the effectiveness of social contracts. In response to rapid food technology advancement, Chan and Lai (2009) conclude that there is a

[59] Chan and Lai (2009), 370.
[60] Chan and Lai (2009), 372.

need for a more integrative understanding of food science and technology to facilitate more suitable ethical practices.

Xiu and Klein (2010) examined the China melamine crisis from a food safety regulatory perspective. They attribute the crisis to "a rapid growth fuelled by large investments from multinational dairy firms, development of a highly modern and concentrated processing sector that obtains its raw materials from millions of small, poor and uneducated traditional farmers and government support, and encouragement for growth, but with little emphasis on inspection and safety issues."[61]

In addition to the call for the Chinese government to address the crisis with food safety policies and regulations, Xiu and Klein (2010) suggest the following measures be put in place to help prevent another similar food safety crisis: (1) the use of farmer associations to help strengthen the internal supervision of the quality of the milk supply; (2) the use of moral persuasion to educate the farmers and other key stakeholders throughout the supply chain about the serious health impact of milk contaminants on consumers; and (3) the use of transparent decision making and product quality information from processing companies, and making this information available to farmers so that they know the impact of milk quality on the products consumed.

Enderwick (2009) examined the China melamine milk crisis from a market quality failure perspective. Enderwick (2009) looked into whether the quality failure associated with the milk contamination could have been foreseen and therefore avoided, and the best transaction model that could have been adopted to avoid such quality failure. Enderwick (2009)

[61] Xiu and Klein (2010), 463.

concludes that the quality failure could have been foreseen by observing the operating environmental conditions in which the Chinese dairy industry operated at the time: "a fragmented industry, inefficient supply conditions, perverse incentives, pervasive government intervention and widespread corruption."[62] Enderwick (2009) suggests that China will likely go through another similar quality failure if the observed market conditions continue, and further research should be focusing on the appropriate mix of responses to another similar market quality failure.

Enderwick (2009) also examined the observed milk quality failure based on a model that determines whether raw milk sourcing should be transacted on contracts or integrated using firm governance that takes into account the following factors: the uncertainty of the price, volume and quality of raw milk supply, and the possibility of buyers and sellers behaving opportunistically in the transaction. In Enderwick's model, dairy processers are more likely to secure their milk supply through contracts when there is a low level of uncertainty associated with quantity, price, and quality of the raw milk supply and low likelihood of opportunism by parties engaged. Alternatively, if the price of the milk is highly volatile and there is high chance of contracting parties acting opportunistically, then the milk supply is likely to be integrated.

Gale and Hu (2009) also suggest that the Chinese dairy industry has been able to grow substantially, with milk production growing from just over 1 million MT in 1980 to over 35 million MT in 2007, on the back of millions of small-scale dairy farmers with a farming scale of 1 to 20 cows per farm. This model persisted until 2008, when it became clear that these

[62] Enderwick (2009), 232.

fragmented small-scale farms were no longer able to supply milk that met acceptable standards.

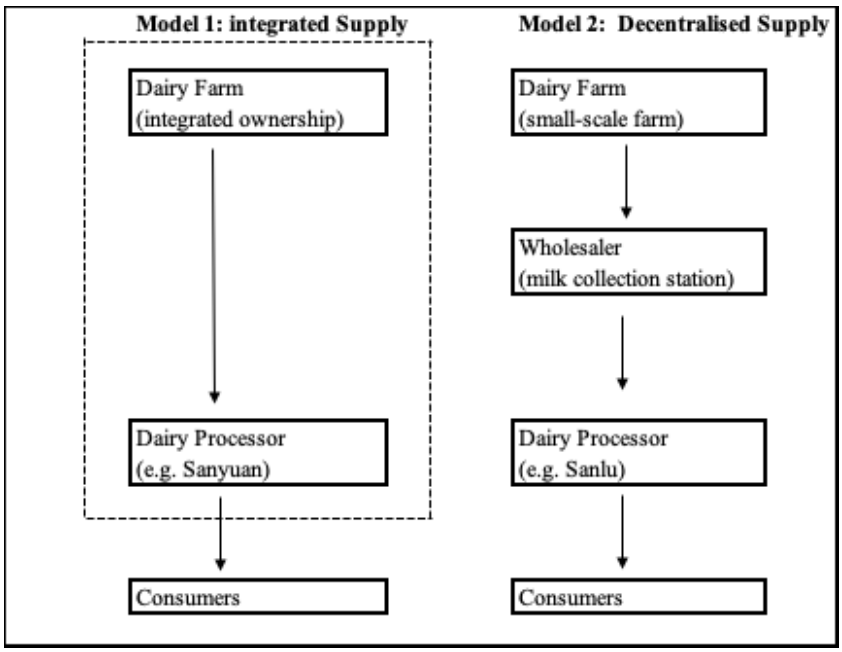
Gale and Hu (2009) attribute the observed milk quality problem to a lack of control and incentives in the fragmented supply model. This model involved many small-scale farmers supplying to large-scale dairy companies, which had a dominant market position and scale to give them unfair advantages on the price paid to small-scale dairy farmers. These fast growing, large-scale dairy companies grew on the network of milk traders, village milk supply stations, and over two million small-scale farms operating in some of China's most remote and least developed regions.[63]

Gale and Hu (2009) suggest that the quality issue (due to the observed fragmented supply from small-scale farmers) can be addressed by: (1) vertically integrating milk supply into the dairy companies; (2) allowing central and local government intervention to control and regulate the prices paid by the large-scale dairy companies; and (3) forming milk supplier cooperatives to increase dairy farmers' market power. However, Gale and Hu also highlight that the implementation of these actions needs to be thought through carefully, as they could introduce other unwanted costs while addressing the milk quality issue.

Chen, Zhang and Delaurentis (CZD) (2014) examined the crisis from a quality control and food supply chain perspective by comparing and contrasting the following two alternative Chinese milk supply models.

[63] Gale and Hu (2009), 1.

Figure 2-1: Alternative Supply Models[64]



In Model 1, the dairy farming operation is integrated into the dairy processor, whereas in Model 2, the processor purchases milk from farmers using contracts. CZD suggest that integration in Model 1 can be achieved through integrating the ownership of the farming assets into the dairy processors, and it could also be achieved by other arrangements such as joint ventures, or any other arrangements such that the joint profit of the vertically integrated dairy operation is maximised.

CZD suggest that in a situation where milk testing and quality monitoring are difficult and costly, and when there is a margin squeeze imposed on the small-scale dairy farmers driven by large-scale dairy processors, then the decentralised supply model involving small-scale dairy farmers supplying through layers of "middlemen" such as milk collection stations and milk traders would result in an inferior quality of raw milk supplied to the dairy processors. The perverse incentives are created by the milk quality information asymmetries between the

[64] Chen, Zhang and Delaurentis, 189.

large-scale dairy processors and fragmented small-scale dairy farmers supplying through a layer of milk collection stations.

2.2 Learnings from Past Research and Remaining Questions

The above studies on the China melamine milk crisis indicate that: (1) a lack of education and awareness on business ethics, (2) a lack of regulatory monitoring and control of the fragmented small-scale dairy farmers, and (3) the scale mismatch between small-scale dairy farmers and large-scale dairy companies, have contributed to the China melamine milk crisis. These studies, however, do not tell us:

1. Why did large-scale Chinese dairy companies choose to secure raw milk supply through contracts with small-scale dairy farmers? They could have, for example, opted to obtain their supply through a cooperative arrangement. What were the market conditions that incentivised the China milk market to grow from less than 1 million MT in 1978 to 35 million MT in 2007, a year before the melamine milk crisis hit, using mainly a contract supply model? and

2. What was the market's response to the crisis, at the time, and in subsequent years? It is important that we learn from how the market responded to the crisis to understand if it is likely to have succeeded at addressing the issues that contributed to the milk market failure. For example, did the dairy industry adopt a centralised supply chain approach to minimise similar crises from happening again in the near future, as proposed by CZD? If it did not adopt the suggested centralised approach, then how has the decentralised approach been corrected to prevent a similar crisis from happening again?

The above observations of the studies on the China melamine milk crisis reveal that one fundamental question has not been addressed: why did contract supply of milk using the

market work for a period of time but stop working around the time of the melamine milk crisis? This is exactly the type of question that motivated Coase (1937) to understand why there are times in which firms would purchase key factors of production using the market price mechanism, and times in which firms would internalise the key factors of production. Coase (1937) explains that firms would be willing to internalise instead of contract their key factors of production using the market when there is a significant cost involved in doing so. For example, if there is only one buyer and one seller of raw milk in China, and it is difficult for each to determine what the market price should be each time the milk is transacted, then it is likely that the buyer and the seller of milk would end up merging and integrating their assets into a common firm ownership and governance.

In Chapter One, I demonstrated how the theory of the firm, built on the work of Coase (1937), helps us understand the development of the New Zealand milk market, which came from an almost 100% vertically integrated milk supplied through cooperative ownership to a rapidly growing milk market using contracts. The theory helps us understand how the New Zealand dairy market participants responded to a one-off reduction in the cost of transacting milk using contracts, enabled by the implementation of Global Dairy Trade (GDT). In this chapter, the same approach is adopted to understand how the China dairy market participants responded to a one-off milk safety crisis, which significantly increased the costs of transacting milk using contracts.

3 The Rise and Fall of China's Raw Milk Market

3.1 Chinese Economic Reform and Creation of the Chinese Milk Market

In 1978, the leader of the Chinese Communist Party, Deng Xiaoping, introduced a series of policies and regulations that significantly changed the way economic activities were conducted in China. The newly introduced policies, which were known as the "Chinese economic reform", migrated China from a planned economy towards a market economy. This reform also changed the way the Chinese dairy industry was structured and transacted.

Prior to the Chinese economic reform, the dairy industry operated through local government-owned dairy farms and processing factories. The assets engaged in: (1) the on-farm production of milk; (2) the collection and processing of milk into consumer dairy products; and (3) the sales and distribution of consumer dairy products to local consumers, which were entirely owned by local municipal governments or bureaus. Such ownership ensured that the assets were collectively owned by the people, which included local dairy farmers, dairy factory workers and local consumers. The Chinese dairy industry was therefore structured in a way that was similar to a cooperative, in which the assets used in delivering the products and services were owned by consumers (consumer cooperatives) or suppliers (supplier cooperatives). Under this structure, the production of milk and dairy products was completely integrated throughout the supply chain.

After the implementation of the Chinese economic reform, the possibility of dairy businesses transacting through a decentralised governance model became a reality. The newly introduced policies enabled the local government-owned integrated dairy cooperatives to become investor-owned companies, where the underlying milk production, processing, and sales and distribution assets were no longer required to be collectively owned by the local dairy farmers, factory workers and consumers through a local government-facilitated cooperative

ownership.[65] This change enabled the dairy industry to grow through: (1) issuing shares to outside investors, which enabled them to have better access to capital; and (2) securing milk supply from dairy farmers who did not have any ownership interest in the dairy companies.

The creation of Shijiazhuang Sanlu Dairy Limited (Sanlu) is a good example of the transition enabled by the Chinese economic reform described above. Sanlu started in 1956 as a local Shijiazhuang government-facilitated dairy cooperative, which was initiated by 18 local dairy farmers. The cooperative was known as Xinfu Dairy Producer Cooperative in the local Shijiazhuang area. The cooperative grew into an integrated dairy business with a dairy processing factory and 300 employees at the time when the Chinese economic reform was implemented.[66]

The Sanlu producer cooperative experienced substantial growth after the Chinese economic reform, and the rapid growth required substantial amounts of capital investment. As a vertically integrated dairy cooperative, Sanlu needed additional capital to invest in increased on-farm milk production capacities, increased milk collection and processing capacities, and increased sales, marketing and distribution capabilities to serve not only the local consumers, but consumers throughout China. The producer cooperative ownership structure made it difficult to achieve growth as: (1) it needed capital to invest in the entire value chain in order to remain vertically integrated; and (2) the cooperative ownership limited the extent to which Sanlu is able to grow by issuing shares to outside investors who were not members of the

[65] Note that the way most Chinese dairy cooperatives are defined is different to that of New Zealand dairy cooperatives. New Zealand dairy cooperatives are supplier cooperatives where the dairy farmers own the on-farm production assets and jointly own milk collection and processing assets through a cooperative member ownership. Chinese dairy cooperatives have full ownership of both the on-farm production assets as well as the milk collection and processing assets, and the assets are jointly owned by the suppliers and local consumers through local municipal government ownership.

[66] The figures are extracted from Tian and Li (2006), 67.

cooperative. In response to these constraints, Sanlu embarked on a process of demutualisation: transitioning from a local government-facilitated cooperative to an investor-owned dairy company.

Sanlu achieved its transition from cooperative to investor-owned dairy company by a capital restructuring initiative in the mid 1980s: "cows go into the villages and milk comes into the cities."[67] This initiative transitioned ownership of the dairy cattle from the cooperative to the local dairy farmers. For the farmers who did not have sufficient capital to pay for the dairy cattle transferred, the cooperative would provide loans, and repayments were made by deducting a percentage of the milk price the dairy farmers received from the cooperative. When the loan was paid in full, the local dairy farmers gained full ownership of the dairy cattle transferred.

This transition took the pressure off Sanlu's balance sheet each time it grew by raising debt and equity from outside investors. At the same time, it also helped ease the capital required from dairy farmers if they wanted to increase their milk supply to Sanlu. In the producer cooperative model, the dairy farmers were not only required to invest in the dairy cattle, but were also required to invest in the collectively owned producer cooperative.

The contract supply to independent dairy processor model initiated by Sanlu was also widely adopted by many other Chinese dairy companies. For example, two of the largest and fastest growing Chinese dairy companies, Yili and Mengniu, also adopted a similar contract supply model to secure the milk needed to fulfil rapid growth in the demand for their consumer dairy products.

[67] Tian and Li (2006), 67

Figure 3-1: China's Milk Production and Cattle Population[68]

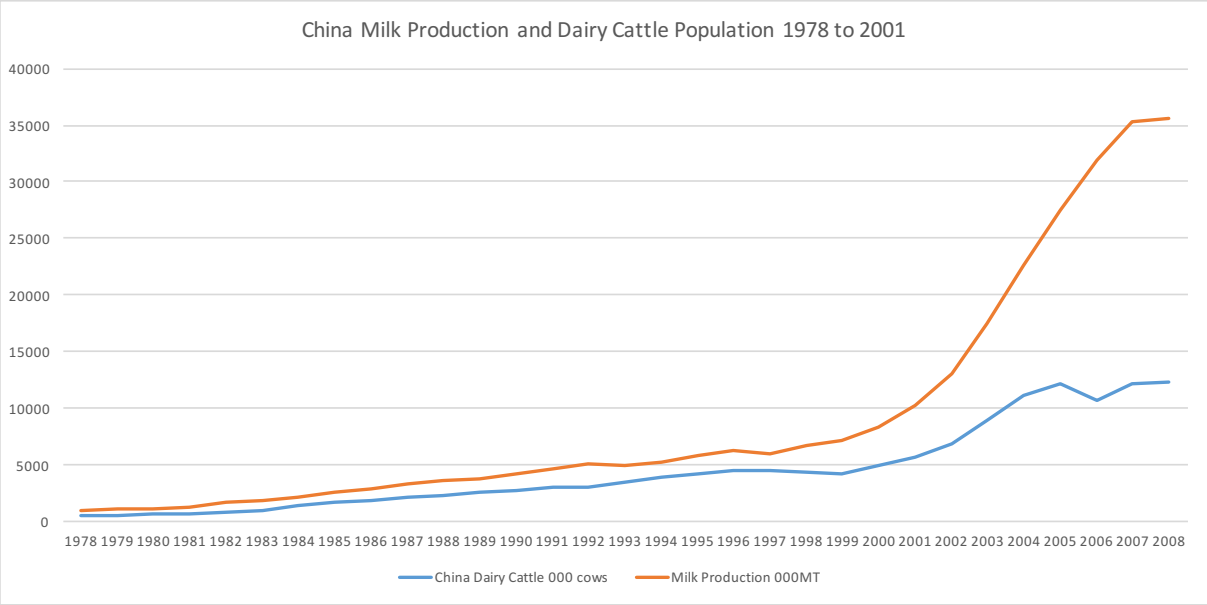
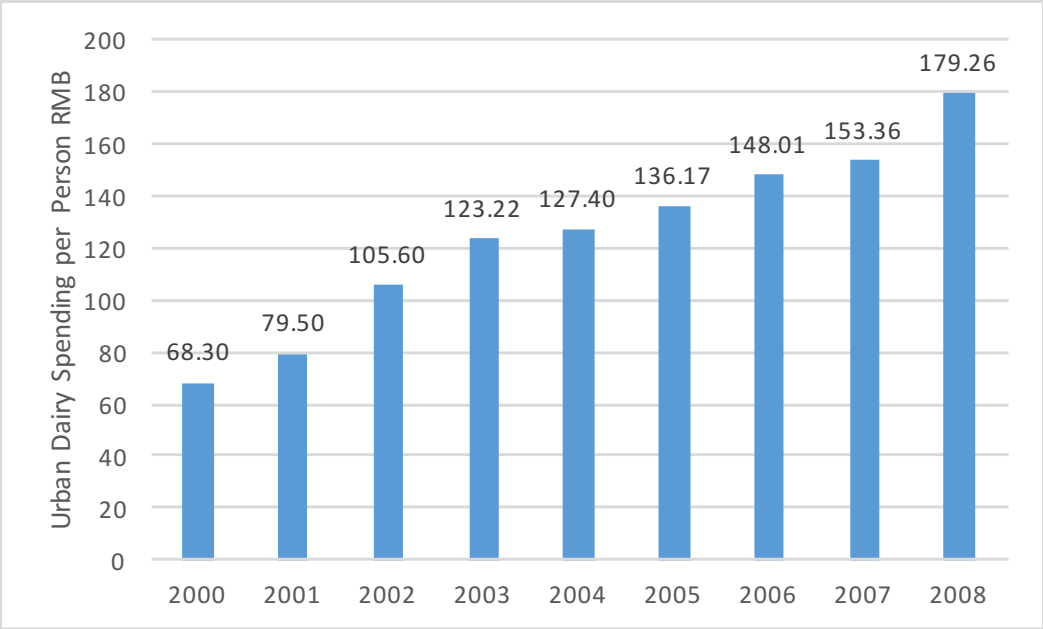


Figure 3-1 shows the growth in the volume of milk production for the thirty-year period starting in 1978, the year in which Deng Xiaoping initiated the Chinese economic reform, to 2008, the year in which the China melamine milk crisis took place. China's milk production grew from 1 million MT in 1978 to 36 million MT in 2008. In the same period, China's dairy cattle grew from 475 thousand cows in 1978 to 12 million cows in 2008.

The rapid growth in milk production was required to fulfil the exponential growth in Chinese consumers' appetite for dairy products. As shown in Figure 3-2, the inflation adjusted annual spending on dairy products per urban person grew from RMB68.3 in 2000 to RMB179.26 in 2008, equivalent to a compound annual growth rate of 13%. Over the same period, the urban population grew from 459 million in 2000 to 624 million in 2008, which led to a rapid increase in demand for milk.

[68] The dairy cows cattle and milk production figures are sourced from China Dairy Annual Statistics 2015 (中国奶业年鉴 2015).

Figure 3-2: China's Urban Dairy Consumption[69]



Most milk growth in this period was realised on the back of milk supplied through a contract supply model, which enabled dairy farmers to increase their milk production without requiring them (or the local government on behalf of the local farmers) to invest in downstream milk processing assets. At the same time, the contract supply model allowed dairy companies to invest in downstream milk processing assets without the need to invest in on-farm production assets. The end result is that supply was able to grow rapidly to support the exponential growth in China's dairy demand.

3.2 Threats to China's Milk Market Efficiency

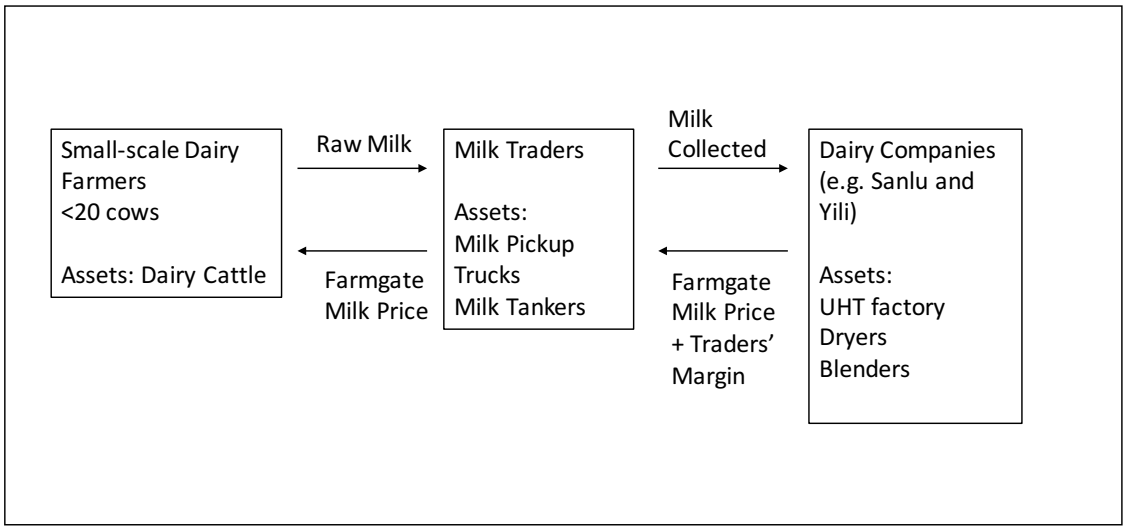
In the beginning, the growth in contract milk supply largely came from the dairy farmers who used to be local cooperative members. These dairy farmers worked closely with ex-cooperative dairy companies and had established relationships with the owners and managers of these dairy companies. However, as large volumes of milk were required to support the

[69] The diary consumption per urban person is extracted from China Dairy Annual Statistics 2014 (中国奶业年鉴 2014) and the inflation data is extracted from China Statistic Bureau website.

rapid growth in Chinese dairy demand, the milk supply base expanded beyond the original cooperative farmers. More and more new farmers started to supply to the dairy companies, which were growing in high speed. Most of these farmers were small-scale farmers with a dairy herd of less than twenty in their back yards, which made it difficult for the dairy companies to have a close relationship and deep knowledge of their supply base. The large number of small-scale dairy farmers created a need for a "facilitator" to bridge the gap between the growing large-scale dairy companies and the fragmented small-scale dairy farmers. This need gave birth to milk traders who specialised in managing and coordinating milk collected from small-scale dairy farmers on behalf of large-scale dairy companies.

The supply relationship managed and coordinated through milk traders is summarised in Figure 3-3.

Figure 3-3: China's Contract Supply Model[70]



[70] This chart also shows how the value chain evolves from dairy companies paying direct to small-scale dairy farmers and capturing all the related margins, to the value being captured through milk trading organisations (milk traders) that exist to help manage and coordinate the fragmented small-scale supply base. The margins are now divided between milk traders and dairy companies.

As shown in Figure 3-3, the milk traders invested in the assets used in milk collection and storage to help dairy companies coordinate and manage fragmented small-scale dairy farmers. This relationship can also be viewed as the large-scale dairy companies outsourcing their milk supply management to the milk traders. This emerging supply model had a profound impact on the economics of contract supply of milk in China in the following ways:

1. Small-scale dairy farmers supplying through milk traders created information asymmetry

In the early stage of the dairy cooperatives' transition to investor-owned dairy companies, the dairy farmers had a close relationship with the ex-cooperative dairy companies, as the dairy companies were sourcing from the same group of local farmers who had been members of the local cooperatives, and the dairy companies also provided finance to dairy farmers purchasing dairy livestock. Such a close relationship helped minimise exposure to information asymmetry.

However, as the local dairy cooperatives grew quickly to become large-scale dairy companies producing and supplying dairy products to consumers throughout China, the local dairy farmers were unable to keep up with the rapid growth in the volume of milk required. Many new small-scale dairy farmers from nearby counties joined, and the contractual relationship between the fragmented, small-scale dairy farmers and large-scale dairy companies was managed through milk traders. The information flow between the small-scale dairy farmers and large-scale dairy companies was not as transparent as before, which gave rise to information asymmetry, increasing the likelihood of small-scale dairy farmers and large-scale dairy companies trying to take advantage of each other using their respective information advantages.

2. Low cost, small-scale dairy operations attracted "free riders"

The small-scale farming practices did not require much up-front capital investment. In many cases, farmers just needed to secure a minimum of two or three dairy cattle in their backyards to become suppliers to dairy companies through milk traders, giving them the flexibility to enter and exit the market relatively easily. At the same time, the milk quality of these small-scale farming operations was collectively managed through milk traders. As a result, it was difficult for the large-scale dairy companies to track and trace milk quality to the individual farm level, which incentivised opportunistic small-scale dairy farmers to join when the milk price was relatively high compared to their alternative farming activities, and to exit when it was low. This flexibility allowed them to be dairy farmers, without having to invest in the on-farm milk quality control practices that would reward them in the long run.

3. Lack of incentive for milk traders to invest in milk quality testing and control assets

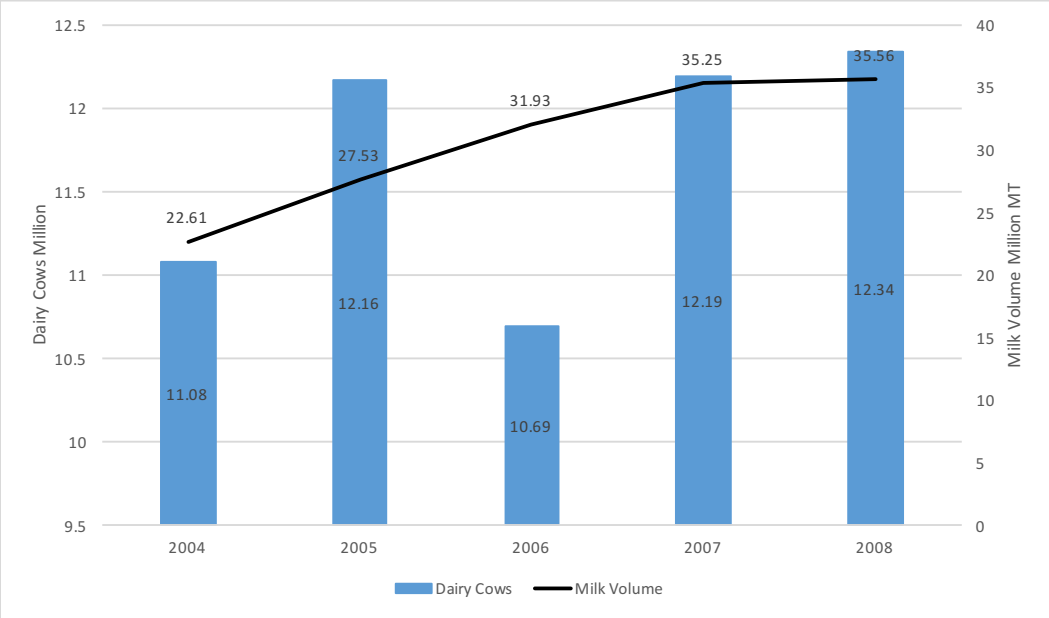
As shown in Figure 3-3, the milk traders were responsible for coordinating and collecting milk supplied by the small-scale dairy farmers and were rewarded by the large-scale dairy companies with traders' margins. Should the diary companies not accept the milk, then the traders would not pay the farmers for the milk rejected. The milk traders' exposure to the transaction was simply the margins forgone on the milk rejected, which did not give traders much incentive to make the capital investment in the milk quality testing and control assets required to ensure that the milk was of good quality when it was collected from the farm gate.

3.3 The Events Leading up to China's Milk Market Failure

The above threats to the contract supply model became imminent in 2006, with many dairy farmers having to reduce their dairy herd in response to a substantial reduction in their on-

farm profitability. Based on industry reports at the time, this reduced on-farm profitability was due to a combination of high feed costs, flat farmgate milk prices and excess supply of milk to the dairy companies, which led to many dairy farmers dumping milk and slaughtering dairy cows to reduce their losses.[71] As shown in Figure 3-4, Chinese dairy farmers responded to the reported margin squeeze in 2006 by thinning the dairy herd from 12.16 million in 2005 to 10.69 million, a reduction of more than 10% (1.47 million cows).

Figure 3-4: China's Dairy Cattle and Milk Production[72]



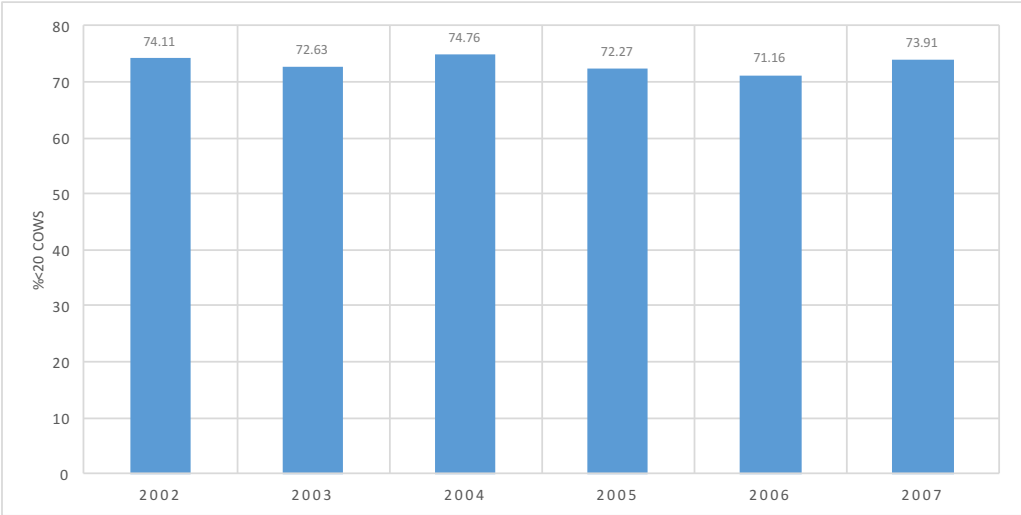
Interestingly, although the number of dairy cattle dropped substantially in 2006, the total volume of milk did not reduce by a similar magnitude. On the contrary, the volume of milk increased from 27.53 million MT in 2005 to 31.93 million MT in 2006. This puzzling observation could be a result of:

1. On-farm productivity improvement due to technological advancement: farmers improved

[71] Qian and Xie (2010), 64.
[72] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015.

their productivity by applying new farming technology. This is unlikely because most of the dairy farmers were small-scale dairy farmers supplying through milk traders using similar farming practices, and there were no apparent technological improvements made specifically for small-scale farms at the time. As shown in Figure 3-5, in 2006, China's cow population managed through small-scale dairy farmers with less than 20 cows tracked close to its historical average of 73% between 2002 and 2007.

Figure 3-5: Percentage of Small-Scale Dairy Farms 2002-2007[73]



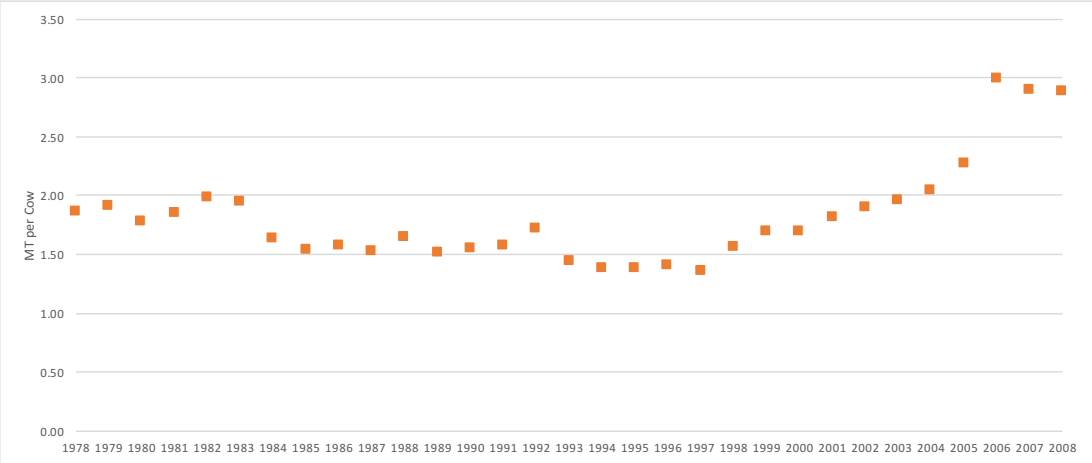
2. On-farm productivity improvement through increasing farming scale: similar to the above, this explanation is probably not valid as most of the milk was supplied by small-scale dairy farmers at the time.

3. On-farm productivity improvement through on-going on-farm learning and improvements: small-scale dairy farmers improved their productivity through on-farm learnings accumulated

[73] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015.

over time. However, as illustrated by the productivity chart Figure 3-6, there is no consistent trend showing that the volume of milk produced per cow increased between 1978 and 2004. The productivity up-lift only took place around the time when the dairy farmers also reduced the dairy herd by 1.47 million in 2006.

Figure 3-6: China's Milk Productivity 1978-2008[74]



4. On-farm productivity improvement through milk dilution: milk volume per cow increased because dairy farmers added water and other fat and protein substances to boost the milk productivity per cow. This was very likely. The diluted milk may not necessarily have been unsafe for human consumption if the substances added were not harmful to human bodies.[75] In the absence of technological advancement and a significant increase in farming scale, the observed up-lift in Figure 3-6 suggests that dairy farmers had found a way to improve the production per cow by maximising the volume of milk produced at the expense of milk quality.

The dairy farmers' inclination to choose quantity over quality was exacerbated by the dairy companies' lack of commitment in paying a milk price that ensured the farmers were

[74] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015.
[75] This is one of the reasons why the health impact was not picked up before August 2008.

protected from supply cost shocks such as the significant margin squeeze in 2006.[76] Because of this, farmers were unwilling to invest in good farming practices that would have benefited the industry in the long run, as they were vulnerable to large-scale dairy companies not paying a milk price that ensured their short-term commercial viability.

In my meetings with the Sanlu milk supply team and other Chinese milk supply experts at various formal and informal Chinese dairy industry forums in 2006 and 2007 (two years before the melamine crisis hit), I often heard at the time, the relationship between the large-scale dairy companies and small-scale dairy farmers described as "when the milk is needed, they (dairy companies) call us (the dairy farmers) friends, when the milk is not needed we are first to be cut, and when there is sufficient milk we are just one of the many suppliers." The relationship between the dairy processors and the dairy farmers changed from a close network of local suppliers supplying to ex-cooperative local dairy companies in the earlier years of the Chinese economic reform to many anonymous small-scale dairy farmers supplying to large-scale investor-owned dairy companies through milk traders.

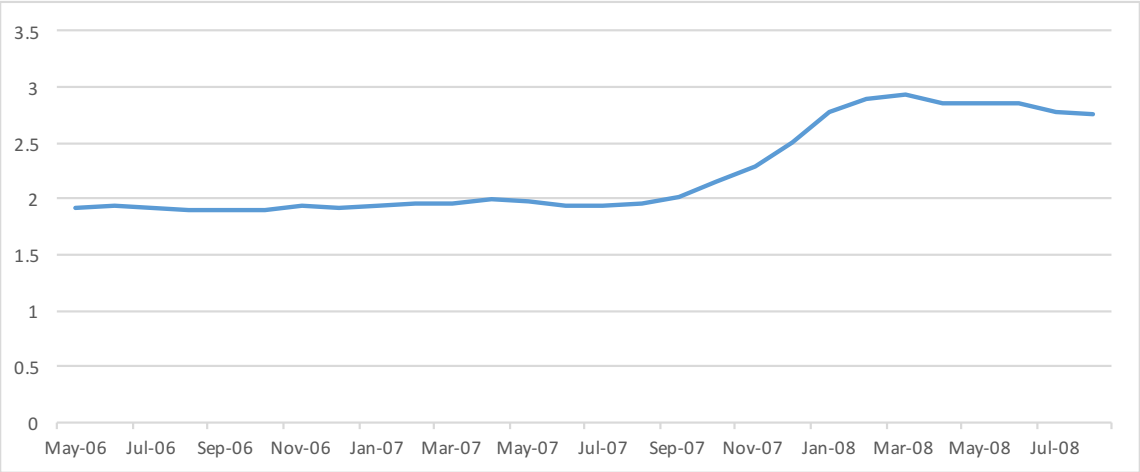
In addition to the pressure of on-farm milk margins that led to the farmers reducing the dairy herd and improving productivity by going for volume at the expense of quality in 2006, dairy farmers were further incentivised to ramp up short-term milk production in response to a significant surge in the farmgate milk price in late 2007 till August 2008. As shown in Figure 3-7, China's national average monthly farmgate milk price went up from RMB2.02 per kg of raw milk in September 2007 to a peak of RMB2.93 per kg in March 2008. For the same

[76] The margin squeezed observed in 2005 and 2006 years came from comments made in Chinese dairy industry reports and forums (for example, Qian and Xie (2010)). There is, however, no China milk price and milk margin data set available for one to undertake empirical analysis.

period, in Figure 3-8, the milk price to corn price mark-up ratio went up from 1.22 in September 2007 to a peak of 1.72 in March 2008.[77]

Note that in the milk price and corn price mark-up ratio charts in Figure 3-7 and Figure 3-8, I was only able to capture the monthly milk price data starting in May 2006. The China national milk price data was not available on the data set I adopted for the analysis. Such lack of transparent and timely milk pricing data exacerbates issues related to information asymmetries, which hinders milk market efficiency.

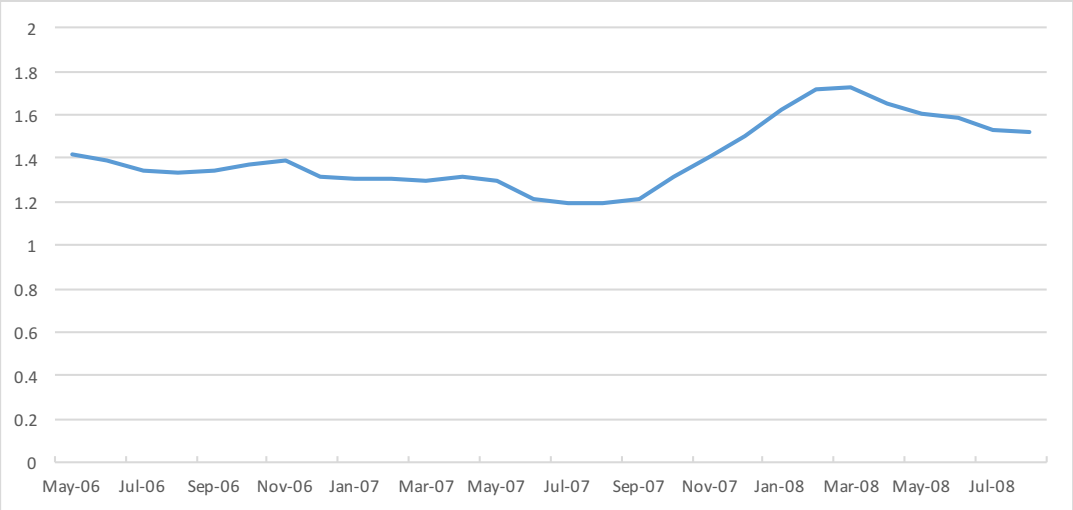
Figure 3-7: China's Monthly Farmgate Milk Price[78]



[77] The Chinese corn price is adopted as a proxy for costs of feed as corn forms the base diet of the Chinese dairy herd.

[78] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015. The milk price data prior to May 2006 is not included as the national milk price data was not collected prior to May 2006.

Figure 3-8: China's Farmgate Milk Price to Feed Mark-up Ratio[79]



The dramatic short-term up-lift in milk price and milk mark-up was largely due to strong Chinese consumer demand for milk over the same period, which was further reinforced by a surge in international dairy commodity prices, as imported dairy commodities such as whole milk powder and skim milk powder were used as acceptable substitutes for raw milk to produce some of the Chinese consumer dairy products. Market analysts at the time observed that rapidly growing large-scale dairy companies were competing for milk from regions that were outside their home supply regions to support the growing dairy demand from consumers.[80] For example, Mengniu Dairy, based in the Inner Mongolia region of China and one of the largest dairy companies in China at the time, normally sourced most of its milk within the region, but began to "grab" milk from Sanlu's supply base in the Hebei region. This short-term milk grabbing played by large-scale dairy companies meant that small-scale dairy farmers were more likely to engage in methods that would maximise their short-term milk volume at the expense of quality, as the relationship between the suppliers and purchasers of milk lacked in mutual commitment.

[79] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015.

[80] For example, Qian and Xie (2010) report the intense competition for milk supply during the time before and around the melamine crisis.

Under these conditions, China's dairy market failed to deliver dairy products that were safe for human consumption. In September 2008, the Chinese central government announced its investigation into one of the world's largest food safety crises, which injured 300,000 Chinese babies and led to the death of six babies.[81] It was found that dairy farmers and milk traders added a fake protein substance, melamine, to boost the percentage of protein in diluted milk, such that they were able to ramp up milk volumes supplied to dairy companies at very low costs. On the 16th of September 2008, the Chinese testing authorities found that 69 batches of infant formula products manufactured by 22 Chinese dairy companies contained different levels of melamine.[82]

[81] "China dairy products found tainted with melamine", BBC News, 9 July 2010.

[82] AQSIQ infant formula testing results published by Xinhua News Agency on the 17th of September 2008. These 69 batches included most Chinese dairy brands including, in addition to Sanlu, two other popular Chinese dairy brands Yili and Mengniu.

4 The China Melamine Milk Crisis: The Theory of the Firm Perspective

In China, the dairy industry started with local government-facilitated dairy cooperatives and evolved into a predominately contract supply model, which led to the formation of one of the world's largest markets of raw milk. The contract supply model helped the ex-cooperative dairy companies to: (1) secure the growth of milk supply required without having to invest their own capital in on-farm milk production and collection assets; and (2) raise capital from outside investors to put in place the milk processing and manufacturing capacities, and sales and marketing capabilities required to serve Chinese consumers' rapidly growing appetite for milk.

There are similarities in the evolution of the New Zealand dairy industry migration from a cooperative only model to a hybrid of cooperative and contract supply model, and the way in which China managed to change from local government-facilitated dairy cooperatives to large-scale dairy companies through securing required milk volumes using contracts. Although the definition of dairy cooperatives is not exactly the same between the two countries, they are similar in the following ways: (1) both China and New Zealand started with a vertically integrated supply chain where the on-farm production, milk processing and sales and distribution assets were internalised through a form of collective ownership; and (2) both China and New Zealand opted to migrate from fully vertically integrated cooperative governance to contract supply in response to changes in market conditions: milk price discovery for New Zealand, and a need for substantial amounts of capital to finance rapid growth in the demand for milk in China.

In this section, I adopt the theory of the firm to help understand the economics of the China melamine milk crisis by: (1) providing an overview of the theory of the firm in the context of

the Chinese dairy industry with the objective of understanding the factors that motivated China towards securing milk supply using contracts; (2) identifying the factors that contributed to the failure of the Chinese milk market in delivering milk that was safe for human consumption; and (3) analysing how the Chinese dairy industry responded to the observed milk market failure.

4.1 Theory of the Firm and Application to the Chinese Dairy Industry

In this section, I apply the theory of the firm in the context of the China dairy industry to help understand how the theory can be used to explain the observed Chinese milk market failure brought about the melamine milk crisis. Some of the theoretical framework set up below is included in Chapter One and Chapter Two.

Coase (1937) demonstrates that the economic framework that regards firms as a "black box" that merely transact using the market price mechanism is insufficient for explaining why we observe resources being allocated within a firm on a planning basis. Coase (1937) explains that we observe transactions organised through firm governance as opposed to market governance because there are costs involved in transacting using the market price mechanism.

Williamson (1979) further demonstrates that if transactions involve: (1) investments in transaction-specific assets, which are specifically designed to facilitate a particular transaction with limited alternative applications, (2) the prices of the goods and services provided using the transaction specific assets are highly volatile, and (3) the transactions take place frequently, then we would expect higher transaction costs for contracting the goods and services provided by the transaction-specific assets using the market price mechanism.

In the case of the Chinese dairy industry, both dairy farmers and dairy companies are required to invest in transaction-specific assets. Dairy farmers invest in on-farm milk production assets such as a dairy herd, and dairy companies invest in milk processing factories. Both assets are of no or little value without the other. If the farmgate milk price and milk volumes are inherently volatile, then transacting using contracts is likely to be costly. However, if there is a way that dairy farmers and dairy companies can work closely together to minimise the volatility of the milk price and milk volume transacted through a long term commitment from both parties, then the costs of using contracts could be managed at a lower level.

Based on the work of Coase and Williamson, Grossman and Hart (1986) and Hart and Moore (1990) (collectively referred to as "GHM") demonstrate that the transaction costs of using the market are not only restricted to the ex-post (after the contract) hold-up behaviour engaged by contracting parties, but are more likely caused by the costs incurred by the ex-ante (before the contract) underinvestment of transaction-specific assets. If contracting parties are unable to put together contractual terms that completely rule out all the possible hold-up behaviours (that is, contracts are incomplete), then there will be no incentive to invest in the transaction-specific assets. For example, if Sanlu wanted to invest in a large-scale liquid milk factory in the Hebei province, and the factory investment had limited alternative processing options, then Sanlu would not go ahead with the proposed investment if it expected that it might be held-up by the local dairy farmers switching their milk supply to competing dairy factories from time to time.

GHM suggest that such under-investment in transaction-specific assets due to costly contracting can be resolved by either the dairy company or the dairy farmers acquiring ownership of both the on-farm production assets and the large-scale liquid milk processing

assets. As we have observed in the case of the New Zealand dairy industry, before the introduction of GDT when suppling milk using contracts was costly, almost all the on-farm production and processing assets were integrated through cooperative ownership.

Although cooperative ownership helps resolve the hold-up problem by integration, the way the cooperative ownership rights are defined also means that investment in a cooperative is more vulnerable to agency problems. The cooperative membership rights are regarded as "vaguely defined" compared to the rights vested in the shares of a limited liability company, as the cooperative membership rights are "redeemable" and not "transferable" to outside shareholders. That is, upon exiting the cooperative, the cooperative members can only get their investment back by selling the rights back to the cooperative (redeeming their membership rights), or by selling the rights to fellow cooperative members (transferring the rights within the cooperative), but they cannot sell the membership rights to investors who are not members of cooperatives (not transferable to outside investors). For example, the inability to transfer the ownership rights to outside investors means that institutional investors are unable to enforce market discipline on an inefficiently managed cooperative by acquiring the ownership rights from the members to gain control such that they are able to make management changes to drive out inefficiencies.

Cook (1995) has categorised the agency costs associated with vaguely defined cooperative ownership rights into the following five categories: free rider problem, control problem, influence cost problem, horizon problem and portfolio problem. In the context of the Chinese dairy industry, the horizon and portfolio agency problems are most relevant.

The horizon problem exists when there is a mismatch between the dairy farmer-suppliers' investment horizon and the time horizon of the return profile of the cooperative's investments opportunity sets. For example, if one of the cooperative's farmer-suppliers has an investment horizon of ten years before his retirement, and, at the end of 10 years, can either redeem his investment to the cooperative at the initial invested amount, or transfer the rights to fellow cooperative members at the same value, then the farmer is unlikely to support a net present value (NPV) investment that returns very little cash in the initial ten-year period but a substantial amount after ten years.

The portfolio problem exists when farmer-suppliers of a cooperative are unable to finance the cooperative's value enhancing positive NPV projects due to: (1) farmers having insufficient funds available to finance the project and the cooperative not having access to capital from outside investors; and (2) farmers having higher costs of capital compared to outside investors, as cooperative farmers have most of their wealth tied up across the dairy value chain and are unable to diversify their exposure through a portfolio investment approach.

The horizon and the portfolio problems are highly relevant to the Chinese dairy industry as significant amounts of capital were required to: (1) finance the growth in milk production from a very low base of 1 million MT in 1978 to 36 million MT in 2008; and (2) finance the milk processing and dairy product manufacturing capacities, and sales and marketing capabilities needed to serve 624 million Chinese urban consumers.[83]

[83] Between 2000 and 2008, urban consumers increased their per capita dairy spending growth at a compound annual growth rate of 13%.

In response to the need for substantial amounts of capital to finance the once-in-a-lifetime dairy growth opportunities, the Chinese dairy industry embarked on a transition from local government-facilitated cooperatives to large-scale investor-owned dairy companies with milk supplied by small-scale dairy farmers. The transition was facilitated by a Sanlu initiative known as: "cows go into the villages and milk comes into the cities"[84]: the sale of dairy cattle by an ex-cooperative dairy company to local dairy farmers, financed by loans granted by the dairy company. The loan was subsequently paid by the farmers by deducting a percentage of the milk price received from the dairy company.

This transition was critical in supporting China's rapid growth in milk production and consumption as the transition helped to:

1. Free up capital tied up in on-farm milk production:

The transition of local government-facilitated cooperatives to investor-owned dairy companies enabled the dairy companies to free up their investment in on-farm milk production assets. The dairy companies were able to invest the freed-up capital to expand the milk processing and distribution capacities to fulfil the rapid growth in demand for dairy.

2. Access capital provided by outside investors:

The transition also meant that the ownership rights of the dairy assets were no longer restricted to local dairy farmers, local consumers, and local dairy factory workers through a local government-facilitated cooperative ownership. The investor-owned dairy companies were able to raise capital from outside investors, who had more financing capacity to invest, and could finance at a lower cost of capital using a portfolio investment approach.

[84] Tian and Li (2006), 67.

The "cows go into the villages and milk comes into the cities" initiative also helped build a close relationship between the dairy companies and the local dairy farmers. This close relationship was pivotal to the initial success of securing milk supply using contracts as it helped minimise exposure to hold-up behaviour due to asymmetric information.

The transition helped mitigate the horizon and portfolio problems discussed above, which were relevant in the context of China's dairy market as it needed to grow from a very low base to a grand scale over a relatively short period of time. The transition, however, would only work if the hold-up problem associated with incomplete contracts could be mitigated. As I have shown in Chapter One using New Zealand data, contract supply became a reality when the farmgate milk prices were no longer theoretical but were derived using international commodity pricing series transacted on the online dairy commodity auction trading platform. Similarly, the Chinese dairy market could only have contract supply arrangements in place if the contracted parties could agree on the milk prices and if the prices were not easily exposed to ex-post opportunism, which results in the contracts becoming incomplete.

4.2 Factors Leading up to the Failure of China's Milk Market

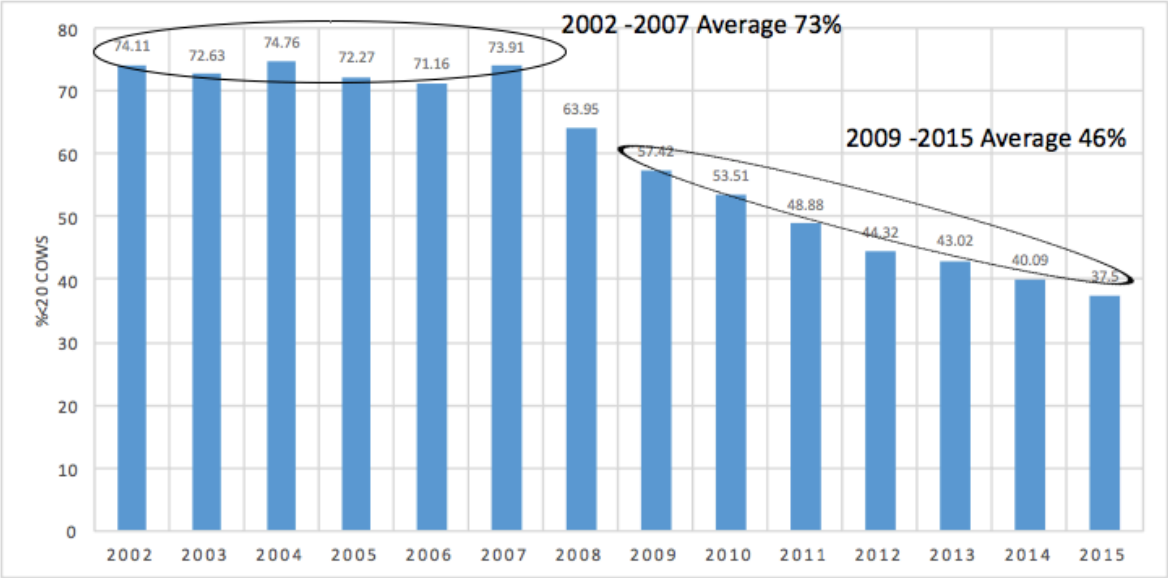
China's dairy industry grew on the back of exponential growth in the demand for dairy using a contract supply model, which created a large market for milk. However, the milk market underpinning the success of China's dairy market clearly showed its failures in 2008, when an unprecedented large-scale milk contamination resulted in injuries to 300,000 babies and the death of six babies.[85] This begs the question: what are the factors that contributed to the

[85] "China dairy products found tainted with melamine", BBC News, 9 July 2010.

failure of the rapidly growing Chinese milk market, which worked well for a long period of time, but, for some reason, clearly showed its failures in 2008?

As the theory of the firm suggests, the success of contracting using the market price mechanism hinges upon market participants' ability to transact using contracts without significant costs. The reason that the Chinese dairy industry was able to grow on the back of the contract supply model largely depended on its ability to minimise transaction costs through the close relationship between dairy farmers and dairy companies. However, this close relationship was weakened by the increasing scale mismatch between the dairy companies and the dairy farmers.

Figure 4-1: Percentage of Small-Scale Farms 2002-2015[86]



As shown in Figure 4-1, an average of 73% of China's total dairy farms in the period between 2002 and 2007 had a scale of dairy herd less than 20 dairy cattle per farm. At the same time, dairy companies had expanded their scale and geographical coverage. The observed inverse relationship made it difficult for both dairy companies and dairy farmers to transact in the

[86] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015 and the years are calendar years.

same way as they used to, when dairy companies were much smaller in scale with a stronger local presence. Instead, the large-scale dairy companies needed to engage milk traders to manage a fragmented small-scale supply base.

These changes led to information asymmetry building up between large-scale dairy companies and small-scale dairy farmers. On the one hand, the information asymmetry meant small-scale dairy farmers lacked incentive to invest in on-farm milk quality that benefited the industry in the long run but was costly for the farmers to put in place in the short run, and that milk traders lacked incentive to invest in milk quality and monitoring assets as they were mainly focusing on the traders' margins they were able to collect on the milk transacted through them.

On the other hand, the information asymmetry meant that large-scale dairy companies could use their scale advantage to manage the milk price downwards by taking milk at the pre-agreed prices when demand for dairy products was strong, and not to take milk at the pre-agreed prices when demand for dairy products was soft. These factors made the prices and the volumes of milk supplied using contracts vulnerable to opportunistic behaviour by all parties involved, which made milk more "costly" to transact using contracts.

In 2006, we observe Chinese dairy farmers reducing their dairy herds and then maximising milk volumes at the expense of milk quality in response to the substantial margin squeeze from surging feed costs and flat farmgate milk prices. In 2008, it was discovered that dairy farmers and milk traders had been able to increase the volumes of raw milk supplied by diluting milk with water and adding non-milk fat and protein substances, which led to one of the world's largest food safety crises in August 2008.

4.3 The China Dairy Industry's Response to China's Milk Market Failure

In response to the world's largest milk safety crisis, China's dairy industry could resolve the problem by: (1) encouraging investor-owned dairy companies to backward integrate the up-stream on-farm milk production assets; (2) encouraging small-scale dairy farmers to forward integrate the down-stream milk production, processing, and sales and marketing investments through a form of cooperative ownership; and (3) addressing the emerged hold-up problem between the small-scale dairy farmers and large-scale dairy companies, which made the prices agreed for acceptable milk quality using contracts vulnerable to ex-post opportunism.

China's dairy industry opted not to fix the observed hold-up problem through integration, but by directly addressing the hold-up issue caused by the scale mismatch between dairy companies and dairy farmers. This was achieved by: (1) consolidating milk supplied by fragmented small-scale dairy farms into milk supplied by large-scale dairy farms; and (2) dairy companies dealing directly with large-scale dairy farmers without engaging milk traders. Some of the large-scale dairy companies facilitated the consolidation of fragmented small-scale milk supply bases by providing seeding funds to establish large-scale dairy farming companies that could facilitate and expedite consolidation.

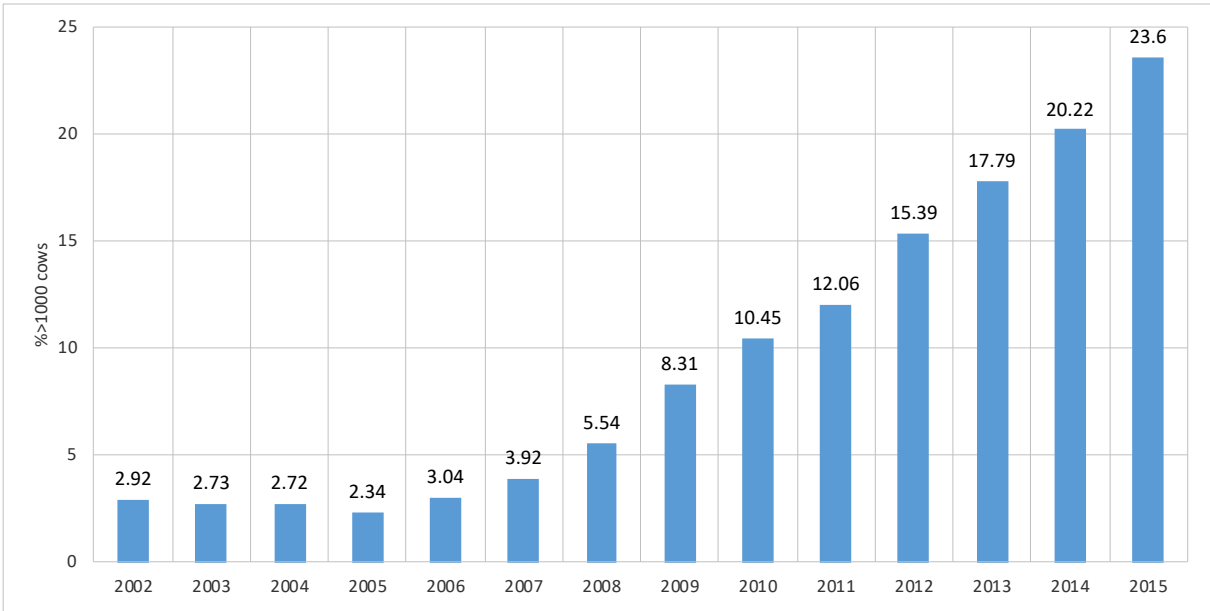
The Chinese regulators encouraged both the large-scale dairy companies to integrate up-stream milk production assets and the consolidation of large-scale dairy farms to ensure that the problem of milk adulteration by fragmented small-scale farmers and milk traders was addressed. This was achieved by: (1) requiring all Chinese dairy farmers to comply with more stringent raw milk quality compliance regulations; (2) putting in place tax and other financial incentives for the formation of large-scale dairy farms; and (3) putting in place tax and financial incentives for large-scale dairy companies to backward integrate milk production

assets. The end result, however, is that most of the milk required by large-scale dairy companies is supplied on a contract basis by dairy farms that are independent from dairy companies.

As shown in Figure 4-1, milk supply from small-scale dairy farmers with less than 20 dairy cattle decreased substantially after the 2008 melamine milk crisis, and reached 37.5% in 2015. The percentage of China's small-scale dairy farms reduced from a seven-year average of 73%, prior to the melamine crisis in 2008 to a post-2008 seven-year average of 46%.

At the same time, we observe a rapid growth in large-scale dairy farms with more than 1,000 dairy cattle after 2008. As shown in Figure 4-2, the percentage of China dairy farms with more than 1,000 cattle increased from 3.92% in 2007, a year prior to the melamine milk crisis, to 23.6% in 2015.

Figure 4-2 :Percentage of Large-Scale Farms 2002-2015[87]



[87] The data is extracted from China Dairy Annual Statistics (中国奶业年鑑) 2015.

In addition to the trends observed in the charts, I have also estimated the following regression models to examine whether the Chinese milk market responded to the China melamine milk crisis by changing the scale of the dairy farms.

Model 1: $<20\%_t = \alpha + \beta_1 Melmaine_t + \beta_2 Melmaine_t (Year\text{-}2009)_t + \varepsilon_t$

Model 2: $>1000\%_t = \gamma + \lambda_1 Melamine_t + \lambda_2 Melmaine_t (Year\text{-}2009)_t + \varepsilon_t$

Where, $<20\%_t$ and $>1000\%_t$, are the dependent variables and represent the percentage of total Chinese dairy farms operating at a scale of less than 20 cows and greater than 1,000 cows respectively;

t = 2002, 2003 to 2015 calendar years;

$Melamine_t$ = 1 where t > 2008, otherwise 0; and

$(Year\text{-}2009)_t$ = the value of the year in which the data is observed subtract 2009, the first year after the discovery of melamine in August 2008.

As shown in the models above, if the market did respond to the China melamine milk crisis by consolidating the milk supplied by small-scale dairy farmers to milk supplied by large-scale dairy farmers, then the estimated coefficients β_1 and λ_1 are expected to be significantly different than zero.

β_2 and λ_2 are included as it is expected that consolidation is likely to take a number of years because of practical constraints, such as setting up the regulatory and environmental consents required to put in place large-scale dairy farms, and the time required to construct the milk production facilities. The results of the two regression models are summarised in Table 4-1.

Table 4-1: Melamine Crisis Regression Result

	<20 Cows	>1,000 Cows
Intercept	71.83% (66.78)**	3.32% (9.95)**
Melamine Dummy	-15.53% (-7.00)**	4.47% (6.50)**
Melamine(Year-2009)	-3.30% (-6.14)**	2.54% (15.24)**
Adjusted R^2	0.96	0.99
Sample Size	14	14

The dependent variables are: (1) the percentage of total Chinese dairy farms with less than 20 cows for "<20"; and (2) the percentage of Chinese dairy farms with 1000 or more cows for ">1,000". The independent variables are (1) the melamine dummy, which has a value of zero if the data is observed in or before 2008, and a value of one if the data is observed after 2008; and (2) the "Year-2009" has a value of the year in which the data is observed subtract 2009. The t-statistics are in the parenthesis. ** means the coefficients are significant at the 1% level.

As shown in Table 4-1, the Chinese dairy market responded to the melamine crisis by consolidating milk supplied by small-scale dairy farms to milk supplied by large-scale dairy farms. The results show: (1) a 15.5% reduction in small-scale dairy farms with less than 20 cows post the 2008 melamine milk crisis, followed by a reduction at an annual rate of 3% in the years after 2009, and (2) a 4.47% up-lift in large-scale farms with more than 1,000 cows, followed by an increase at an annual rate of 2.54% in the years after 2009. All estimated coefficients are statistically significant at the 1% level.

5 Concluding Remarks

In this study, I documented how China built up its milk supply from less than 1 million MT in 1978, the year when Chinese economic reform was introduced, to 36 million MT in 2008, the year when the China melamine milk crisis took place. China's milk production grew more than 40 times during this period to support rapidly growing Chinese consumers' demand for dairy products. This spectacular growth represented great opportunities, but also great challenges.

China was able to deal with the required growth in milk volume by creating one of the world's largest milk markets. The market was initiated by local government-facilitated dairy cooperatives transitioned into large-scale dairy companies by outsourcing: (1) milk production to a large number of small-scale dairy farmers, and (2) milk collection to milk traders. This transition helped: (1) the dairy companies allocate their capital from on-farm production to down-stream milk processing assets and sales and marketing capabilities; (2) the dairy companies have better access to outside capital; and (3) small-scale dairy farmers join the industry with a low up-front capital investment.

The milk market worked well for a period of time, when the costs of transacting using contracts between small-scale dairy farmers and large-scale dairy companies were low. This was achieved by the ex-cooperative dairy companies and local dairy farmers having a close supplier-buyer relationship because: (1) the dairy companies provided finance to local farmers to purchase dairy cattle and farmers repaid the dairy companies through a deduction from their milk payment; and (2) the dairy companies acquired milk from local dairy farmers operating close to their milk processing facilities. This close relationship between dairy

companies and local dairy farmers helped alleviate hold-up concerns, which could otherwise make contracting costly.

However, as the dairy companies continued to grow and expand their facilities beyond their local milk supply footprints, and, at the same time, as milk production continued to grow through increasing numbers of small-scale dairy farmers in the local areas, dairy companies had to manage milk supply through milk traders. As a result, the model that had been performing well was under serious threat from information asymmetry that had built up between dairy farmers and dairy companies. This led to a lack of transparency and trust among contracting parties, which incentivised small-scale dairy farmers and milk traders to maximise milk volumes at the expense of milk quality, and the large-scale dairy companies to take less volumes from farmers when the milk prices resulted in lower profitability.

This threat began to make contract supply of milk costly when there was a surge in the costs of feed, but the farmgate prices did not increase to the same extent, which affected small-scale dairy farmers' profitability. This eventually led to dairy farmers lowering the cost of their milk production by adding water, and non-milk fat and protein substances. In August 2008, the milk market underpinning the success of the Chinese dairy industry was found to be serving consumers with dairy products that were contaminated with melamine.

Instead of replacing the milk market with the integration of milk production and milk processing assets, the Chinese dairy industry responded to the observed market failure by addressing the hold-up issues that caused the failure: scale mismatch between dairy companies and dairy farmers, and transacting milk through milk traders. This observation is supported by the regression analysis using Chinese dairy farm ownership data, which reveals:

(1) a 15.5% reduction in the percentage of small-scale dairy farms with less than 20 cows per farm immediately after 2008, followed by a further reduction of 3.3% per annum in the period 2010 to 2015; and (2) a 4.47% increase in large-scale dairy farms with more than 1,000 cows per farm immediately after 2008, followed by a further increase of 2.54% per annum in the period 2010 to 2015.

In addition to addressing the contracting issues by consolidating the small-scale farms into large-scale corporate farms, the observed efficiency improvement in New Zealand through the establishment of market based on-line dairy commodity and raw milk markets indicates that there is an opportunity for China to achieve further efficiency in transacting its milk using contracts by establishing its own on-line dairy commodity and raw milk markets. The transparency and liquidity brought about by the dairy commodity and milk markets not only help the buyers and sellers of milk to transact more efficiently, they also minimise the observed information asymmetries that led to China's largest milk market failure.

CONCLUDING REMARKS AND FUTURE RESEARCH OPPORTUNITIES

In this thesis, we have seen how two exogenous shocks took place in 2008 affected the way milk was transacted in New Zealand and China: (1) the introduction of Global Dairy Trade (GDT) that enabled contract supply in New Zealand; and (2) the world's largest milk safety crisis, the China melamine milk crisis, which migrated milk supplied from small-scale dairy farms through milk traders to large-scale dairy farms. Both events changed the governance/ownership models through which farmers supply their milk to dairy processors.

In New Zealand, the dairy industry migrated from a predominately cooperative supply model to a hybrid of cooperative and contract supply as GDT provided milk price discovery that enabled contracts to be put in place. Before the introduction of GDT, milk prices could not be easily set and determined in such a way that both dairy farmers and dairy processors could be confident that the milk supply contracts were not subject to hold-up problems, which made contracts incomplete and costly to transact. After the introduction of GDT and its linkage to the farmgate milk price (FMP), dairy processors and dairy farmers were able to transact using contracts based on the milk prices set.

The empirical analysis also shows that the migration from a cooperative only model to a hybrid model increased the efficiency of the New Zealand dairy processors. This evidence gives strong support to the theory of the firm's hypothesis: contracting parties are willing to transact using contracts when contracting parties have confidence that prices agreed in the contracts are no longer subject to hold-ups and can therefore be transacted efficiently.

In China, we observe how contract supply worked for a long period of time through the close relationship between ex-cooperative dairy companies and small-scale dairy farmers. Milk was

able to be transacted using contracts as contracting parties had trust and confidence that the milk prices and volumes agreed would be honoured without hold-ups. However, in 2008, the contract supply model failed to deliver milk that was safe for human consumption because of the information asymmetry that had built up between large-scale investor-owned dairy firms (IOFs) and small-scale dairy farmers. Such information asymmetry made contracts costly to transact as the prices and volumes were subject to: (1) manipulation by the large-scale IOFs not taking all the milk volume supplied when the milk price agreed in the contract impaired their profitability, and (2) dairy farmers increasing milk volumes by diluting their milk with substances such as melamine so that they could increase the milk prices received to maximise their own profitability. The outcome of such opportunism cost the health of 300,000 children and the lives of six babies in China.

After the crisis, China had the option of: (1) developing an integrated model, such as agriculture cooperatives, to solve the issues associated with contract supply; or (2) addressing the information asymmetry between large-scale IOFs and small-scale dairy farmers that led to the milk market failure. The Chinese dairy industry opted for the second option: fixing the contracting issue by consolidating small-scale dairy farms into large-scale corporate farms to address the issue associated with information asymmetries.

The above observations also demonstrate how rules and regulations can be engaged by the regulators to put in place market infrastructures that help provide better milk price discovery, which minimises information asymmetries to enable efficient contracting. I therefore suggest the following three research questions that future research can explore to further enhance the efficiency of the New Zealand and Chinese milk markets.

1. Are there any modifications that New Zealand regulators can consider to make the GDT platform more efficient? For example, as at the completion of this thesis, the ownership of GDT is with the largest dairy cooperative in New Zealand, Fonterra. The volumes that are transacted on the platform are largely Fonterra products. Should some form of industry ownership take place to encourage more dairy commodity suppliers to join the GDT platform?

2. Are there any other ways derivatives such as milk futures and options can be engaged closely with the GDT platform to further enhance milk contract efficiency? In addition to GDT and FMP, there is currently a futures and options market for both dairy commodities and milk transacted through the New Zealand Stock Exchange (NZSE). There is value in developing research to: (1) document how the NZSE derivative market interacts with GDT and FMP in providing transparency and less volatility in commodity and milk prices; and (2) examine whether one could make further refinements to how the NZSE derivative market, GDT and FMP work together to provide more transparent and relevant spot and futures prices that could further enhance the efficiency of dairy commodities and milk contracting.

3. Is there value in introducing a form of GDT and NZSE dairy commodity and milk derivative markets in China? China has been relying largely on the close relationship among contracting parties to alleviate the hold-up problems related to information asymmetries. A Chinese version of the GDT and NZSE milk options and futures platforms could help provide better milk price discovery and minimise sole dependency on the close relationship between IOFs and dairy farmers, which could help to enhance the efficiency of the Chinese milk market.

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