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The Application of Cost-Based Value Stream Mapping to a Container Loading Analysis

A Dissertation
submitted in partial fulfilment
of the requirements for the Degree of
Bachelor of Commerce with Honours

at
Lincoln University
by
Tiffany McIntyre

Lincoln University
2014

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Lean production emerged in the 1990's as an academic term, with the publication of the book 'The Machine that Changed the World'. The philosophy was born out of the Toyota Production System, with the objective to eliminate waste within firms. Originally applied to the manufacturing industry, the philosophy has been applied to other industries such as services and healthcare with varying levels of success. However, to date, very little research has been conducted in the agricultural sector. The aim of the study is to use the Lean tool Value Stream Mapping to determine its ability to improve performance within a logistics setting, through conducting a cost analysis on container utilisation for an existing New Zealand dairy company. A case study methodology was used in the study to draw a non-traditional Value Stream Map, which was then used to conduct the cost analysis. The results of the project suggest that container utilisation could be improved through reducing the pallet weight load.

Keywords: Value Stream Mapping, Lean tool, cost analysis, container load, dairy

Acknowledgements

I would like to acknowledge Westland Milk Products and the staff that provided me with the information for this dissertation. Thank you for the invaluable opportunity you have provided me with to work alongside a great New Zealand company with such a rich history and exciting future. I was made to feel welcome and part of the team which is more than anyone could ask for. I would like to specially thank J. Kenny, J. Dwyer, S. Scott and C. Murcott. You took the time to answer my many emails and phone calls, and for that I sincerely thank you and hope that this project will be useful to your firm.

I would like to thank the Faculty of Agribusiness and Commerce here at Lincoln University for the opportunity undertake this degree and a special thank you to all the lecturers of the courses I took as a postgraduate student. Your input into my study has been invaluable.

Thank you to my family for your encouragement over the year and a special thank you to my twin Brittany for your time and your kind words when needed. I could not ask for a better support group.

Finally, an incredibly humble thank you to Jeff Heyl. Your knowledge and enthusiasm for the area of Lean Manufacturing has been inspiring. Thank you for the long hours and effort that you have put into my project this year. I am truly grateful for the knowledge that you have imparted and the dedication that you have shown. I wish you all the best.

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Chapter 1

Introduction

In the current business environment firms are forced to become more competitive and aware of customer needs to survive. In the recent economic recession many firms were forced to downsize, or were forced out of business altogether. This highlights the need for firms to implement continuous improvement both internally and within a supply chain context (Keyes, 2013). One of the most prominent business philosophies that centre on this ideology is Lean. Lean production offers a way for firms to introduce continuous improvement through focusing on customer value and elimination of waste throughout the various processes within a firm. This helps to improve efficiency within the organisation and ultimately the supply chain. The merits of this philosophy, coupled with a curiosity of supply chains has been the inspiration for the scope of this project.

Lean production as we know it today emerged as an academic term in 1990 with the publication of Womack, Jones & Roos' book entitled 'The Machine that Changed the World'. The main goal within the philosophy is the elimination of waste, or Muda, to facilitate perfect value for the end consumer (Lean Enterprise Institute, 2009; Ohno, 1988; Zokaei & Simons, 2006). More specifically, Muda is one of three forms of waste and refers to a wide range non-value-added activities, such as holding old stock. The roots of Lean extend from Henry Ford's perfection of the mass production line through standardisation and the moving assembly line. Ford's desire was to produce an automobile that was affordable for the masses. To achieve this, Ford developed precision machinery that led to standardisation and the effective use of interchangeable parts (Womack, Jones & Roos, 1990).

Taiichi Ohno, Toyota's production engineer, built on Ford's work. He recognised that Toyota would not be able to compete in the automobile market using the large batch sizes that the dominating manufacturers used. Thus, Ohno set out to develop a system that would eliminate waste and create value for the customer (Liker, 2004). This new system was aptly named the Toyota Production System (TPS). The system moved the focus of production from the machines to the flow of materials through the assembly line. The result was an ability to drive out waste, maintain a wide product range, manufacture in small batches and compete on cost (Holweg, 2007).

The ability of Lean production to drive out waste and to deliver value to the customer rests in its combination of both craft and mass production, i.e. avoids the high cost of craft production while simultaneously avoiding the rigidity of mass production. Hence, Lean production offers flexibility in terms of manufacturing what the customer demands, with the ability to do so on a large scale (Womack et al, 1990). The nature of the two aforementioned firms is manufacturing. Hence, this is

where many of the early published works of Lean lie. In recent years as the merits of Lean have been recognised and academics and practitioners have begun to adopt the philosophy in other industries. This is particularly true in the case of service industries, such as the healthcare sector (Jones, 2006; Radnor, 2012; Holweg & Waring, 2012). However, to date, very little research has been conducted in the field of agriculture/agribusiness. As agriculture is New Zealand's largest export sector (Ministry for Primary Industries (MPI), 2013), it seems appropriate that this be the area of focus within the study.

1.1 Research Purpose

New Zealand is an isolated nation near the bottom of the Pacific Ocean. The population is small compared to the landmass, with the majority of the population living in urban areas. This, coupled with the temperate maritime climate and abundance of natural resources, such as water, has led to the country being able to produce a surplus of agricultural products with a low cost competitive advantage. The major implication of this is that New Zealand has come to rely on exports. Thus, there is a major supply chain component present in business and good supply chain management is crucial for an exporting firm. The majority of exports are produced in the primary sector and are sold on the world market as commodities. This is of great significance because it means that firms must effectively manage their supply chains in such a way as to keep export costs low. All of which is in a bid not to pass additional costs on to the consumer.

During an undergraduate degree in Agribusiness at Lincoln University, the concept of Lean was introduced throughout a number of courses. The described benefits of Lean indicated that it has huge potential in New Zealand. The benefits largely rest with the idea that Lean leads to continuous improvement of business processes, yet the end consumer still remains the centric focus of the firm. However, a more in-depth investigation into Lean implementation in New Zealand reveals a disappointing trend; Lean is mostly carried out in manufacturing firms and healthcare services, with little research in the service industry and next to none in agriculture. Within agribusiness the concept was briefly discussed in relation to creating value chains, however this is where the discussion of Lean ended.

Dairy production in New Zealand is worth \$10.4 billion in annual export earnings (NZIER, 2010). In terms of exports, the New Zealand dairy sector accounts for 26% of the country's merchandise exports and one third of world dairy trade – the world's number one exporter (New Zealand Trade & Enterprise, 2013). This makes the dairy industry hugely valuable to the New Zealand economy. In addition to these notable impacts, the dairy industry's influence on the economy extends beyond these obvious immediate effects. The industry is also invaluable to the country in terms of jobs created, rural economic growth, and the amount of tax revenue that dairy generates. For instance,

the industry provides 35,000 jobs (excluding the self-employed) and in 2009 dairy injected over \$700 million into the Southland district economy (NZIER, 2010).

Despite the aforementioned benefits, the dairy industry is not without its fair share of issues. These range from environmental to supply chain problems. One particular environmental concern that impacts the dairy industry greatly is greenhouse gasses. Although carbon is recycled, about 1% of converted carbon dioxide is recycled by cattle and dispersed back into the atmosphere as methane, a potent greenhouse gas, around 25 times more harmful than carbon dioxide. The impact is further amplified in a nation like New Zealand where livestock are farmed and fed on pasture. Animal excrement and fertiliser application to paddocks contains nitrous oxide, which is also a potent greenhouse gas (NIWA, 2013). This is often leached through the soil, resulting in not only losses of soil fertility but also pollution (Cameron, Di, Moir, Christie & Pellow, 2005). The environment is of great concern to all people and will remain a heated topic for years to come.

Many livestock issues also vary from region to region. For example, facial eczema is found mostly in the North Island of New Zealand where the temperature and humidity is often higher. This problem is caused by ingested fungal spores growing on pasture. The spores produce a toxin that causes liver damage and also damages bile ducts. The result of which is reduced production and sometimes death (DairyNZ, n.d.). Other, more localised problems such as deficiencies and sickness are often related to the immediate environment and the mineral composition of the soil.

In terms of supply chain issues, there are generic business supply chain management issues present as well as more specific issues, particularly around logistics. Many generic issues relate to the marketing mix that a firm will adopt as well as other factors such as supply chain collaboration. While these are very valid and important concerns, they are not the primary focus of this research project. Logistics issues on the other hand are, and these vary within each area of New Zealand. For example, in the South Island one of the two major ports is located on the East Coast of the island in Lyttleton, Christchurch. The West Coast produces around 3% of the country's total milk production and is home to New Zealand's third largest dairy company (LIC & DairyNZ, 2011; Coriolis, 2011). However, the two coasts are separated by the Southern Alps. This creates some very obvious logistical difficulties that must be overcome, i.e., how to ship product in the most efficient and cost-effective way possible from one coast to the other. This project will explore this problem more thoroughly with the help of the Lean tool Value Stream Mapping.

1.1.1 Project Aim

The aim of this research is to conduct a case study analysis of a dairy firm's transport process using the Lean tool Value Stream Mapping. The intent is that this project will add to current understanding of this tool and its usefulness to logistics processes within a firm.

A secondary aim of this project is that the firm featured within the case study will be able to benefit from the findings of the research. The analysis results will be fully available to the firm to aid in the process of double stacking pallets within shipping containers.

1.1.2 Objectives

The goals of this project are:

- To understand the milk drying process and the implications that different milk drying technologies and milk properties have on bulk density variability
- To gain an understanding of factors involved in freight transport
- To understand the Value Stream Mapping process and how it is currently used within manufacturing
- To analyse how Value Stream Mapping can be applied to a logistics setting and conduct a Value Stream Map analysis
- To determine whether Value Stream Mapping has the ability to improve performance within a logistics setting through analysing its usefulness for an existing New Zealand dairy firm
- To report back to the firm on the findings of this project in terms of efficient transport of finished product in containers

Chapter 2

Literature Review

The aim of this literature review is not only to summarise literature within the context of this project but also to aid in satisfying the first three objectives of this research project. A review of past and present literature was conducted to gain an understanding of the milk drying process, considerations that need to be made when freighting product, and of Value Stream Mapping. The review assumes no previous knowledge of the topics at hand.

2.1 Description of Milk Processing

Raw milk produced on dairy farms must be transported to a dairy processing plant and treated before it enters the market. Processed milk is most commonly sold on the world dairy market as a commodity powder product to be used as an ingredient in consumer products (Fonterra, 2013). Thus, literature in this section is focused on the transformation of the raw milk to a finished powder product after it arrives at a factory and is placed into raw milk silos.

2.1.1 Heat treatment and separation

The pasteurisation process, in short, is a thermal treatment applied to the raw milk (Ibarrola, Sandovai, Garcia-Sanz & Pinzolas, 2002). Walstra, Wouters & Geurts (2006) noted that the heat treatment of milk is important for three main reasons. Firstly, heat treatment helps to kill bacteria that may otherwise be harmful to the consumer. Furthermore, it is specifically concerned with destroying pathogens such as *Mycobacterium tuberculosis*, *Salmonella* strains, *Coxiella burnetii*, *Staphylococcus aureus*, *Listeria monocytogenes* and *Camplobacter jejuni*. Raw milk also contains bacilli and streptococci, which, when in high numbers can reduce the milk pH and decrease its heat stability (Lewis, 1986). Secondly, heat treatment increases the keeping quality of milk. Spoilage organisms are killed and enzymes excreted by microorganisms or enzymes native to the milk, are inactivated. This can improve the shelf life of up to six months. Thirdly, heat treatment establishes specific product properties. For example, heat treatment is used to increase coagulation stability of evaporated milk during sterilisation. Lewis (1986), added that a milder heat treatment of milk, such as low pasteurisation, also helps to change the flavour profile of milk. It can correct odd aromas and off-flavours that can be present due to things such as weed taints.

Batch pasteurisation

Batch pasteurisation is the simplest and oldest pasteurisation method and involves heating the milk to 63 degrees Celsius for no less than 30 minutes (Juffs & Deeth, 2007). The milk is heated in a

jacketed vat surrounded by either water, steam or heating coils of water and steam and must be constantly agitated for the 30 minutes. After this the milk is cooled either in situ, or removed from the vat and cooled elsewhere (Goff, 1995). Due to the nature of the process, commerciality of batch pasteurisation is low. The process is more labour intensive than high-temperature short-time pasteurisation and also the energy costs are higher (Lewis, 1986). Generally, it is limited to on farm use for dairy farmers to feed to young stock before weaning (Godden et al, 2003; Stabel, 2001).

High-temperature short-time pasteurisation

High-temperature short-time pasteurisation occurs when the raw milk is heated to 72 degrees Celsius for 15 seconds and immediately cooled to a temperature of no more than 10 degrees Celsius (Lewis, 1986). Currently, continuous flow heaters are typically used. The milk is fed into the heating section of the plate heat exchanger. This is a series of stainless steel plates placed together. In between the plates are a series of tubes where the heating agent (usually steam) and the milk flow separately. A plate heat exchanger is made up of four different sections; a regeneration, heating, holding and cooling section. The regeneration section warms the milk to between 57 and 68 degrees Celsius before flowing into the heating chamber. Here the milk is heated to 72 degrees Celsius (the required pasteurisation temperature). Milk then enters the holding tube where, after 15 seconds, will pass through to the regeneration section where the cold milk and hot milk act against each other, i.e. the heat from the hot milk warms the cold milk and vice versa. Finally the milk flows through to the cooling stage where a coolant or water brings the temperature of the milk down to the required heat (Walstra et al 2006; White, 2010).

2.1.2 Centrifugal milk separation

Separation of the milk into cream and skimmed milk enables standardisation of fat content prior to spray drying (JWC, 2014). This is easily achieved by centrifugal separation (the most common method of separation) as the fat globules of milk are much lighter in density than the fat free fraction of milk. The output of this process is cream and skim milk. In addition, applying ultrafiltration to the fat free portion of the milk in the separation phase will separate milk proteins from other components of the milk. The implication of this is that the protein content of the skim milk can be standardised for further processing (Jelen, 2011). McCarthy (2011) explained that in the context of the dairy industry, centrifugal separation refers to both centrifugation and cyclone separation; the difference of which rests in the machinery utilised. In terms of centrifugation, separation occurs in centrifuges with power driven rotating bowls. Cyclone separation on the other hand, occurs where the milk is fractionated, but no part of the machine rotates. However it should be noted that cyclone separation occurs after powder drying, and before packing.

Raw milk is fed into the top of the rotating bowl. When the bowl reaches rotational speed, the force of gravity is overcome by centrifugal force, which is 5000 to 1000 times greater than gravity. Every particle is subjected to this force, with the lighter molecules (fat globules) being forced towards the axis of rotation. A number of angled discs (approximately 60 degrees) lie within the bowl and are known as 'disc stacks'. These act as separation channels. Fat globules are captured on the upper surface of the discs and forced inwards, whilst the skim milk is captured on the lower surface of the discs and channelled outwards (O'Mahoe, 1988; Towler, 1986). From this point the skim milk and cream are transported into separate vats to be used again in future stages of the transformation process.

2.1.3 Milk drying

Milk drying is the process where the liquid milk is dried into a powder form. This is achieved by using large driers. The two main spray drying technologies used within the dairy sector are a centrifugal disc and a pressure nozzle (JWC, 2014). However, although not the focus of this literature review, there are other dryers available on the market such as drum drying, foam drying and freeze drying (Walstra et al, 2006). To spray dry milk, small droplets are sprayed into hot air and instantaneously transformed into powder particles (Walstra & Jenness, 1984). In order for this process to happen the milk is atomised (essentially turned into fog-like mist) to create a large surface area. The milk is then exposed to a flow of hot air where the liquid is evaporated, leaving behind only powder (Knipschildt, 1986).

Throughout the process of milk drying there are many sources of variation present:

- Preheating of the milk
- Degree of pre-concentration
- Pressure nozzle or spinning disk to produce droplets
- The pressure, and disk speed
- Temperatures of the air at the start and end of drying (Walstra & Jenness, 1984)

During disk atomisation, the disk spins at 200-300 revolutions per second. The advantage of this is small droplets, no clogging and disk atomisation is still possible when processing highly evaporated milk. However, a large number of vacuoles are formed in the particles and the chamber must be wide in order to prevent the droplets from touching the wall (Walstra et al, 2006). Vacuoles increase the porosity of the powder and reduce the bulk density. Pressure nozzles on the other hand, force the milk out of a small opening by using large amounts of pressure. The advantage of this is that vacuole content is low. However, because the opening is small the pressure nozzles become easily clogged when the viscosity of the milk increases and so highly evaporated milk cannot pass through (Walstra

et al., 2006). It can be seen by this that the two dryers clearly have different purposes. Considering that most dairy processing plants contain more than one drier it is possible that this could cause some issues around product standardisation.

2.2 Product Freight Considerations

There are five main transportation modes for goods: airfreight, motor carriers, pipelines, railroads and by water. In terms of this project, railroads, are the main focus as the majority of milk powder in the South Island is transported from the West Coast to the East Coast using trains. Rail transport is ideally suited to low value bulk goods and provides a relatively inexpensive form of land transport (Fawcett, Ellram & Ogden, 2007). However, Murphy and Wood (2011) argued that while this is the case, there is often limited service and pricing options as due to the lack of competition in the market place. Indeed, in New Zealand KiwiRail is the only major rail company. Based on these factors, in terms of a firms logistics operations, this means that there is very little opportunity to improve transport costs. Therefore the firm must look at loading efficiency, particularly around container utilisation.

Containerisation has revolutionised the way that goods are transported. They have allowed bulk transportation of goods to the global marketplace. It has even been suggested that containerisation has been the largest driver of global growth over the last 50 years (Levinson, 2006; The Economist, 2013). These steel boxes first emerged in the United States of America in 1956, and ten years later the Fairland sailed from Port Elizabeth in the United States to the Netherlands with 236 containers on board, marking the first intercontinental shipment (World Shipping Council, 2014). Since the introduction of containers the industry has grown exponentially with around 2 billion tons of cargo, through more than 500 ports being shipped annually (Ham & Rijsenbrij, 2012). In order for a firm to use containerisation as efficiently as possible there needs to be a number of considerations made. These mainly revolve around the physical container, product packaging, palletisation and loading, and warehouse design.

2.2.1 Containers

Containers are a “reusable transport or storage unit for moving products and raw materials between locations or countries” (Shabani, Seyed Mohammed & Reza, 2011). These storage units are generally made of aluminium or steel and literature shows that there are a variety of container sizes available, with the most common sizes being 20-foot or 40-foot by 8-foot by 8-foot (Chartered Institute of Transport, 1995; Desrochers, 2007; OECD, 2002; World Shipping Council, 2014). Higher containers are called hi-cubes and are typically 9-foot high, however these generally attract a surcharge and are only available on some routes, i.e., not available for train transport (Mainfreight, 2014). Due to the

construction materials and modern information systems, containers are relatively safe. Shabani et al. (2011) argued that containers provide security because the contents of each container are unknown to shippers, which discourages theft.

There are many different types of intermodal container. Aside from conventional end opened containers, the main alternatives are refrigerated containers, tanks, open tops and flat-racks (Wehrheim, 2011). Refrigerated containers, or reefers as they are more commonly known, are electricity powered containers. Reefers are required by 31% of the world's food supply chain as refrigeration maintains the integrity of perishable goods (Fitzgerald, Howitt, Smith & Hume, 2011; Jolly, Tso, Wong & Ng, 2000). Tanks are used in the transport of liquids and are generally spherical containers with a metal frame that meets ISO standards. All tanks are insulated and manufactured from carbon steel and stainless steel (Fahy & Tiernan, 2001). Open top containers on the other hand are used to transport goods that are loaded from the top, such as coal, and flat-rack containers carry goods that can be exposed to the air, such as machinery (Levey, 2001).

2.2.2 Product packaging

Product packaging is important not just for aesthetic and promotional reasons, but also to maintain product integrity and to provide a stackable stability to aid in palletisation. In the case of New Zealand produced milk powder, the finished product is typically packaged in a multi-wall bag with an inner polyethylene line with no staples or metal fasteners used (Fonterra, n.d; Westland Co-operative Dairy Company, 2013). This allows the milk powder to be distributed evenly throughout the bag to help with palletisation for shipment. Murphy & Wood (2011) provided a list of several functions that protective packaging should perform and included functions such as, enclose the materials, restrain from undesired movements, provide reasonably uniform weight distribution, be tamperproof, etc.

Over recent years consumer trends have indicated an increasing environmental awareness and concern for environmentally friendly products and packaging (Russell, 1996; Baker, 2009). The use of plastic has grown drastically in the last 30 years due to its versatility, low cost and consumer friendliness over that of paper (Murphy & Wood, 2011). In the case of food products, polyethylene is the most common type of plastic used. Plastic is viewed as a way to deliver safe food from the farm gate to the plate. For example, polymers been approved by the Food and Drugs Administration and used in the United States of America for the decades (American Chemistry Council, n.d). However, the environmental impacts of plastic cannot be ignored. It is a well-known fact that plastic is not bio friendly and can take several hundred years to biodegrade. Other problems with plastic packaging include its dependency on petroleum in manufacturing and the level of plastic litter, particularly in the ocean (Murphy & Wood, 2011). Because of this, various strategies have been put into place by

firms and governments worldwide. For example, in the 1990's in Germany, the government enacted a Packaging Ordinance with the intent to avoid the impact of packaging on the environment (Association of German Chambers of Industry and Commerce, 2013). Other strategies may include things such as using recycled plastics and using environmentally friendly packaging materials.

2.2.3 Palletisation and loading

One key decision when transporting a containerised product is what sort of pallet to use. The most common pallets are made of steel, plastic or wood. There are also alternatives to using traditional pallets, such as slip sheets. Slip sheets are a unit load support device used in place of a conventional pallet. Typically these sheets are constructed of plastic, fibreboard or solid Kraft board, or are a corrugated design with two Kraft liner boards forming the outer surface and an adhesively bonded corrugated interior (Sebastian, 1999). The decision made regarding unit load support depends on the type of product being transported. Typically, in the dairy industry unit loads are supported by conventional pallets as they provide a greater stability and keep the product off the floor, thus aiding in minimising rodent and water damage.

Pallet configuration is a key consideration when palletising a product. The configuration dictates the pallet load, size, weight and stability. All of these factors are extremely important in transporting the finished product to the final customer, particularly when ensuring product integrity is maintained throughout transport. As a result, many studies have been conducted around the pallet problem, especially in the case of irregular sized packages and creating stability (Kocjan & Holmstrom, 2010; Martins & Dell, 2008; Steudel, 1993). The mathematics of this type of research is beyond the scope of this project, however it should be noted that the results of such studies are utilised and developed into computer programs to aid many organisations in developing stable efficient loads. In addition to this, palletisation also has a direct impact on loading containers. If the pallet is too high to double stack then there is unutilised space within the transport container. The same can be said for pallets that are not loaded to the optimum height. This is inefficient as firms pay the same rate for transport whether the container is full or not.

2.2.4 Warehouse design

Facility location is of tremendous strategic importance to many firms and so the decision requires several considerations to be made. These include things such as proximity to major ports and factory, natural resources, proximity to the customer and population characteristics (Murphy & Wood, 2011). In the context of dairy processing factories, there are large location restrictions due to factors such as perishability of the product and transport costs. This means that the proximity to natural resources is one of the most powerful factors in determining location. This rests on the concept of weight-losing

and weight-gaining products. If products lose weight through processing, such as milk, factories should be located close to extraction of raw supply and warehouses located closer to market (Murphy & Wood, 2011). Due to New Zealand's small geographical area and isolated position on the globe, other location factors such as proximity to customers and to major ports are not as important to New Zealand exporting dairy companies; especially when a comparison is made between New Zealand and landlocked exporting dairy producers.

Design considerations of the warehouse or distribution centre are also important. These considerations pertain to factors such as aisle width and pallet storage systems. Aisle width is the distance between adjacent racks and is determined by the turning circumference of a forklift and the size of the pallet (Richards, 2011). Calculating the optimal aisle width is crucial as this decision determines productivity, space utilisation, flexibility, safety and equipment costs of the specific application (Piasecki, 2002). Richards (2011) noted that a 2008 study conducted by Baker and Perotti revealed that there are currently around 11 different pallet storage systems in use today. However, for the purpose of this literature review only the top three will be noted:

- Floor/block storage – the goods are packed in their unit loads and stacked to their maximum safe height.
- Single deep racking – pallets are racked one deep. This is the most common storage method worldwide and is the most versatile
- Narrow aisle racking – the aisle width is reduced to just 1.6 meters. As a result, specialised forklifts, known as turret trucks are required.

In terms of storing milk powder in a warehouse or distribution centre, often times the floor/block storage method is used. The shape of the pallets allow for easy stacking and the floor stacking allows for quick picking when sending product to transport.

2.3 Value Stream Mapping

A study by Radnor, Walley, Stephens & Bucci (2006) assessed the application of Lean in the public sector in order to evaluate its impact on productivity and/or quality of service. This section of the literature review has adopted the structure of that piece of research in order to logically provide an overview of Value Stream Mapping under the three headings perceptions, implementation and outcomes. Following that is a brief overview of recent developments in Value Stream Mapping literature pertaining to two developments: Value Stream Costing and the transportation Value Stream Map.

2.3.1 Perceptions of value stream mapping

Many articles have been written about Value Stream Mapping since the emergence of Lean and it is viewed as one of the most suitable tools to use when undertaking a value stream analysis. Value Stream Mapping and value stream analysis have become so commonplace within the context of Lean that the two terms are used interchangeably (Nasution & Nasution, 2013). However, the fundamental difference between the two is that Value Stream Mapping is a tool to undertake a value stream analysis, not the analysis itself. Other analysis tools include, but are not limited to, affinity diagrams, causal mapping, knowledge maps and process flow diagrams (Davies, 2010). Womack (2006) noted that the objective of drawing the map is to identify each action needed to create value. When these are carefully recorded it becomes relatively simple to assess performance and identify waste within a process. This has the potential to be particularly helpful in the context of logistics because it is one business area where costs are generally quite high.

Value Stream Mapping is commonly undertaken using teams and workshops. The main purpose of this being that there will be a pooling of knowledge from all functions of the business regarding the process being analysed (Dickson, Singh, Cheung, Wyatt & Nugent, 2009). Liker (2004) stressed the importance of people within teams, as they often have extensive knowledge in their respective fields and are the ultimate drivers of Lean implementation. Indeed, Toyota who have set the benchmark for today's Lean, hold people at the core of every aspect of their business. Liker (2004) demonstrated the importance of people in Toyota through the house of Lean. This "house" is built on the foundation of the Toyota way philosophy and work processes, and is held up by the pillars of continuous improvement, quality and just in time processing.

2.3.2 Implementation of value stream mapping

Rother & Shook (1998) described the five phases of Value Stream Mapping. These are:

- Selection of a product family
- Current state mapping
- Future state mapping
- Defining a working plan
- Achieving the working plan

Just like all foundational works of Lean, this instruction is applied to the area of manufacturing. However, it can be argued that the process is reasonably generic and thus, can be applied to other areas such as logistics. The first two phases of Value Stream Mapping are quite clear but phase three is not. Lasa, Laburu & Rodolfo (2008) noted that guidelines are required for the definition of the

future state map. The authors went on to argue that Lean provides guidelines such as; “establishment of continuous flow where possible” (p. 41). These guidelines aid users in how the map should be drawn. Phase four and five of the process of creating a Value Stream Map differ between each individual project conducted as there is variability in what each project aims to achieve and also between the people working on the project.

Organisational management is pivotal to the success of any sort of business improvement attempt and the ‘top down approach’ is well recorded throughout business management literature (Lok, 1997; Su, Yang & Yang, 2012). This can also be applied to Value Stream Mapping. Dickson et al. (2009) also added that many managers need to alter previously hardened mind sets in order to implement Lean techniques successfully. Unfortunately this is not as commonly adopted as it should be and, as a result, many attempts to implement Lean through techniques such as Value Stream Mapping fail to do so.

2.3.3 Outcomes of value stream mapping

The key outcome of Value Stream Mapping is to improve a process, and by extension, the business. This is explained consistently across literature, and involves improvements such as improved lead times, higher productivity and increased quality (Hines, Rich & Esain, 1999; Seth, Seth & Goel, 2008). These outcome goals do not have to be one large overarching goal to improve every aspect of business, but instead are able to be smaller more attainable goals, as long as they are consciously linked to the overall goal (Radnor et al, 2006). In order to benchmark results it is important that desired tangible outcomes are noted. This leads to the next point. Outcomes are able to be separated into two categories, tangible and intangible. Although intangible outcomes are not heavily referenced within a manufacturing process, they are of importance (and recognised within a service setting) as intangible outcomes can provide management the opportunity to assess impacts upon employees (Radnor et al, 2006).

Intangible outcomes still deliver value to the end consumer and may include things such as process change, culture change, better understanding of customer needs and greater staff satisfaction (Radnor et al, 2006). Perhaps the most notable intangible outcome is the culture change. Changing an organisation's culture can be an extremely difficult task for a number of reasons. Smith (2003) denoted several factors. Examples include an inward looking, bureaucratic and autocratic culture, senior managers losing touch, leadership loses confidence etc. Value Stream Mapping provides a pathway to this culture shift. The outcomes of Value Stream Mapping exercises are seen rapidly and so can encourage staff to think of the overall business (Espinosa, Reficco, Martinez & Guzman, 2014).

2.3.4 Developments of value stream mapping

Over recent years new value stream applications have been developed. These new applications use the original Value Stream Map as the foundation but incorporate specific changes. This literature review will discuss two new developments:

- Value Stream Costing - emerged in 2004 with Ward's publication "Costing for competitiveness: cost management and accounting for lean enterprises" (Salah & Zaki, 2013).
- Transportation Value Stream Map - emerged in 2012 with Villarreal's paper "The transportation Value Stream Map".

Value stream costing

Traditional accounting methods clash with lean manufacturing implementation. This is because traditional accounting has many limitations, such as distorted costs (Ruiz-de-Arbulo-Lopez, Fortuny-Santos & Cuatrecasas, 2013). In order to address this problem, activity based costing was introduced by Johnson (1987). However, this accounting method requires a lot of time to accurately cost activities and so critics argue that it is simply an extension of traditional accounting (Salah and Zaki, 2013). In reaction to this, as stated above, Ward introduced the concept of Value Stream Costing. This method Li, Sawhney, Arendt and Ramasamy (2012) argue, bridges the gap between operational views and financial views of lean.

Ruiz-de-Arbulo-Lopez et al (2013) defined Value Stream Costing is the process whereby the information from the Value Stream Map is used to calculate the cost of the whole value stream. In order to do this, costs such as materials, labour and machine depreciation, as well as others such as consumables are considered. Salah and Zaki (2013) also had a very similar definition and defined Value Stream Costing as "the process of assigning the actual expenses of an enterprise to value streams, rather than to products, services, or departments" (p. 90). Unlike many concepts, Value Stream Costing seems to have a consistent definition across various pieces of research, thus, allowing empirical research to be undertaken.

Transportation value stream map

The Transportation Value Stream Map is a tool that Villarreal (2012) developed in his publication "*The transportation value stream map*". The author argued that the transport of goods closer to the final customer can be said to be a value adding activity and that by viewing the supply chain as a process, non-value and value adding activities in road freight could be measured and exposed waste eliminated. The result of which is an improvement in the transport portion of the supply chain.

The tool was developed on the foundation of the 'overall vehicle effectiveness' measure. The main objective of Simons, Mason and Gardner's (2004) work was to create one overall operational measure of road freight efficiency. The authors designed the measure to reflect the importance of the road freight industry to the "UK's sustainable development strategy, and to leverage transport providers' profitability" (p. 119). This was achieved by altering the principles of the 'overall equipment effectiveness' measure to measure the effective utilisation of a vehicle in the freight transport industry. This research led to the definition of the five transport wastes:

- Driver breaks
- Excess load time
- Fill loss
- Speed loss
- Quality delay

The five wastes identified and defined by Simons et al. (2004) were used to identify non-value adding activities on the map. They were adapted from Ohno's seven manufacturing wastes:

- Overproduction
- Waiting
- Transporting
- Too much machining (over-processing)
- Inventories
- Moving
- Making defective parts and products (Ohno, 1988, p. 129)

When the transportation wastes are compared with Ohno's seven wastes then it can be identified that the wastes of driver breaks and excess load time contribute to waiting. Fill loss and speed loss both entail paying more for a process than strictly necessary and thus may be considered over-processing, and finally, quality delay is associated with the waste of making defective parts and products.

2.4 Conclusion

Milk processing is the process in which raw milk is transformed into the final product. In this particular case, the finished product is in a powdered form. It was explained that there are two main types of milk pasteurisation, with the most common commercial method being high-temperature short-time pasteurisation. During the separation phase, the milk is split into cream and skim milk.

During further stages in the process the cream may be added back to the milk in order to achieve different product specifications. Milk drying is the stage where the most variation is introduced to the product. Most dairy processing plants operate more than one drier and so this can cause some problems in terms of product standardisation.

In terms of product freight considerations, a review of the literature found that there are four main decisions to be considered. The first of these is the physical container. Firms not only have the choice of different sizes, but also what type of container to select for the transportation of the final product. The second consideration is the packaging of the product. The packaging is not selected just for aesthetic appeal but also needs to meet several needs. In terms of milk powder, this is often in a multi wall bag with an inner polyethylene lining. The third consideration to be made revolves around the pallet and its load. These choices impact the storage of the product as well as container utilisation. Warehouse design considerations rest in the location choice as well as the facility design. Milk powder is a weight losing product and so the factories should be located close to the raw extraction and the warehouses and distribution centres should be located closer to market. All of these decisions impact not just the ability to maintain product integrity through to market but also impact on the operating costs of a firm.

Value Stream Mapping is a very useful Lean tool, especially when undertaking a value stream analysis. The mapping is commonly undertaken in teams and workshops because there is a pooling of knowledge around the process being mapped. When attempting to draw the map there are five phases. In order for the exercise to be a success, managers must be open to the changes proposed. Unfortunately this is the reason many efforts to implement Lean into a workplace fail.

Over the recent years new value stream applications have been developed. This literature review looked at two developments. The first was value stream costing in which the authors discussed the incompatibility between traditional accounting methods and Lean implementation and then attempted to bridge the gap with value stream costing. The second development was the publication of a Transportation Value Stream Map. The author mapped the transportation process and then used Ohno's seven wastes to develop the five transportation wastes. Despite these developments, there is still a gap in the literature surrounding agricultural firms in general, Value Stream Mapping of the product transportation process from a manufacturing firm's point of view, and also introducing cost as the main measure of a Value Stream Map. This project will attempt to address these issues.

Chapter 3

Methodology

Chapter 1 outlined the importance of lean manufacturing and supply chain management in the dairy industry of New Zealand, and identified the project's aims and objectives. Chapter 2 provided a literature review on milk processing, containerisation and transport, and Value Stream Mapping. This chapter begins by stating the objectives that have not been previously considered, since these will suggest appropriate research methods appropriate for this study. These were:

- To analyse how Value Stream Mapping can be applied to a logistics setting and conduct a Value Stream Map analysis
- To determine whether Value Stream Mapping has the ability to improve performance within a logistics setting through analysing its usefulness for an existing New Zealand dairy firm
- To report back to the firm on the findings of this project in terms of efficient transport of finished product in containers

As stated in the aim, this research will adopt a case study approach. Section 3.1 will explain and justify why a case study has been chosen. Subsequent sections within this chapter will introduce the case for the project and then explain the research methodology to be followed.

3.1 Research Design

A case study approach has been chosen for this research. This is an appropriate method given the aims and objectives of the project outlined in Chapter 1. Gerring (2004) defined a case study as “an intensive study of a single unit with an aim to generalise across a larger set of units”. Stake (1995) went deeper than this and characterised three main types of case study; intrinsic, instrumental and collective. This current project will use a combination of an intrinsic and instrumental approach. This approach utilises a particular case (for this research it is Westland Milk Products) in an attempt to gain a better understanding of Value Stream Mapping as a Lean tool and its potential application in an agricultural supply chain context (Grandy, 2010). However, it is important to note that there are many critics of Stakes case study classification as it does not provide a definitively clear distinction between the different case study approaches (Blaikie, 2010; Kohlabacher, 2006).

According to Yin (2003), case studies are the preferred research method when “how” or “why” questions are being asked, the researcher has little control over events and the focus is on a current real-life phenomenon. This method allows for a holistic and meaningful understanding of the process to be gained. The greatest advantage of a case study over other research methods is that it allows a

very specific and extensive investigation into a particular problem or phenomenon. However, it must be noted that Zikmund (2007) warned that the data gained has the potential to become overwhelming and information can take quite some time to interpret and become usable. Thus, great care must be taken in the data gathering phase in order to collect all relevant information, yet not gather so much data that analysis becomes very difficult.

Case study research is generally considered to be qualitative in nature. Qualitative research involves a phase of fieldwork in which the researcher gathers information directly from the people experiencing the problem or phenomenon (Creswall, 2003). However, because there is a human element present subjectivity is introduced into the research. This subjectivity is subsequently present when collecting data and interpreting the results, hence, often times some element of bias is introduced. Lin (2003) argued that this limits the basis for scientific generalisation. He then went on to note that though case studies cannot be applied to populations or universes, they are generalizable to theoretical propositions. Thus, the aim of a case study is to expand and generalise theories, not to enumerate frequencies.

Stake (1995) identified five steps for conducting a case study:

1. Identify approach – use the research problem to identify a case study approach
2. Case study selection – the researcher selects the case or cases
3. Data collection – researcher determines type of data collection and collects data
4. Data analysis – the researcher selects the type of analysis, develops a description of case and sets focus on key issues
5. Interpretation – researcher reports the study

The steps outlined above will be used in this project as a basis for conducting the current case study. The proceeding sections of this chapter will outline the case organisation, the steps to be taken, and the types of data collection to be used. Chapter 4 will contain an analysis and discussion of the results. A final report will subsequently be provided for Westland Milk Products for their own use.

3.2 Case Selection

Westland Milk Products (WMP) has been selected as the organisation within the case study. The firm is a dairy processing co-operative based in Hokitika on the West Coast of the South Island, New Zealand. Operating since 1937, the business is the major employer of the Westland province, employing over 250 staff (Crawshaw, 2004; Westland District Council, n.d). Suppliers are mainly located on the West Coast of the South Island, with some members being located in Canterbury. Milk collected in Canterbury is then condensed and shipped back over to the West Coast to be

transformed into processed goods ready for export. WMP mainly produce commodities to sell on the market. However, the company does produce some branded value added products, such as EasiYo yogurt powder and Westgold butter. Other key milk products sold include, but are not limited to, casein powder, milk powder (including skim milk powder and whole milk powder) and milk powder concentrate (Westland Co-operative Dairy Company, 2014). Once these products have been processed they are transported to the warehouse in Rolleston, before being shipped from Lyttleton Port to overseas sales destinations.

3.3 Research Methodology

Taking the research objectives outlined in the introduction to this chapter into consideration, the following methodology and steps are proposed:

3.3.1 Background research

Before interacting with a dairy processing firm of which I have very limited knowledge, some considerations need to be made:

- An illiteracy around Value Stream Mapping
- The lack of knowledge surrounding WMP and the firms operations

The first of these considerations is an illiteracy about Value Stream Mapping. This includes proper interpretation of a Value Stream Map as well as value map design. Therefore significant research needs to be undertaken around previous case study mapping research as well as Value Stream Mapping literature. Academic publications in general tend have a greater emphasis placed upon the literature reviews, results, discussion and conclusions, and thus, do not provide a great amount of detail into how the case study was actually conducted. The implication of this is that Value Stream Mapping literature is relatively simple to research. However, information regarding case study research is not as easily found. Hence, a great amount of attention needs to be paid to the process and then documented.

A lack of knowledge of WMP exists in all area of the business. This includes all business processes from milk processing, to computer systems, and health and safety requirements. A lack of knowledge also exists around employment positions within the business and the roles and responsibilities of those specific positions. This will result in difficulty around data gathering and making contact with appropriate staff members. The implication of this limited knowledge is that research may take on a more unstructured and non-traditional approach than is originally anticipated and outlined within the research method.

3.3.2 Developing a research method

A research mandate has been provided by WMP. This outlines some of the key personnel involved within the project as well as a brief background to the project and an outline of the firm's objectives. The project outline goes some way in identifying which staff to approach for access to appropriate data. However, the mandate does not include all interested staff members and data needed. Therefore, it is important to identify staff interactions and gain an understanding of how to approach staff to gather relevant information. This is particularly true in the case of gaining an overview of processes within WMP. Once staff information and interactions have been discovered, staff contact can be made throughout the course of the project.

Familiarity of computer systems will also need to be gained. This will aid in the gathering of information relevant to the project. This understanding will be gained on site at the plant in Hokitika. A list of accessible files will need to be recorded in order to allow efficient use of the system. Company specific software packages will also need to be understood as the software will aid in data gathering. Once a basic literacy is learned, access to the computer system will also be available from the main sales office in Rolleston.

3.3.3 Data gathering and analysis

The result of the initial research will be the production of a current state Value Stream Map. In order for this to happen, visits to both the Hokitika and Rolleston sites need to be made. Field notes will be taken at both sites and will be as detailed as possible. This detail will include information on business processes, diagrams and graphs, as well as any additional information gained from personal communication with staff members. The data gathering methods of this project stage will be through the use of observation and targeted information gathering from specific employees. These field notes will then be re-recorded in a more formal manner on a computer using a software program, such as Microsoft Word.

Once the field notes are more permanently recorded they will be used to create a Value Stream Map. It is likely that the program Microsoft Visio will be used to create the Current State Map. Any gaps identified in the process maps will require communication with WMP in order to obtain the missing data. The final map output of the software will then be discussed with my supervisor Dr. Jeff Heyl in order to guarantee accuracy and discuss the future direction of the project.

3.3.4 Reporting

One of the most important parts of the reporting process is the drawing of the Value Stream Map, as the accuracy of this information will determine the quality of the analysis. This reporting is directly

related to the quality of information gathered from staff at WMP as well as my own observations and personal information gathering. As the map is created they will be analysed by supervisors to ensure accuracy. Not only that, but also the relevance of the information contained within the Maps and any gaps where information is lacking is assessed.

Reporting needs to be communicated with WMP staff involved in the project. This will give the firm an opportunity to assess developments throughout the progress. Staff will also have an input into the areas of focus that may need more attention. This however, is likely to be from a commercial view point, not an academic one.

3.3.5 Dialogue and final report

Contact is to be made with my university supervisor Dr. Jeff Heyl, WMP project executives and the Continuous Improvement Leader J. Kenny at each stage of the project. This will allow any corrections to be made in order to ensure accuracy of content.

At the completion of the project a final report will be produced for WMP. This will contain the Value Stream Map, analysis and final recommendations made to WMP in order to improve the efficiency of container transport between Hokitika and Rolleston. The Value Stream Map and the cost analysis conducted will provide the base for the recommendations. At this point it is at the discretion of WMP whether the proposed changes are undertaken or not.

3.4 Summary

Just as with any research conducted, a level of adaptability and flexibility must be demonstrated. Case study analysis allows for both of these. Hence, although the proposed methodology is the framework for this research, small changes to this are likely.

The information gained throughout the data collection phase will ultimately be used to create a Value Stream Map. This Current State Map will show the current process of transportation of product from Hokitika to Lyttleton. In order to achieve this, information gathered from targeted information gathering and observations will be crucial. The final results will ultimately depend on this phase of the project, particularly in terms of accuracy.

Due to the purpose of this project, the case study will lack a longitudinal design. The case study itself focuses heavily on the current state and will then make a recommendation to WMP on the best future state, in terms of achieving double stacked pallets within the containers. The report received by WMP will then be used at their discretion and it is the sole decision of the company whether or not to act upon these findings.

Chapter 4

Results

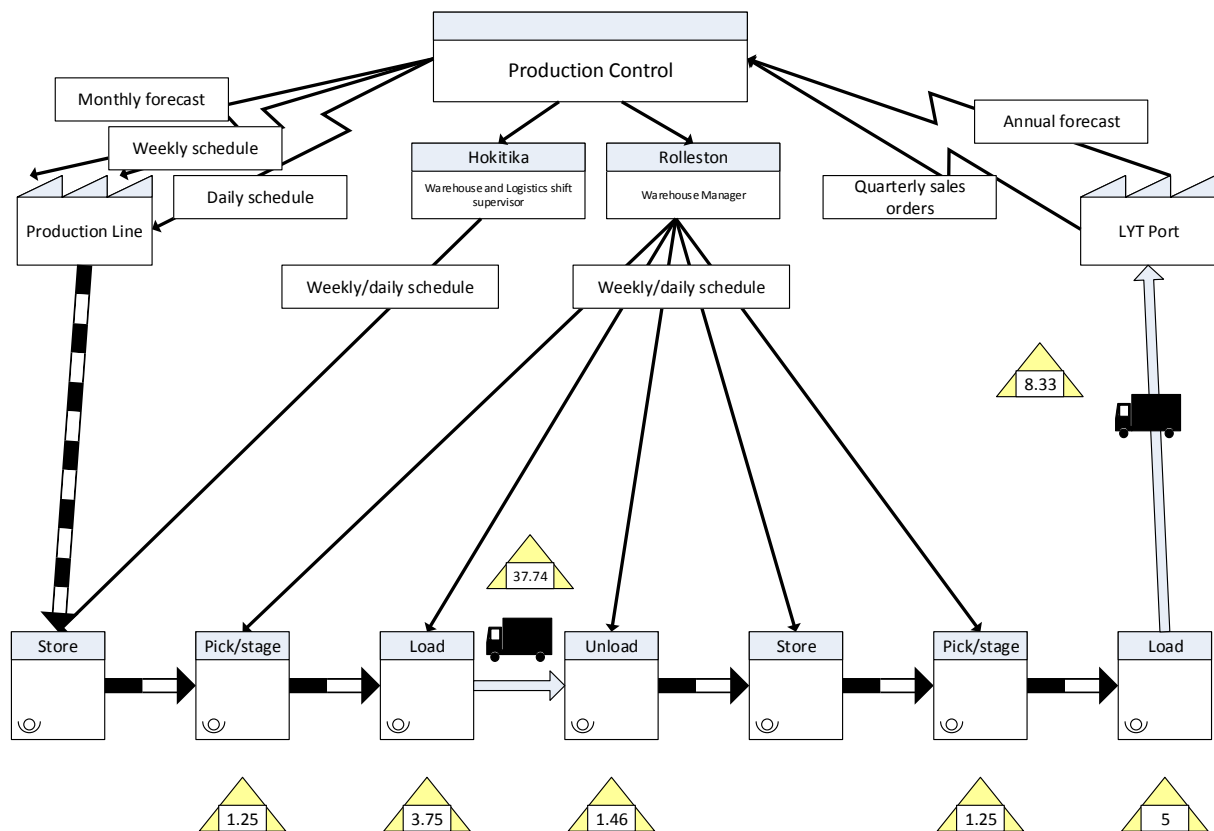
In order to be able to draw a Value Stream Map, visits to both the Hokitika and Rolleston sites were organised. This meant a basic understanding of the milk manufacturing process and transportation of the finished milk powder was able to be gained. Following the initial visit, one additional meeting in Rolleston was organised in order to observe the train arriving and the loading and unloading process that accompanied. Proceeding this, targeted information gathering was undertaken in order to gather the appropriate gain data about specific stages in the process.

The project mandate supplied by WMP had the objective of achieving double stacking of 20 foot containers between WMP Hokitika and WMP Rolleston. This meant that the nature of the project was not improving the transport process, particularly since the logistics provider is outside of the control of WMP, but rather improving container utilisation. The implication being that, the Value Stream Map and analysis needed to be cost based rather than time based.

This chapter will show the Value Stream Map developed and explain some of the features, describe costs that were gathered and provide an explanation of the calculations used. Finally this chapter will provide a detailed explanation of the analysis that was carried out.

4.1 Value Stream Map

As stated above, the Value Stream Map and analysis needed to be cost based. In terms of the Value Stream Map, this creates some difficulties in drawing the map. Traditionally, the Value Stream Map shows the overall process and indicates details such as level of inventory, cycle time and time spent on value added activities and non-value adding at each stage of the process (Rother & Shook, 1998). However, the developments in Value Stream Mapping, which were described in section 2.3.4 of the literature review (Chapter 2), show variations of a traditional map. The Value Stream Map developed in this study takes the structure of a traditional map and adopts some symbols in a non-traditional manner. It is shown below:



4.1.1 Value stream map symbols

It can be seen from the Figure 1 that the Value Stream Map takes on a traditional structure. The process displayed is the transportation of skim milk powder, whey protein concentrate and acid caseinate powder from the Hokitika WMP distribution centre to the Rolleston site warehouse. Although named the transportation process, the map shows the flow of product moving along the value chain. This is very different from Villarreal's (2012) Transportation Value Stream Map, where the focus was purely on the efficiency of the actual transport.

According to Rother and Shook (1998), the inventory of a Value Stream Map is illustrated by a warning triangle symbol. As the purpose of this map is to demonstrate the cost of each stage, these triangles have instead be used to demonstrate either cost per pallet, or cost per tonne. The justification of this being that, in a traditional Value Stream Map inventory and time are the main metrics used. In this map cost is the metric. Time, in a traditional Value Stream Map is shown at each process stage in the form of cycle time and also as a timeline at the bottom of the map to help separate the value added cycle time from non-value added time. Therefore, because time is included in the cost and value added and non-value added time is not a function of the map drawn for WMP,

it can be argued that this eliminates the need for a cycle time measurement and timeline. The implication being that only the inventory symbol remains.

In terms of the literature, there is no clear correct symbol to use for cost as no instances of monetary cost used as a main measure could be found. Hence, for the purposes of this study, the inventory icon has remained in the Value Stream Map, but has been adapted to cost to suit the needs of the study. All other elements within the map maintain the icons accepted and used in academic research.

When viewing the processes in Figure 1 it can be seen that the process “store” has no cost affixed. Storage costs have been excluded as they are based on the total annual budget for the warehouse cost centres, divided by the total annual budgeted production. As the container utilisation is to be analysed, and not production, the volume of milk powder handled does not change and thus, the cost should not be affected by this project outcome.

4.1.2 Cost calculations

Looking at Figure 1, it can be seen that costs are split into two categories; handling costs and transportation costs. A summary of these categories is shown below:

Handling Costs (NZD)		Transportation costs (NZD)	
Pick and Stage	1.25	Hokitika to Rolleston	37.74
Load	3.75	Rolleston for Lyttleton	8.33
Unload	1.46		
Pick and stage	1.25		
Load	5		

Table 1: Summary of handling and transportation costs

The handling costs included costs that vary depending on the number of pallets handled. The general calculation for these was the total labour cost divided by the number of pallets per container. Only the variable wages of those that come into direct contact with the product were included in the calculation. This was the forklift driver. Other staff, such as the Container Handler driver were

excluded as the number of containers transported will remain the same. WMP currently handle 1.8 tonne double wide pallets. The number of double pallets placed inside of a container is currently five. Hence, this was the consideration made when developing in the handling costs calculation for each stage of the process.

The pick and stage activity in Hokitika included the forklift driver picking the pallet from the storage location within the Hokitika distribution centre, and then placing the pallet within the staging area. Employees of WMP revealed that this process took the forklift driver three minutes to complete. They also communicated that the average hourly wage of a forklift driver was \$25, and this was the same across both sites. Using this information the following cost was calculated:

$$(25/60)*3 = \$1.25 \text{ per pallet}$$

The load stage of the process in Hokitika involved picking the pallet from the staging area and placing it into the container and finally closing and locking the container. Three forklift drivers were responsible for loading containers for the train in Hokitika. Staff indicated that that four containers could be loaded in one hour. The resulting calculation of this was:

$$(25*3)/4 = \$18.75 \text{ per container}$$

$$18.75/5 = \$3.75 \text{ per pallet}$$

Unloading of the train from Hokitika is carried out by two forklift drivers. Data collected noted that 24 containers of product could be unloaded in three and a half hours. This resulted in a calculation of:

$$(25*2)*3.5 = \$175 \text{ in wages}$$

$$(175/24)/5 = \$1.46 \text{ per pallet}$$

The second pick and stage process involves the same process as Hokitika, just at the Rolleston site warehouse. Again this process takes one driver three minutes to move one pallet from storage to the staging area. As stated above, the wages for jobs are the same across both sites. Hence the following calculation was derived:

$$(25/60)*3 = \$1.25 \text{ per pallet}$$

As with the pick and stage process, the load process in Rolleston is the same as in Hokitika. However, staff contacts indicated that three forklifts load the train containers for export and that one container can be loaded in 20 minutes. This provides a figure of:

$$(25 \times 3) / 3 = \$25 \text{ per container}$$

$$25 / 5 = \$5 \text{ per pallet}$$

The transportation costs were calculated per wagon and on a per tonne basis. The calculation was simply the price of the wagon transport divided by the weight capacity. In terms of the train from Hokitika to Rolleston, the containers have a flat rate of \$500. Two containers sit on a wagon; hence one wagon costs \$1000. According to the project mandate and confirmation from employees of WMP, it was confirmed that the wagons have a 31.5 tonne gross weight capacity. A search for the tare weight of a 20 foot intermodal shipping container revealed a range of container weights. The container specifications by provided by Mainfreight (n.d.) were selected as the reference weight because the tare weight of 2300 kilograms seemed to be the mean weight. Allowing for variance, a final weight of 2500 kilograms was selected. This resulted in a net weight capacity of 26.5 tonne. This resulted in the final calculation of:

$$1000 / 26.5 = \$37.74 \text{ per tonne}$$

The same method of calculation was applied to the train from Rolleston to Lyttleton Port. Employees of the firm confirmed that the wagons have a 36 tonne net weight limit. The cost of one container on this route is \$150. If multiplied by two to find the cost to WMP for transporting a wagon, the result is \$300. The final calculation:

$$300 / 36 = \$8.33 \text{ per tonne}$$

Although WMP does not technically lose money with under-utilisation of the containers, the firm is introducing waste. Within the philosophy of Lean anything that does not add value is considered waste, and waste is a cost in any organisation (Liker, 2004). In this situation, WMP is paying more for the container than is strictly necessary. Within this study the concept of waste was introduced in section 2.3.4 of the literature review with the description of Ohno's seven wastes and the transportation value stream map. Hence, when referring to the seven wastes, under-utilisation of the containers can be classified as over-processing. The implication of this is that a numerical value is able to be placed upon each tonne to determine the cost of waste.

In order to do ensure accuracy and generalizability of the results across the three powders, two additional assumptions were made:

- All three products (Skim Milk Powder, Whey Protein Concentrate and Casein Powder) have approximately the same bulk density
- Each product is regularly made on the same drier and so will have a relatively consistent bulk density

4.2 Analysis

As stated above, the main objective of the case study was to improve the container utilisation of the three milk powder products for railroad transport between Hokitika and Rolleston. The current pallets used are double wide pallets loaded with 1.8 tonne of milk powder. In order to achieve double stacking a few options were considered. The most feasible of these options was to change the pallet size. There are two ways to do this. The first is to change the physical pallet size and shape. The second option is to change the weight placed upon the pallets in order to change the height.

It was determined that changing the physical wood pallet area will not positively impact the capacity and/or cost of the product in the containers. The justification being that the floor space in the containers is currently fully utilized. This would have one of the following three implications. Firstly, physically altering the pallet size would reduce the floor space utilised within the container and would increase costs. Secondly, if pallets were able to be altered to utilise all of the floor area within the container, there would be increased handling costs for little additional benefit. The height gained in order to maintain the same pallet weight would either exceed the maximum container weight allowed or, would exceed the WMP set export height of 1200 centimetres. According to New Zealand Trade and Enterprise (2014), packaging requirements are often country specific. Hence setting a limit ensures that pallet heights are within specification of the customer export destination. Finally, WMP would need to invest resources in changing the pallet configuration. Thus, it is likely that the costs of altering the pallet would outweigh any possible benefit to be gained.

The remaining feasible option is to alter the total volume of the pallet in an effort to achieve double stacking within the container. Altering the height would not impact on the floor area utilised but would allow more product to be loaded. This could result in some significant cost savings. However, there is potential for the benefits to be offset by the increased costs of handling both upstream and downstream of the transportation process. In order to investigate this further a cost based analysis was conducted. Pallets within the 1 to 1.8 tonne range were investigated. This range was selected based on two particulars. Firstly, pallets weighing over 1.8 tonne would only be able to marginally improve container utilisation. However, this would not have met the project mandate and also there is the possibility of breaching the 1200 millimetre height restriction. Secondly, pallets under 1 tonne would result in significantly increased handling costs and would likely have no greater container utilisation than the stacking of pallets within the 1 to 1.8 tonne range as triple stacking of pallets would be introduced.

As stated above, the pallets currently used by WMP are double wide and are loaded with 1.8 tonne of product. Each bag of powder weighs 25 kilograms and is stacked nine layers high, with eight bags per pallet, i.e., a total of 72 bags of powder per pallet. From this it can be determined that one layer

of the pallet weighs 200 kilograms. The implication being, that to stack full layers, the tonnage must be of an even number, i.e. 1 tonne, 1.2 tonne, 1.4 tonne etc. In order to achieve stability as well as space utilisation only those weights resulting in a full layer of product were considered. Of the four options remaining (five if considering the current weight), it was found that to double stack a 1.4 tonne or a 1.6 tonne pallet, the total wagon weight which holds two containers, would exceed the net wagon limit of the train from Hokitika to Rolleston. The result of this is that only two alternate pallet weights are feasible; a 1.2 tonne pallet and a 1 tonne pallet if double stacking is to be utilized.

As stated above, the train wagon from Hokitika to Rolleston has a 31.5 tonne gross weight capacity. The average tare weight of a container is around 2300kg. Allowing for a 200kg variation per container, the net wagon weight allowance is 26.5 tonne. It was noted by WMP that the current 1800 kilogram pallet was only a few layers off being able to be double stacked. When the product is transported from Hokitika it is loaded on wooden pallets. However when the product is sent to export, the wooden pallet is removed, leaving behind a plastic slip sheet (described in section 2.2.3) which allows for double stacking. Therefore, when considering pallet heights, any pallet with less than nine layers should theoretically be able to be double stacked. When considering a 1.2 tonne pallet, this is indeed the case. This size pallet would result in 12 layers of powder plus the additional two wooden pallets; well below the 18 layers plus two pallets that a double stacked 1.8 tonne pallet would contain. In addition to this, double stacked 1.2 pallet would have a wagon weight of 24 tonne; well within the 26.5 tonne limit.

When considering a 1 tonne pallet option, double stacking the pallets would result in a wagon weight of just 20 tonne. The implication of this being that there is 6.5 tonne of unutilised space. WMP currently has a second project underway to investigate the feasibility of custom built containers. This would increase the height of the containers and potentially allow for triple stacking of a 1 tonne pallet. In terms of the 1 tonne pallet, this would allow for much better utilisation of the container with two additional options to be considered. Firstly, a wagon holding 25 tonne could be achieved through triple stacking one container and double stacking the other. Secondly, a 26 tonne wagon load could be achieved by fully double stacking each container and then partially triple stacking the containers to hold a total of 26 tonne. The proceeding table shows the handling costs of the current pallet size and the additional four options investigated:

	Hokitika to Rolleston				Rolleston for Lyttleton			
Pallet Weight (kg)	No. of Pallets per Wagon	Pick and Stage	Load	Unload	No. of Pallets per wagon	Pick and Stage	Load	TOTAL
1800 (CURRENT)	10	1.25*10 12.5	3.75*10 37.5	1.458*10 14.58	20	1.25*20 25	5*20 100	189.58
1200	20	1.25*20 25	3.75*20 75	1.458*20 29.16	30	1.25*30 37.5	5*30 150	316.66
1000	20	1.25*20 25	3.75*20 75	1.458*20 29.16	30	1.25*30 37.5	5*30 150	316.66
1000	25	1.25*25 31.25	3.75*25 93.75	1.458*25 36.45	30	1.25*30 37.5	5*30 150	348.95
1000	26	1.25*26 32.5	3.75*26 97.5	1.458*26 37.91	30	1.25*30 37.5	5*30 150	355.41

Table 2: Handling costs per wagon

The scope of the project was the transportation phase of product between Hokitika and Rolleston. However, as Figure 1 shows, the transportation process of product involves a much wider scope than just the initial transport from Hokitika to Rolleston. This makes it important to acknowledge and understand the flow on effects that changing the pallet size in Hokitika will have on the next phase; the transportation element involved in sending product to export. Hence the impact on handling costs were calculated for “Rolleston for Lyttleton” as well.

Each stage of the process was calculated by multiplying the cost per pallet by the number of pallets placed in a wagon. As stated above, the number of pallets placed in a container will differ between the two sites as the wooden pallet is removed in favour of plastic slip sheets. In addition to this, the train from Rolleston to Lyttleton is able to hold more weight. The net weight limit of a wagon is 36 tonne which consequently, is the total weight of a double stacked 1.8 tonne pallet wagon. As the number of pallets increase so to do the handling costs. However, handling costs are only part of the total cost and so the cost of wagon utilisation also need to be taken into account.

The table below has taken the cost of transport into account to give each tonne of a dollar value. Although the container price of transport is a flat rate, when the full container capacity is not used there is waste. By working out the per tonne cost based on the total weight capacity it is possible to work out the cost of waste. This was calculated by subtracting utilisation away from the wagon capacity and multiplying by the per tonne value. A value was calculated for both Hokitika to Rolleston and Rolleston to Lyttleton Port:

	Transport Hokitika to Rolleston			Transport Rolleston to Lyttleton			
Pallet Weight (kg)	No. of Pallets per Wagon	Wagon Weight (tonne) Hokitika	Waste	No. of Pallets per wagon	Wagon Weight (tonne) Rolleston	Waste	Total Waste
1800 (CURRENT)	10	18	(26.5-18)*37.74 320.79	20	36	36-36 0	320.79
1200	20	24	(26.5-24)*37.74 94.35	30	36	36-36 0	94.35
1000	20	20	(26.5-20)*37.74 245.31	30	30	(36-30)*8.33 50	295.31
1000	25	25	(26.5-25)*37.74 56.61	30	30	(36-30)*8.33 50	106.61
1000	26	26	(26.5-26)*37.74 18.87	30	30	(36-30)*8.33 50	68.87

Table 3: Cost of wagon waste

Using the total figures of both Table 2 and Table 3, the table below has been constructed to summarise the total savings, or cost, that changing the pallet size may have on total handling and transport costs per wagon:

	10 pallets* 1800kg (current)	20 pallets* 1200kg	20 pallets* 1000kg	25 pallets* 1000kg	26 pallets* 1000kg
Transport Waste	320.79	94.35	295.31	106.61	68.87
Handling Costs	189.58	316.66	316.66	348.95	355.41
Sub Total	510.37	411.01	611.97	455.56	424.28
Current total less total		510.37 - 411.01	510.37 - 611.97	510.37 - 455.56	510.37 - 424.28
Total Saving/(Cost) Per Wagon		99.36	(101.60)	54.81	86.09

Table 4 Summary of total saving/ (cost) per wagon

*Pallet numbers per wagon, shipped from Hokitika.

Table 3 shows that three out of the four proposed pallet changes would be a feasible option, given the current pallet situation. This is based on the premise that an option is acceptable if the total costs are lower than those of the current 1800kg pallet. The three feasible options will be discussed further in Chapter 5 and are summarised below in terms of rank, with one being the most favourable option and three the least favourable:

1. 1200 kilogram pallet. Potential savings of \$99.36 per wagon.
2. 1000 kilogram pallet, shipping 26 pallets from Hokitika. Potential savings of \$86.09 per wagon.
3. 1000 kilogram pallet, shipping 25 pallets from Hokitika. Potential savings of \$54.81 per wagon.

Chapter 5

Discussion and Recommendations

This chapter is broken into four sections and the outline of the chapter is as follows. The first section of the chapter discusses the analysis that was undertaken and recommendations stemming from this. The second section touches on the case study method that was used, and the challenges and successes of using this method. The third fragment discusses and evaluates the use of the non-traditional Value Stream Map in this study, and the final section provides some potential areas for future research.

5.1 The Analysis

Table 4 in Chapter 4 showed that the 1.2 tonne pallet is the most cost effective option, with the savings per wagon totalling around \$99, based on the current 1.8 tonne pallet. Over a 12 month period this has the potential to generate significant cost savings. In terms of the 1 tonne pallet, savings can only be made if the pallets are able to be triple stacked. It is difficult to say if this triple stacking could be achieved given the current container sizes. Certainly it could be achieved from Rolleston to Lyttleton. However, Hokitika to Rolleston is doubtful. If triple stacking could be achieved with proposed custom built container changes then it could become a more feasible option.

The analysis did show fewer savings with the 1 tonne pallet, however, there are other considerations to be made regarding this particular pallet size. For example, current orders for skim milk powder, whey protein concentrate and casein powder are made per tonne. Changing the pallet may have some further downstream impacts on the value stream (including exports), especially in terms of customer order fulfilment. When the impact on the whole downstream supply chain is taken into account, the total potential savings or costs may change, either in a positive manner or a negative one. As the concentration for this project was on transportation of powder from Hokitika to Rolleston, these additional considerations were outside the scope of the analysis.

Given the results of the analysis, the following recommendations are made:

1. 1.2 tonne pallets provide the greatest cost savings and more analysis should be undertaken in order to study further value stream impacts.
2. Given the current container sizes, 1 tonne pallets should only be considered if triple stacking can be achieved between Hokitika and Rolleston.
3. If containers are custom built in the future, 1 tonne pallets should be considered as a feasible option. However, only if further downstream savings can be achieved over the 1.2 tonne pallet.

5.2 The Case Study Method

The case study method was used to carry out the analysis in this body of work. As noted in section 3.1, this research method was appropriate given the aims and objectives outline in Chapter 1. Indeed, the flexibility and adaptability able to be demonstrated in a case study was crucial to this project. The understanding gained of the transportation process and the flow of milk through the value stream was invaluable. The scope of the project was transportation of milk powder from Hokitikka to Rolleston. However, without the understanding gained of the wider processes involved in transport, the analysis would have been inadequate in meeting WMP's needs.

Throughout the investigation, observation and targeted information gathering were the tools selected for collecting data. The tools served two different purposes. Observation was crucial for understanding the process and drawing the Value Stream Map. Targeted information gathering on the other hand, provided the data needed to conduct the analysis. Combined, the two tools were effective. However, if this project were to be done again, perhaps a third case study tool would be employed. A few issues were experienced in regards to responsiveness. Scheduled interviews either in person, or over the phone would be able to improve timeliness of information gathered. The implication being that improved timeliness could lead to a more thorough analysis being conducted.

Skim milk powder, whey protein concentrate and acid caseinate were the three products analysed. Through communication with staff it was determined that the three products were handled in the same way and had similar pallet heights. Using this information the following assumption was made:

- All three products (Skim Milk Powder, Whey Protein Concentrate and Casein Powder) have approximately the same bulk density

In addition to this, one more assumption was made:

- Each product is regularly made on the same drier and so will have a relatively consistent bulk density

The purpose of this second assumption was to aid in the generalizability of the analysis conducted. Removing the assumptions would require a much more detailed analysis of each individual product. The downside of this however, is that given the assumptions, the accuracy of the analysis may have suffered a little. Overall, given discussions with WMP staff, the data collected throughout the case study appeared to be accurate.

5.3 Value Stream Mapping

The Value Stream Map showed the process of transporting the finished powdered product from Hokitika to Lyttleton. The map aided the analysis as it provided an overview of the whole process, as opposed to just the transportation phase between Hokitika and Rolleston. It was also used to help identify gaps in the data. Because the costs on the map were shown by the triangle symbol, any missing gaps were quickly identified. Targeted information gathering allowed the missing data to be filled.

In terms of drawing of the Value Stream Map, the major issue was what, if any additional measures were to be used in the map. The final decision was to only include cost. However, this introduced a further issue around which icon to use to represent this cost. As noted above, the choice was the triangle, previously used as the inventory icon. The case for the use of this symbol was argued in section 4.1.1. However, in the future there is scope for a new symbol to be developed. The final map presented in section 4.1

5.4 Contributions, Limitations and Future Research

In terms of the amount of literature existing on Value Stream Mapping, an abundance of research has been undertaken on traditional mapping. However, in regards to developments or adaptations of the Lean tool, very little literature is available. As described in Chapter 2, just two papers were found to discuss Value Stream Mapping in the context of cost or transportation. In addition to this, neither of these papers were based within the agricultural/agribusiness industry. The fourth objective of this project was to analyse how Value Stream Mapping can be applied in a logistics setting by conducting a Value Stream Map Analysis. By fulfilling this objective it is believed that this study contributes to filling a gap in research using a Value Stream Map to analyse a process, based on cost rather than time, especially when describing this in a logistics setting within agriculture.

In regards to the dairy industry, this project provides evidence on how loading can affect total transportation costs. In New Zealand railroads are a great way to ship a commodity product such as milk powder to port. Trains allow a high volume of product to be shipped at a relatively low cost, especially in comparison to other forms of transport such as motor carriers. Hence, by firms analysing loading operations, there is potential for a significant amount of money to be saved annually. When this is put into the context of the whole business, these savings allow for additional investments, price savings for customers or slightly higher profit margins for the firm. In this sense, this study is not confined only to the context of the dairy company analysed. Due to the purpose of a case study making findings generalizable, the methodology has the potential to be applied to other New Zealand firms that transport commodities, low value goods or high volumes by rail.

One particular limitation of this study is that it was not longitudinal. Instead, it was completed from a consultancy viewpoint as the project manager position was supplied by Lincoln University. This caused restrictions in terms of time and scope. The analysis of this project was completed between late July and early November 2014, with one visit to the Hokitika site and two visits to the Rolleston site. As noted previously, the scope of the report was the railroad transport between Hokitika and Rolleston. However, as Figure 1 showed, the transportation process involved much more than just the initial transport. In order to acknowledge this, the transportation between Rolleston and Lyttleton was also calculated in the analysis. Despite this, the time limit and scope of the project did not allow for a more detailed analysis of activities that impact company costs and the customer to occur. This has the potential to introduce some inaccuracies into the analysis as there may be missing values for some activities that would otherwise have an impact on the potential total savings or costs. An additional limitation that also pertains to a lack of longitudinal design is that no further analysis is able to be conducted. If WMP does in fact choose act upon the findings of this study, without further analysis of the first study the ability to assess the usefulness of the methodology used in this project is limited.

There are some future research opportunities stemming from this project. The first of these relates to the dairy industry. Because New Zealand is a large dairy producer in terms of world exports, much of the milk produced is processed and transported to the sea ports to be shipped to the customer. Therefore there is the potential for this methodology to be applied to other dairy firms. There is also potential to conduct a New Zealand industry analysis, assessing loading utilisation using a Value Stream Map based on the same calculations across all firms. This would allow the researcher to compare and contrast the different companies and identify trends among the largest and smaller dairy companies

In an academic context, there is some potential for future research in applying the Value Stream Map and cost analysis in other industries to assess the adaptability and usefulness of the Value Stream Map developed. The symbols used in the map should also be developed further. The triangle symbol for cost used in the Value Stream Map should be investigated to determine if it is the best symbol to use, or whether it should be replaced with a newly developed symbol. There is also a potential research avenue to integrate a traditional Value Stream Map analysis with the cost-based Value Stream Map developed in order to conduct a two pronged analysis on both time and cost.

Appendix A

Report for Westland Milk Products

Lincoln University
Corner Ellesmere Junction Road and Springs Road
Lincoln

November 7, 2014

Westland Milk Products
56 Livingstone Street
Hokitika, 7842

Dear Jud Dwyer and Sam Scott,

Please find attached the report regarding Project Double Stack as commissioned by your firm in June 2014, with guidance from Dr. Jeff Heyl of Lincoln University.

I would like to thank the both of you and your colleagues for the enthusiasm shown for this project and the willingness staff have shown in answering my many questions and discussing the progress of this project.

I thoroughly enjoyed the opportunity to visit the West Coast and the Rolleston warehouse to gain an understanding of the dairy manufacturing process and some of the supply chain issues around transporting the finished powdered product. I wish you both the best and thank you for the opportunity to work with your firm.

Yours sincerely,

Tiffany McIntyre

A dark green vertical bar runs down the left side of the page. A light green arrow points to the right from this bar, containing the date.

November 7, 2014

Westland Milk Products Limited

Report: Project Double
Stack

Produced for Jud Dwyer and
Sam Scott

Tiffany McIntyre
tiffany.mcintyre@lincolnuni.ac.nz

LINCOLN UNIVERSITY

Executive Summary

The purpose of this report was to investigate the issues involved in double-stacking the 20 foot rail wagons with powder products from Hokitika to Rolleston. Achieving double stacking could potentially have great financial benefits for Westland Milk Products.

Visits to the Hokitika plant and Rolleston warehouse enabled an understanding of the transportation process to be gained and a Value Stream Map to be created. The costs displayed in the Value Stream Map provided the base for the cost analysis to take place.

Changing the pallet height the most appropriate way to achieve double stacking. After investigating different pallet weights, it was shown that only the current pallet weight (1.8 tonne), a 1.2 tonne pallet and 1 tonne pallet are options in which costs are either not increased or are decreased.

Using the current 1.8 tonne pallet as a base, an initial cost analysis shows that per wagon savings of \$99.36 can be achieved through changing the pallet size to 1.2 tonne. In terms of the 1 tonne pallet, savings of either \$54.81 or \$86.09 can be achieved through the use of double and triple stack configurations. The 1 tonne pallet savings are lower, however there is potential for further downstream savings to be made. This needs further analysis.

Given the analysis conducted, the following recommendations are made:

1. 1.2 tonne pallets provide the greatest cost savings and more analysis should be undertaken in order to study further value stream impacts.
2. Given the current container sizes, 1 tonne pallets should only be considered if triple stacking can be achieved between Hokitika and Rolleston.
3. If containers are custom built in the future, 1 tonne pallets should be considered as a viable option. However, only if further downstream savings can be achieved over the 1.2 tonne pallet.

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1.0 Introduction

This report was commissioned by Jud Dwyer, Production Manager, Powder, and Sam Scott, Production Manager, ITN/Nutritionals of Westland Milk Products Limited with assistance from Dr. Jeff Heyl of Lincoln University. The purpose of this report is to investigate the issues involved in double-stacking the 20 foot rail wagons with powder products.

Achieving double stacking of product in the containers could potentially have great financial benefits for Westland. However, the downside of this is that the cost of exporting product has the potential to increase. This report has used a cost based analysis to calculate the potential gains versus potential losses on a per wagon basis.

In order to make the analysis generalizable, five key assumptions have been made:

- All three products (SMP, WPC and casein powder) have approximately the same bulk density (BD)
- Each product is regularly made on the same drier and so will have a relatively consistent BD
- Storage costs will not be impacted as the same volume of product is handled, however handling costs will differ.
- The cost of every forklift drivers wages are the same i.e. \$25 an hour
- The tare weight of a container is approximately 2500kg, to allow for variation in the container weights.

2.0 Analysis and discussion

This section of the report shows a Value Stream Map of the transport process, explains some of the rationale behind the metric units used and displays the cost analysis results in table form. The analysis includes the variable costs of the milk powder process from the point where the fully wrapped pallet is stored, to the point it is loaded and transported from the Rolleston Warehouse to the Lyttleton port for export. The figures were calculated as a per wagon cost.

2.1 Analysis

The first stage of the project was to learn about the milk refining process to gain a basic understanding of milk processing and then to gain an understanding of the transportation phase of the finished milk powder. To do this a Value Stream Map (VSM) was created. VSM's are a lean manufacturing tool that allow a process to be visually mapped, with the purpose of allowing the user to identify areas for improvement. In this particular case the VSM has been created in a slightly different way than conventionally used. It has been created in order to map costs associated with the process stages as opposed to time. It is shown below:

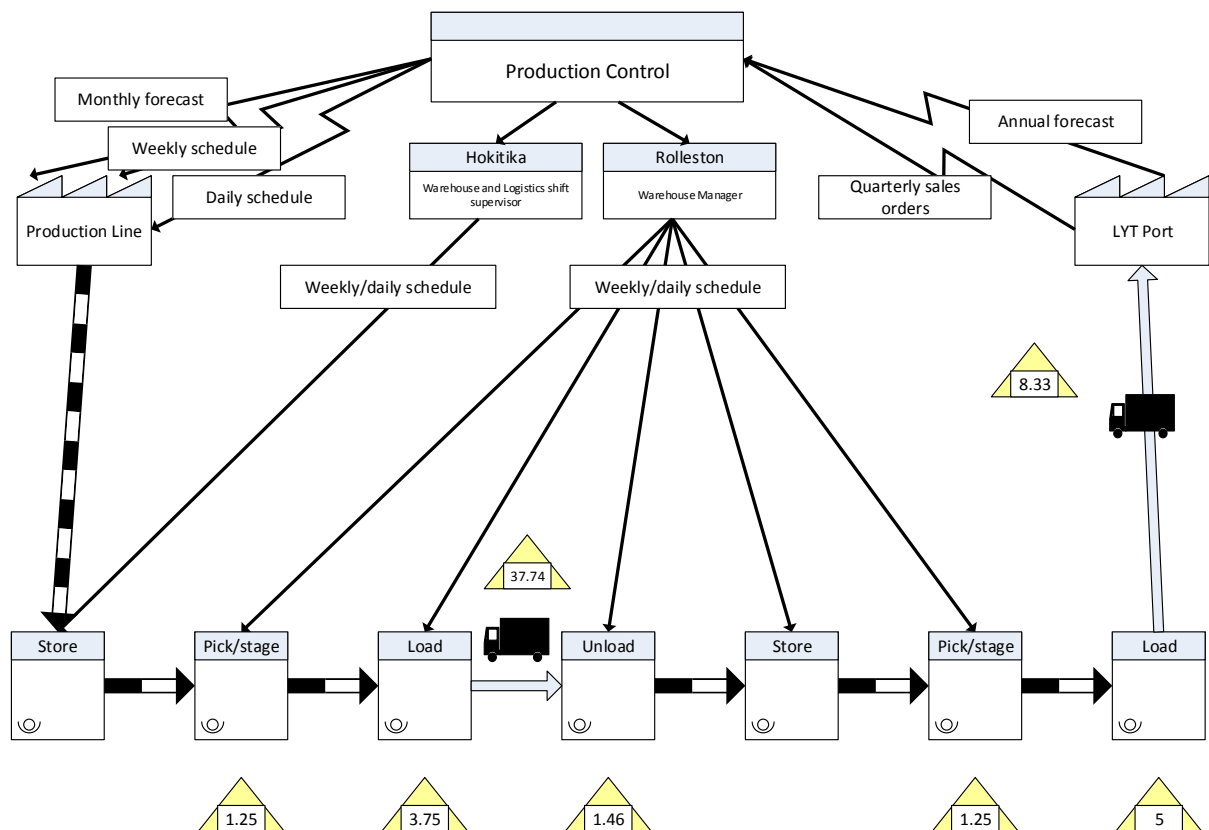


Figure 1: VSM of the product transport process

The VSM shows that nine stages in the process were identified. Traditionally the triangles contain some sort of metric value in order to help an analysis be undertaken. In this particular case, a dollar value has been assigned in order to measure the cost associated with each stage of the process. The values were generally worked out by incorporating time taken, the forklift driver and the cost of wages. The exception was transport, which was calculated on a per tonne basis. The calculations of these values can be found in Appendix 1. The resulting values are below:

1. Store*
2. Pick and stage – \$1.25
3. Load – \$3.75
4. Transport from Hokitika to Rolleston – \$37.74 per tonne
5. Unload – \$1.46
6. Store*
7. Pick and stage – \$1.25
8. Load - \$5
9. Transport from Rolleston to Lyttleton – \$8.33 per tonne

*Deemed to be fixed and so excluded from the analysis.

Storage costs have been excluded as they are based on the total annual budget for the warehouse cost centres and divided by the total annual budgeted production. Hence, they should not be affected by this project outcome.

Changing the physical wood pallet area will not positively impact the capacity of product in the containers. However, changing the total volume of the pallet to achieve double stacking could. For this reason, various pallet weights were investigated within the range of 1-1.8 tonne. The current pallets weigh 1.8 tonne, the bags weigh 25kg, are stacked eight on a pallet, nine layers high. This means that one pallet layer weighs 200kg. The implication being, that to stack full layers, the tonnage must be of an even number, i.e. 1t, 1.2t, 1.4t etc. Of the options remaining, it was found that to double stack a 1.6 tonne or a 1.4 tonne pallet, the total wagon weight, which holds two containers, would exceed the net wagon limit of the train from Hokitika to Rolleston. The result of this is that only two alternate pallet weights are appropriate; a 1.2 tonne pallet and a 1 tonne pallet.

The wagon from Hokitika to Rolleston has a 31.5 tonne gross weight capacity. The average tare weight of a container is around 2300kg. Allowing for a 200kg variation per container, the net wagon weight allowance is 26.5 tonne. When considering a 1 tonne pallet option, double stacking the pallets would result in a wagon weight of just 20 tonne. If triple stacking was able to be achieved through the current container sizes or through the proposed custom built containers, much better container utilisation could be achieved. Hence, two additional 1 tonne pallet options have been

considered; firstly, a wagon containing 25 tonne through triple stacking one container and double stacking the other, and secondly, achieving 26 tonne through placing 13 tonne in each container.

The proceeding table shows the handling costs of the various pallet sizes investigated:

	Hokitika to Rolleston				Rolleston for Lyttleton			
Pallet Weight (kg)	No. of Pallets per Wagon	Pick and Stage	Load	Unload	No. of Pallets per wagon	Pick and Stage	Load	TOTAL
1800 (CURRENT)	10	1.25*10 12.5	3.75*10 37.5	1.458*10 14.58	20	1.25*20 25	5*20 100	189.58
1200	20	1.25*20 25	3.75*20 75	1.458*20 29.16	30	1.25*30 37.5	5*30 150	316.66
1000	20	1.25*20 25	3.75*20 75	1.458*20 29.16	30	1.25*30 37.5	5*30 150	316.66
1000	25	1.25*25 31.25	3.75*25 93.75	1.458*25 36.45	30	1.25*30 37.5	5*30 150	348.95
1000	26	1.25*26 32.5	3.75*26 97.5	1.458*26 37.91	30	1.25*30 37.5	5*30 150	355.41

Table 1: Handling costs per wagon

Each stage of the process was calculated by multiplying the cost per pallet by the number of pallets placed in a wagon. It can be seen that the number of pallets placed in the wagons for transport at each warehouse differs. Pallets leaving the Hokitika warehouse are placed on wooden pallet. However when the pallet is picked and staged at Rolleston to send to export, the pallet is removed leaving just a slip-sheet. Therefore, the pallet heights will differ, allowing for more product to be placed in the containers at Rolleston. Secondly, more pallets are able to be placed into the container at Rolleston as that the wagons can handle more weight, i.e. a net weight of 36 tonne.

The table below has taken the cost of transport to give each tonne of a dollar value. Although the container price of transport is a flat rate, when the full container capacity is not used there is waste. When talking about waste, particularly within lean manufacturing, it is viewed as a cost. By working out the per tonne cost based on the total weight capacity it is possible to work out the cost of waste, by taking utilisation away from capacity and multiplying by the per tonne value:

	Transport Hokitika to Rolleston			Transport Rolleston to Lyttleton			
Pallet Weight (kg)	No. of Pallets per Wagon	Wagon Weight (tonne) Hokitika	Waste	No. of Pallets per wagon	Wagon Weight (tonne) Rolleston	Waste	TOTAL WASTE
1800 (CURRENT)	10	18	(26.5-18)*37.74 320.79	20	36	36-36 0	320.79
1200	20	24	(26.5-24)*37.74 94.35	30	36	36-36 0	94.35
1000	20	20	(26.5-20)*37.74 245.31	30	30	(36-30)*8.3 3 50	295.31
1000	25	25	(26.5-25)*37.74 56.61	30	30	(36-30)*8.3 3 50	106.61
1000	26	26	(26.5-26)*37.74 18.87	30	30	(36-30)*8.3 3 50	68.87

Table 2: Cost of wagon waste

Using the total figures of both Table 1 and Table 2, the table below has been constructed to summarise the total savings, or cost, that changing the pallet size may have on total handling and transport costs:

	10 pallets* 1800kg (current)	20 pallets* 1200kg	20 pallets* 1000kg	25 pallets* 1000kg	26 pallets* 1000kg
Transport Waste	320.79	94.35	295.31	106.61	68.87
Handling Costs	189.58	316.66	316.66	348.95	355.41
Sub Total	510.37	411.01	611.97	455.56	424.28
Current total less total		510.37 - 411.01	510.37 - 611.97	510.37 - 455.56	510.37 - 424.28
TOTAL SAVING/(COST) PER WAGON		99.36	(101.60)	54.81	86.09

Table 3: Summary of total savings/ (cost) per wagon

*Pallet numbers per wagon, shipped from Hokitika.

Table 3 shows that three out of the four proposed pallet changes would be a viable option, given the current pallet situation. This is based on the premise that an option is acceptable if the total costs are lower than those of the current 1800kg pallet. These are discussed below.

2.2 Discussion

It can be seen from Table 3 that the 1.2 tonne pallet is the most cost effective option with the savings per wagon totalling around \$99, based on the current 1.8 tonne pallet. Over a 12 month period this has the potential to generate some significant cost savings. In terms of the 1 tonne pallet, savings can only be made if the pallets are able to be triple stacked. It is difficult to say if this triple stacking could be achieved given the current container sizes. Certainly it could be achieved from Rolleston to Lyttleton, however, Hokitika to Rolleston is doubtful. If triple stacking could be achieved with proposed container changes then it could become a more viable option.

Even though the figures contained within this report show fewer savings with the 1 tonne pallets, there are other considerations to be made regarding this pallet size. For example, Current orders for SMP, WPC and casein powder are made per tonne. This will have implications in loading product etc, which may very well result in a different end cost. As the concentration for this project was on transportation of powder from Hokitika to Rolleston, these additional considerations are outside the scope of this report.

As noted above, the scope of the project was really the transportation phase of product between Hokitika and Rolleston. However, it can be seen from the VSM that the transportation process of products involves a much wider scope than just this initial transport. This makes it important to acknowledge and understand the follow on effects changing the pallet size in Rolleston will have on the next phase, the transportation element involved in sending product to export. Hence the impact on cost and container utilisation has been calculated for Rolleston for Lyttleton as well. It is acknowledged, however, that there may be other considerations to be made when sending product to export which are not contained within this report.

3.0 Recommendations

After research of the process the VSM was created. This allowed for the analysis to be conducted and with the previous assumptions and caveats noted throughout the report, the following recommendations are made:

4. 1.2 tonne pallets provide the greatest cost savings and more analysis should be undertaken in order to study further value stream impacts.
5. Given the current container sizes, 1 tonne pallets should only be considered if triple stacking can be achieved between Hokitika and Rolleston.
6. If containers are custom built in the future, 1 tonne pallets should be considered as a viable option. However, only if further downstream savings can be achieved over the 1.2 tonne pallet.

4.0 Appendices

4.1 Calculations

- Pick/stage
Three minutes to move a pallet from storage to the loading bay.
$$(25/60)*3 = \$1.25 \text{ per pallet}$$
- Load
Four containers can be loaded in one hour. This equates to 15 minutes per container with three forklift drivers.
$$(25*3)/4 = \$18.75 \text{ per container}$$
$$18.75/5 = \$3.75 \text{ per pallet}$$
- Transport from Hokitika to Rolleston
\$500 flat rate per container, i.e. \$1000 per wagon. However, the current underutilisation of a container/wagon can be considered waste and so a numerical value can be placed on the value of each tonne within the wagon. A wagon has a 31.5 tonne gross weight capacity. The average tare weight of a container is around 2300kg. Allowing for a 200kg variation per container, the net wagon weight allowance is 26.5 tonne.
$$1000/26.5 = \$37.74 \text{ per tonne}$$
- Unload
Two forklifts unload the train. 24 containers can be unloaded in three and a half hours.
$$(25*2)*3.5 = \$175$$
$$(175/24)/7.29 = \$1.46 \text{ per pallet}$$
- Pick/stage
Assume 3 min per pallet to pick and stage from storage.
$$(25/60)*3 = 1.25 \text{ per pallet}$$
- Load
Three forklifts load the train. A container can be loaded in 20 minutes.
$$(25*3)/3 = \$25$$
$$25/5 = \$5 \text{ per pallet}$$
- Transport from Rolleston to Lyttleton
\$150 flat rate per container, i.e. \$300 per wagon. A wagon has a 36 tonne net weight limit.
$$300/36 = \$8.33$$

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