Opportunities to improve efficiency in the fresh produce supply chain

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Executive Summary

The fresh produce sector in New Zealand produces some of the world's greatest fruit and vegetables. There is a complex all-encompassing machine that connects the farms these products are grown on to the final consumer. This machine is the Fresh Produce Supply Chain (FPSC). New Zealanders enjoy an excellent range of fresh fruit and vegetables that can be purchased through a variety of sales channels. The most dominant and effective channel is through supermarkets which have access to supply via fresh produce marketers and growers directly. These suppliers provide fresh produce of good quality, at scale consistently and at a reasonable price throughout the year to meet the tastes and preferences of consumers.

This project has been completed to further understand the FPSC and seek efficiencies that can be made that reduce volatility in supply, reduce food waste and reduce the margin between what the consumer pays, and grower receives. We aim to answer three key questions being: what are the challenges for the current fresh produce supply chain from the farm gate in New Zealand? What technology and supply chains exist today outside of fresh produce? And does a different, more efficient system fit in today's fresh produce supply chain and would this be accepted by industry stakeholders?

The key findings were growers in NZ are aligning themselves with retailers and marketers in partnership style relationships. Growers with smaller scale struggle to compete in fragmented industries where information is less available and less direct from the consumer. Over time there has been a shift in the paradigm from growing for the market floor auctions, to growing for consumer demand based on high information sharing from retailers and marketers. This has resulted in a more deliberate crop rotation and sustainable growing system, reducing wasted product and improving price stability.

Technology in FPSC has huge potential however supply chain participants are cautious and considerate on technology they invest in. Blockchain technology can support efficiencies by reducing reliance on trust on intermediaries. The internet of things can provide an interface between supply chain practice and software systems. This can log important information which can give retailers and consumers confidence in quality of product and appropriate handling.

Consolidation of fragmented industries will support greater efficiencies as grower scale increases and vertically integrate to control more downstream practices. We also see intermediaries investing in upstream practices such as farms and greenhouses.

Recommendations are summarised as follows:

- Encourage vertical integration where supply chains are owned or controlled between grower and retailer. For growers that have the scale and access to capital they should build partnerships with retail entities and invest in infrastructure to reduce reliance on other supply chain participants.
- Cooperate within sector to vertically integrate if scale is not achievable. This can be done by the establishment of regional cooperative organisations to allow smaller scale growers to pool resources, invest in infrastructure and supply direct to retailers.
- Increase communication between FPSC participants with accurate data in fragmented product categories to share accurate crop details

- Drive increased consumer awareness of imported vs local produce with signage and branding that clearly differentiates products.
- Encourage investment in internet of things and Blockchain technology for import product to reduce volume of poor-quality import product brought to NZ consumers.

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1. Introduction

Supply chain issues have become more prevalent in New Zealand and Overseas. We have recently seen COVID19 come into our lives, causing the majority of our labour force to be locked down in their homes and massive disruptions to supply chains. In addition, we have seen changes in consumer behavior which has resulted in inefficiencies in supply chains being exposed. Society in New Zealand has experienced these by way of significant food price inflation and partially empty supermarket shelves. Issues in the fresh produce supply chain have been further exacerbated by weather, shipping and labour shortages.

In New Zealand, we have two supply chains, one is a highly efficient export supply chain that is a vacuum for the best quality products. Fresh fruit and vegetables are produced and shipped to antipodes with premiums returned to growers. The other is sold domestically in New Zealand that is made up from produce that does not meet export quality standards or is too perishable with the balance being imported (Proudfoot et al., 2022). Often the quality of imported produce is of a lessor quality to NZ fresh produce which can hinder consumer's appetite for NZ grown produce (Anon. Pers.Com. 2022).

FPSC's are primarily dictated by consumer tastes and preferences for products sold at the retail store. This information and data are then passed from actor to actor through a series of "Chinese whispers" up the supply chain eventually to the grower. The grower might act on this information although at the very quickest there could be a 50 day (in terms of vegetables) growing period that allows the grower to respond to consumer demand. In the case of fruit there is typically a significant financial investment from growing businesses with 3-5year establishment period the grower may have completed in response to consumer tastes and preferences. The traditional FPSC is fragmented and "old school" (Anon. Pers.Com. 2022) with intermediaries working hard to compete with one another for supply and pricing. This has resulted in consolidation in fresh produce industries and key players vertical integration to own as much of the supply chain as possible. This provides closer to perfect information from consumer back to grower, improved efficiencies with a reduced number of intermediaries and investment in the overall supply chain, becoming a value chain overtime. In all fresh produce markets, we see the benefits of economies of scale which improves negotiation power with downstream supply chain actors and improved on farm efficiencies.

Wastage in fresh produce is quickly becoming a major topic on the agenda for governments and international organizations. In NZ the Ministry for the Environment (MFE) estimates that globally one third of all food produced is wasted or lost before it is eaten, which amounts to approximately 1.3 billion tonnes of food waste, grown for consumption and never eaten (Ministry for the Environment, 2022). This concern is compounded when we consider the effects on greenhouse gasses (GHG's) and climate change. On the production side there is GHG's produced from typical growing practices, processing, and logistics in the supply chain. Based on MFE's information, one third of these GHGs are created to produce a product that goes straight to landfill. On the waste side, there are the GHGs that are created from the wasted produce that is decomposing. In New Zealand, 9% of biogenic methane emissions and 4% of total GHG's are from food and organic waste (Ministry for the Environment, 2022).

At the United Nations Food Summit 2021 there was a strong focus on the global food system and progress on ambitious sustainable development goals were reviewed including ending world hunger by 2030. Progress towards this goal has been disappointing with an increase in the prevalence of global undernourishment from 8.4% in 2019 to 9.4% in 2020, meaning that 720-811million people

are in a state of undernourishment across the globe (FAO, IFAD, UNICEF, WFP and WHO, 2021). In NZ one in five children experience moderate to severe food insecurity (Ministry for the Environment, 2022). The increase in hunger across 2020 has been related back to COVID19, conflicts in Eastern Europe and climate change with significant flooding and droughts across the globe. To change the direction of the hunger crisis and achieve such a target set by the UN will take a united effort in building resilient supply chains that are efficient and can tolerate shocks and stresses that come from unforeseen events.

2. Aims and Objectives

This study examines the current state of fresh produce supply chains in New Zealand. We consider what technologies and systems are available today and in the future that could drive efficiencies. The main objective is to recommend actions to industry and government in New Zealand that are practical and can be implemented into current practice. The aim of this study is to answer three key questions being: What is the current fresh produce trading mechanisms from the farm gate in New Zealand? What technology and trading systems exist today outside of fresh produce? Finally, does a more efficient system fit in today's New Zealand fresh produce supply chain and would this be accepted by stakeholders?

Understanding the current trading mechanisms is important to analyze the challenges that face the system and restrict its efficiency. Fresh produce is a challenging basket of products as it is, so this is also vital to understand what is currently being done to achieve the outcomes occurring today.

The study aims to understand different technology and trading systems outside of the fresh produce chain. There has been a large amount of technology implemented in new disruptive industries driven by major advancements in software and hardware application over the past two decades. By analyzing wider applications and engaging pan sector thinking there are efficiencies and knowledge that can be gained from other industries and nations.

Finally, to achieve the main objective this study analyses and evaluates the information captured to come up with key actions that can be taken by industry leaders that support efficiencies in the FPSC. The cross industry thinking of this project aims to bring knowledge and insights from outside industries and apply, where possible, to current systems operating.

3. Methodology

In order to achieve the aims and objectives of this study a methodology is required that is robust and can support the recommendations. Because the agribusiness supply chain is complex and includes many different parties there are two different research methods that have been utilised. A literature review has been completed to provide insights into supply chain management from an academic perspective. A thematic analysis using Braun & Clarke (2006) method has then been completed to provide a practical perspective. The findings from both analyses are then compared, contrasted, and evaluated in the discussion and recommendations at the end of this report.

3.1. Literature Review

A literature review has been completed to critically analyse material sourced through library stock and online. Qualitative and quantitative literature was reviewed to gain perspective of the current academic knowledge available with respect to fresh product supply chains and modern technology.

The first part of this literature review is to understand what limitations currently hinder the Agricultural Supply Chains along with opportunities that have already been explored in the global context and New Zealand context. The agricultural supply chain literature discussion is broken down into four key themes being supply chain challenges, supply chain management, supply chain relationships and consumer demands.

The second part focuses on modern trading systems and technology where literature reviewed provides direction towards blockchain, smart contracts and the internet of things (IoT). These futuristic themes support discussion from an academic perspective and help to build on recommendations for industry that could be implemented in the future.

3.2. Thematic Analysis

This paper provides discussion and recommendations with a practical perspective that can be understood and implemented by industry bodies and business leaders. To get the best understanding of practical limitations and ideas, a thematic analysis has been conducted.

Thematic analysis as a research methodology is useful to these study objectives because it provides a process to identify, analyse and report themes within a data set that is acquired through interviewing several stakeholders (Braun & Clarke, 2006).

This study has gone through a process that begins with generating a list of questions (shown in Appendix I) that relate back to the aims and objectives. These questions have driven a series of semi structured interviews that were conducted with three different subgroups in the FPSC. These subgroups are made up of growers, marketers and retailers. In each subgroup business leaders have been chosen to provide a separate perspective from one another that is different by way of products grown/supplied, business scale, route for products to market and part of the supply chain they own or control. These interviews provided a data set that was analysed using thematic analysis.

Once the data corpus was collected, the researcher goes through a process of familiarisation with the data and produced initial codes in 10.2 Appendix 2: Thematic Coding that has formed a basis for the themes that are described later in this report in 5. Thematic Analysis.

The thematic analysis is then used to test the initial conclusions drawn from the literature review and provide a practical perspective specific to the New Zealand context.

Individuals interviewed have been made anonymous to enable a fluid and rich discussion based on their personal perspectives. Themes have been discussed at a sector level to help with confidentiality.

4. Literature Review

4.1. Fresh Produce Supply Chain

There are many different forms and functions of the FPSC. The FPSC starts from farm supplies (i.e., inbound materials and services for farm level operations) and ends with ultimately satisfying the consumer through a specific distribution channel (Routroy & Behera, 2017).

4.1.1. Supply Chain Challenges

Routroy & Behera (2017) complete a systemic literature review that provides a good summary of complexities and challenges facing current FPSC models. FPSC is significantly more complex than other supply chains, primarily due to the perishable nature of agricultural products. Because of the perishability the challenges that arise include short shelf-life, lack of temperature control or appropriate facilities for storage and transportation, wastages, and pricing pressures (Chandrasekaran & Raghuram, 2014 cited in Routroy & Behera, 2017). To retain freshness that the consumer demands, the supply chain must retain the product's perishability. This becomes more challenging with the more perishable the product is. The FPSC manages to retain such perishability by cleaning, grading, preservation centres, cool stores and processing facilities being shifted nearer to farm. In New Zealand we see this with major infrastructure being constructed in fresh product growing regions in addition to main centres. This becomes an extreme case as explained under (Roth & Zheng, 2021) where the likes of LufaFarms in Montreal, Canada innovates on both the production and distribution sides of an end-to-end food value chain. On the production side, they build rooftop greenhouses on the roof of industrial buildings in the inner city and use hydroponic technology. This gives them a comparative advantage with travel distance to market and ability to supply ultra-fresh product under controlled conditions all year round. On the demand side, the organization maintains its own website where customers can purchase fresh produce to be delivered to their door. This is quite literally bringing the paddock to the plate.

The biological nature of fruit and vegetable production can pose further challenges with seasonal production cycles, unpredictable weather and pest and disease outbreaks. This makes it difficult to guarantee continuity of supply and maintain quality standards. While all fresh products exhibits these challenges, the extent of which they do so will vary. Some products, being more perishable and fragile than others or more susceptible to the uncertainties of biological production (Clemants et al., 2008). These challenges make fresh product the most complex of supply chains. Where each chain participant is purchasing a product that comes with risk over and above the market risk, where products are perishable, there is risk that can perish from a multitude of causes while it is held by that participant, rendering their product worthless. This is realised in a fast-moving consumer good (FMCG) environment where marketers are working to shift large volumes of product as quickly as possible, for the best price possible.

4.1.2. Supply Chain Management

The New Zealand supermarkets have a large amount of control over the fresh produce supply chain. Clemants et al. (2008) found that challenges are posed for management of different supply chains in New Zealand by the customer requirements and product characteristics. This means that supermarkets or wholesalers liaise closely with preferred suppliers on production planning. Producers, in turn, gear their production operations to the supermarket requirements to ensure supply continuity, and make investments in facilities such as cool stores or greenhouses to smooth fluctuations with supply. The supermarkets then also speed up or slows down the flow of produce during gluts or shortages through its pricing policy. As required, it can also source periodically from non-preferred suppliers outside of normal seasonal supply.

Luo et al., (2018) completed a study focussing on supply chain management (SCM) in New Zealand. The study highlights the influence of low-integration and lack of supply chain knowledge in New Zealand operations. Supply chains are highly pressured by customers requirements to reduce cost and maintain high reliability of product procurement. In New Zealand most people involved in supply chain practice do not have a supply chain back ground which inhibits the decision making process and efficiency in operations. The culture in New Zealand at the time of the study is considered positive, however, lacking open communication with internal and external stakeholders. One of the foremost barriers in supply chain integration is the lack of understanding of the outcome of collaboration. Understanding this and developing communication channels between partners are critical to enhance integration and information exchange, coordinate overall SCM objectives and improve flexibility with short response times. While literature shows reliance on avanced IT systems are essential to achieve successful supply chain management the NZ supply chain systems are not mature enough to adopt such IT systems. This also inhibits collaboration between chain participants from fear of losing company specific information, not finding a suitable partner to appreciate the given information or finding value from information given back.

Bilali et al., (2021) completed a systemic review that focusses on the global supply chain for food. The writers argue that the world is not on track towards achieving the United Nations' Food Systems Summit Sustainable Development Goals which includes ending hunger, food insecurity and malnutrition in all it's forms by 2030. Current literature shows the Agri-food system is failing to ensure nutritious and affordable foods are available and increasing global interest is being focussed on sustainable food systems. Interestingly, Bilali et al., (2021) acknowledges historical literature sufficiently addresses environmental and natural sciences however social, economical and political sciences are often overlooked. Bilali et al., (2021) explains how crucial it is that to strengthen the science to policy interface for improved system governance and how future studies should focus of a holistic approach, 4-P, being planet, people, profit and policy.

Supply chain management in New Zealand remains in an immature stage with literature outlining the inhibators to improving SCM. There is little oversight, collaboration or communication in the Fresh Produce SCM which stems from the high level management decisions and culture around efficient SCM (Luo, et al., 2018). Pressure from consumer expectations of pricing, quality and reliability will continue to impact on decision making within the supply chain. New Zealand supply chains are starting to focus more emphasis on environmental, social and governance in term of inputs and outputs however there is a long way to go before achieving the ambitious goals of the United Nations' Food Systems Summit in terms of food wastage and food availability (Ministry for the Environment, 2022) & (FAO, IFAD, UNICEF, WFP and WHO, 2021).

4.1.3. Supply Chain Relationships

It has been well documented that the relationships within FPSC's in New Zealand have been changing. There has been trend away from adversarial relationships with a multitude of grower's suppliers towards closer and on-going, or even exclusive, relationships (Clemants et al., 2008).

This is further supported by Martinez, (2005), in his study focussing on the business relationships and their connectors in fresh produce in New Zealand. Martinez predicted this change in relationships in 2005. He explained how there is an expectation over the preceding decade that for manufacturing firms to be competitive they need to move away from the traditional approach of adversarial relationships to one of forging longer term relationships with a select few suppliers.

There are various reasons that have advanced the phenomenon of FPSC's moving toward partnership type, exclusive relationships. It is argued that on-going relationships can allow retailers to access adequate volumes to maintain continuity of supply. This can even lead to a competitive advantage over other retailers through exclusive access to the best and most innovative producers. This can also add competition among producers to produce a superior product for market. Closer relationships can also result in economies of scale, reduction in search times and cost and productivity through the integration of retailer and supplier systems. Importantly, producers are thought to benefit from preferred or exclusive supplier status through increased security and reduced risk (Clemants et al., 2008).

4.1.4. Consumer Demands

A superior product should be defined in terms of what the consumer demands. Changes in consumer requirements have changed over the past decade and the trend is expected to continue. Trends that have been identified were new products, greater differentiation of existing products (such as different sizes, ages and varieties), declining demand for traditional products (such as potatoes) and increased demand for others (such as broccoli), pre-peperation to reduce time (such as washed vegetables and packaged vegetable mixes) and providing greater product safety (pre packaging). Interestingly, product pricing was not seen by any chain participants as an important customer requirement (Clemants et al., 2008).

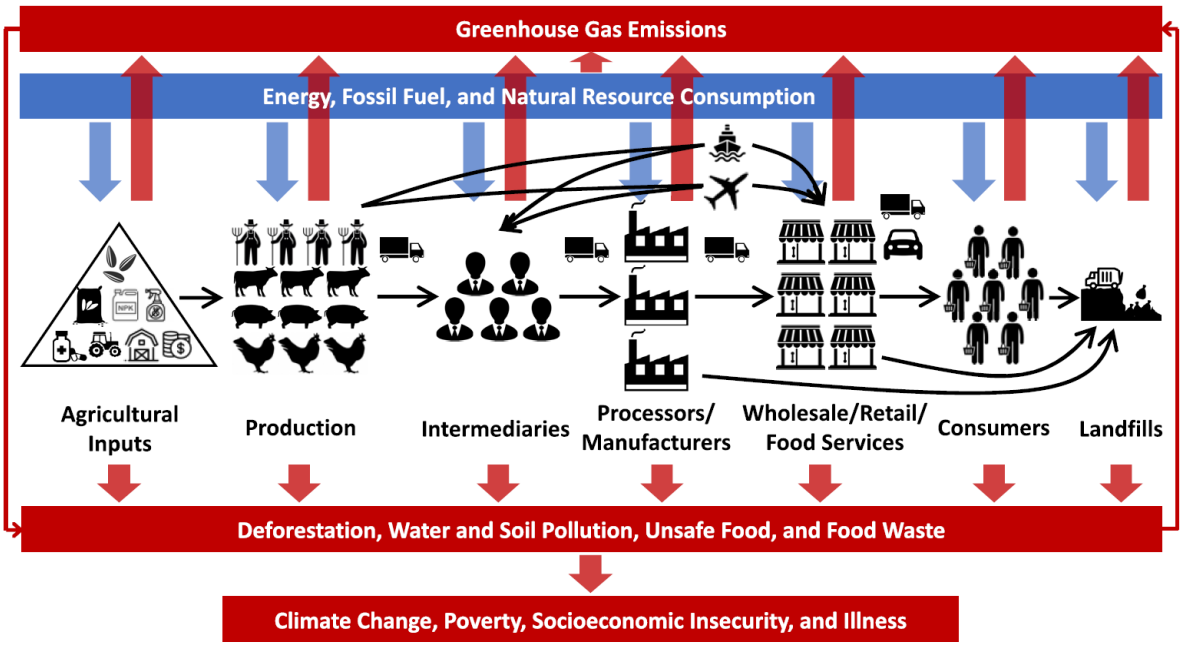
This remains current in 2022 when we consider the Whole Foods: Top 10 Food Trends for 2022 which includes a mixture of new/modern variances of currently marketted products along with a focus on the growing principles behind the products. New farming practices perceived to be more sustainable than traditional farming practices. This includes "Ultraurban farming" and "Eco-friendly, sustainable grains". Ultraurban farming is a modern way of farming, typically indoors with hydroponic growing systems located within city boundaries, often with a direct to consumer supply model. "Eco-friendly sustainable grains" are grains grown using traditional agricultural practices that helps address soil health (Whole Foods Market, 2021). Roth and Zheng (2021) reflected on the same list for 2020 which included regenerative agriculture in the number one spot. Roth and Zheng go one step further, conceptualizing a new value chain that incorporates technology and regenerative principles to produce a closed loop supply chain from "dirt to table".

4.1.5. Sustainable Supply Chain

Supply chain risk management is becoming a significant issue for companies. Sajjad, et al., (2015) finds that supply chain sustainability issues pose a substantial reputational risk to companies, which can negatively impact the companies performance. Sustainable supply chain implentation was found to have minimal economic benefits, however there are other benefits that may have indirect economic benefits such as brand differentiation. The business case for sustainable implementation has not yet surfaced, which is limiting as business investments for sustainability functions need to be linked to financial returns by organization leaders. The study reported a lack of awareness in sustainable products, supplier and customer issues, and lack of government support are barriers to the implementation of sustainable supply chain management.

Some of the answers can be found in the study by Roth & Zheng (2021). The writers present a generic overview of the conventional food supply chain as shown in Figure 1. They explain the many systemic changes that need to be made to supply chain management in order to implement a "regenerative organic food value chain" shown in Figure 2. being; fairer risk and value sharing between producers and their buyer, implementation of digital platforms and market places (which is discussed later in this paper), consumers should be educated to contribute to a circular closed loop ecosystem and finally farm to table transaprency, traceability and trust must be encaptulated within the value chain.

Figure 1. *The Conventional Food Supply Chain (Roth & Zheng 2020)*

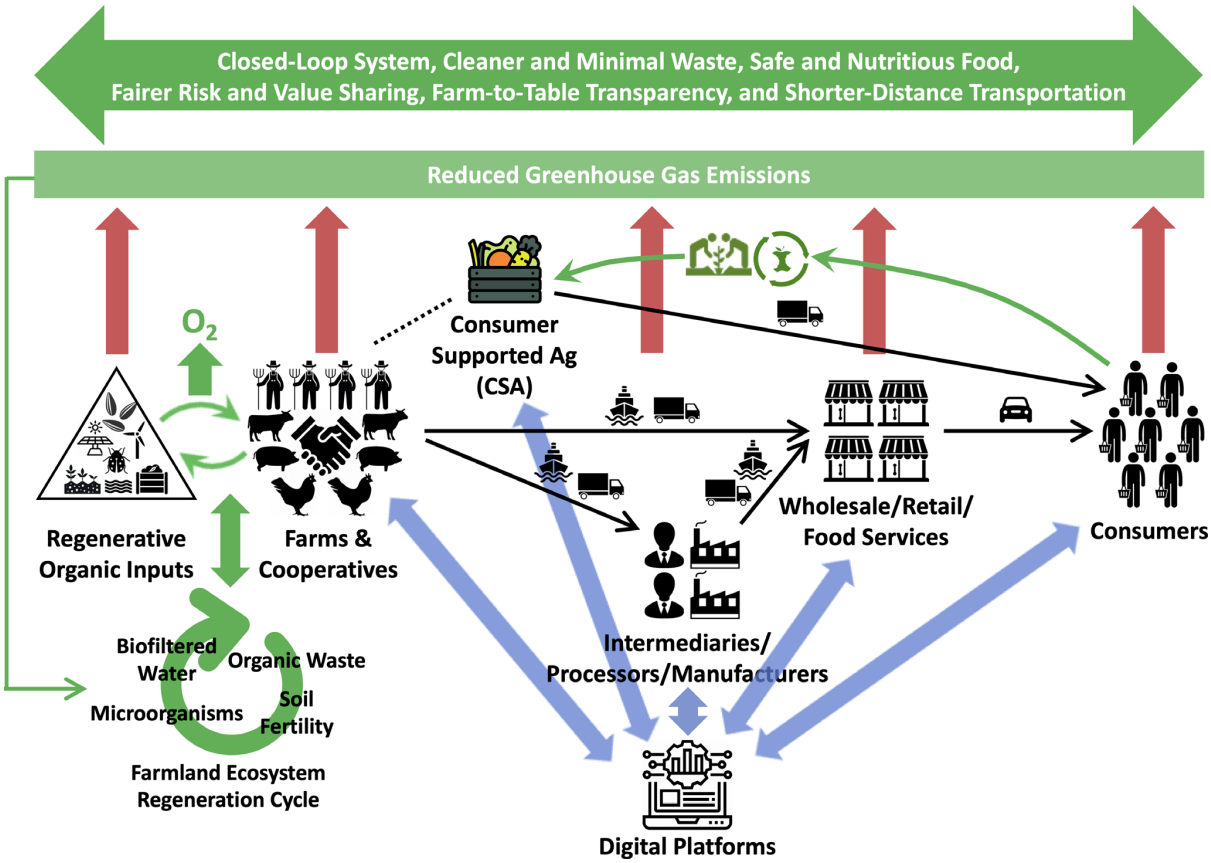


Some of these changes can already be found in some of New Zealand's most well established value chains as reported by Trienekens et al., (2018). Although these value chains are primarily servicing an export market, some of the characteristics could be explored in the context of domestic fresh produce market.

In terms of the kiwifruit value chain, fairer risk and value is achieved through the shareholder structure. Growers have power to take a stand if they do not agree decisions or actions taken by the

lead company. In addition, actors in the chain are represented in within industry consultation groups that meet once a month to discuss major industry issues. Prices are based on pool of market returns for growers. Payments are based on size and taste/drymatter.

Figure 2. *The Regenerative, Organic Food Value Chain (Roth & Zheng 2020)*



Market places are less required because formal contracts are held throughout the chain, further the head company is constantly completing different types of research, providing this information upstream within the chain and focussing attention on breeding of new variety in response to market research.

The paper doesn't refer to customer education although, from a marketting perspective, perhaps more importantly, the head company is doing different types of research focussing on consumer usage and consumer attitudes towards its products, tracking consumption trends, consumer brand awareness, loyalty and engagement.

Traceability and trust is encapsulate throughout the value chain. Included within the Network Governance of the chain, the lead company facilitates chain collaboration by giving assistance to growers for the implementation of Global GAP (Global Good Agricultural Practice Compliance), knowledge transfer, workshops, online seminars and intensive production support. Incentive systems and belief in the single desk structure contribute to the relationships between the New Zealand chain participants as a way of managing transparency.

4.2. Modern Technology

4.2.1. Blockchain

Blockchain is a decentralized, shared and immutable ledger. The block is a list of code representing transactions that have taken place. The chain is a list of blocks. Transactions record the ownership of assets on a ledger that cannot be tampered with which removes the reliance on any trust that may be relied on (IBM, n.d.).

The use of blockchain technology outside finance has been largely experimental. Some of the most promising non-finance applications of blockchain technology are expected to include those in SCM, power and food/agriculture (Gurtu & Johny, 2019)

Gurtu & Johny (2019) found that based on current literature the advantages that blockchain can offer in terms for supply chain management are: data security, reduction in finance and banking risk and the potential to address fraudulent and manipulative activities, add value in transparency and digitizing administrative operations, provide better operational efficiency and finally it has the potential to improve trust through increased visibility within industries and across organisations. There are many projects underway to apply blockchain technology by adding value in supply chain transparency and digitizing administrative operations. The study illuminates the key role of blockchain technology in supply chain management. Blockchain can be instrumental with export and import in supply chain. Blockchain could potentially replace letter of credit along with many other shipping documents using smart contracts between the financier, buyer and seller. The value of blockchain technology is expected to be focussed on three primary areas: smart contracts, supply chain finance, increased supply chain visibility and traceability.

Kumar et al., (2020) presents an overview of permissioned blockchain systems along with a use case for a food supply chain that illistrates the major functionalities then ellaborates on the key challenges that arise from an end user. The studies aim is to dispel misguided notions and myths about blockchain as a silver bullet for all businesses.

Kumar et al. (2020) agreed that as a nascent technology blockchain allows business transactions among multiple parties to be recorded in a reliable immutable and secure manner. They create trustworthy networks by enabling non trusting parties to transact with each other which in turn is a further step toward disintermediation. Blockchain will also improve efficiencies in global supply chains in particular with shipping as it will discourage litigation because all parties will have equal access to legitimate, verified information.

The article argued blockchain is not a silver bullet for all applications. It incurs very high overhead in terms of storage, networking and processing costs. These costs, nor the environmental implications haven't been explored at any length. Because of these costs and the lack of research to establish these costs Kumar et al. (2020) concludes that blockchain should be deployed selectively, mainly for interorganizational transactions among untrusted parties and in applications that need high levels of provenance and visibility.

4.2.2. Smart Contracts

Smart contracts are essentially containers of code that encode and mirror the real-world contractual agreements online. The key premise for contracts is that they represent a binding agreement between two or more parties; where every entity must fulfil their obligations according to the

agreement. The agreement is enforceable by law, usually through a legal centralised entity. However, smart contracts replace the trusted third party, that is the intermediaries between contract members. They leverage this with the help of automatic code execution that is distributed and verified by the network nodes in a decentralised blockchain network (Macrinici et al., 2018).

Hiwa et al., (2021) completed a survey on blockchain based smart contracts and presents their applications. One of the applications presented is in the agricultural supply chain for regulatory compliance in terms of logistics management.

The authors learn the main features of the blockchain-based smart contracts for the logistics and supply chain industry are the data provenance and decentralized autonomous operation. The data provenance is important to evaluate the alignment of the delivery with the regulatory requirements of a particular product. The emergence of internet of thing (IoT) infrastructure will increase the usability of blockchain based smart contracts in the logistics industry. The blockchain based smart contract systems are required to improve further in order to integrate with the logistics systems. The systems are required to incorporate with mobile applications to improve usability. For instance, the FPSC milestones can be stored in blockchain and view of the supply chain to the chain participants via mobile application. Instead of developing the blockchain alone, the integration is required to consider. The efficiency of smart contracts requires optimization in the autonomous execution enablement of smart contracts in the logistics context (Hiwa et al., 2021).

The authors find that further work is required to understand solutions to the challenges of implementing smart contracts. If the smart contract nodes are operating with unstable network connectivity when the nodes are on the sea, the block synchronization functionality requires to identify. The error handling procedures for inconsistent blocks due to unstable network connections require further improvements. The leading smart contract platforms will develop a specialized version for the logistics-related services in future use (Hiwa et al., 2021).

Literature reviewed regarding smart contracts and block chain application found efficiencies that could be made in terms supply chain traceability, transparency, and regulatory compliance. The challenges for this technology come as they are in their infancy and while there appears to be potential, there are real challenges that exist to the full adoption and integration of blockchain and smart contracts into the agribusiness supply chain.

4.2.3. Internet of Things & E-commerce

In the simplest terms, the IoT is how we describe the digitally connected universe of smart devices. Smart devices have capability with internet connectivity, sensors and other hardware that support communication and control via the web (Built In, 2022).

A study of the Indian textile industry whereby an IoT embedded sustainable supply chain framework was developed to deliver textile items using a business to business (B2B) e-commerce business model (Prajapati et al., 2022). The study concluded Implementation of the IoT based on new technologies in the logistics and supply chain will become a vital concern for any industry. The implementation of these types of new technologies in their supply chain is not only for the better management of information but also improves the system efficiency. A virtual supply chain (VSC) provides support to enhance the quality by monitoring the logistics and supply chain processes and should take real-time corrective actions. The virtual logistics and supply chain services become more flexible, faster, smarter, and easier by implementing the IoT in the system. Virtualization might become a vital aspect for e-commerce businesses to be sustainable in this competitive world

globally. The IoT facilities, along with the Radio Frequency Identification (RFID) tags, constituted a significant part of the total cost of the supply chain network. With this the study found implementation of IoT facilities in every transport vehicle is costly. However, it could be implemented to be sustainable in the current competitive business world globally for smarter, traceable, and more efficiency.

Pranto, et al., (2021) designed a blockchain based model and explored the different aspects of using blockchain and smart contracts with the integration of IoT devices in pre-harvesting and post-harvesting segments of agriculture. They argue that pre-harvest and post-harvest processing are still done by following traditional methodologies while tracing, storing, and publishing agricultural data. As a result, growers are not getting deserved payment, consumers are not getting enough information before buying their product and intermediate person/processors are increasing retail prices. Using blockchain, smart contracts, and IoT devices, we can fully automate the process while establishing absolute trust among all these parties (Pranto, et al., 2021).

The authors explain growers have an expectation of a fair crop at the end of a multitude of inputs. However, this is not always the case in times where there can be adverse events throughout the season that can cause the growers to produce a less than expected crop volume. Regardless of the cause of a reduced crop volume, or in extreme cases, no crop volume, the growers are always the one to be hit hard and suffer. Growers are always in a constant state of risk starting from the very beginning of cultivation until product sold. On the other hand, according to a survey done by the US Bureau of Labor Statistics (BLS), growers were the lowest-paid workers among several other worker categories (Fayer, 2014). The price in retail shops is much higher, sometimes twice or thrice, than the price sold by the growers although the heart of the agricultural structure is the growers, who keep the wheel of agriculture running (Pranto, et al., 2021).

In addition to the high cost to setup IoT devices, sensors, and RFID tags, IoT devices discussed in earlier literature, Pranto, et al., (2021) concludes IoT devices are also vulnerable to security issues and if they get damaged it would be impossible to complete checks or data collection. While the system designed tries to avoid dubious conditions by implementing smart regulatory contracts, there are still some flaws. As blockchain is still in its inception stage, there is an issue of optimizing it for real world systems.

4.2.4. Digital Supply Chain

The customer requirements discussed by Clemants et al. in 2008 reflect a point in time. Customer demands are further explained by Roth and Zheng in 2021 in the context of 'regenerative, organic food value chains' (ROFVC) versus 'conventional food supply chains' (CFSC). Roth & Zheng (2020) review the concept of the entire conventional supply chain from the supply of farming inputs right through to the consumed product. The writers then recreate the conventional supply chain with regenerative and organic practices in mind. The ROFVC model focuses on regenerative and organic farming inputs with a downstream value chain supported by digital platforms with end of product life in mind including waste product being returned to the grower in the form of compost.

Levi, et al. (2020) discusses the impacts of the major reform that has been undertaken in Karnataka, India with the implementation of a Unified Market Platform (UMP) to support returns to growers for commodity based product. The article refers to the eNational Agricultural Market (eNAM), an online agri-platform setup by the Indian government. In 2014 eNAM was created to replace the previous trading platform that were localized regulated agricultural markets called "Mandis" situated throughout the State. The reason eNAM was produced was to increase market competition, enable

transparency of the price discovery process, and ultimately, improve growers' profitability. The study found that online agri-platforms can provide desirable infrastructure to enable potential integration of distant agri-markets, however success critically depends on systemic supply chain logistics and process design considerations that affect trades in the physical markets. The results show that an integrated agri-platform such as UMP generates greater benefits for far growers who produce high-quality products.

The two articles show positive results for growers returns with the integration of digital platforms to support agri supply chain. Roth & Zheng (2020) focus on a virtual regenerative, organic agricultural supply chain that is potentially a view into the future of fresh produce supply chains. The article by Levi, et al. (2020) focuses on a live example of national reform in Karnataka, India where a digital platform has been implemented in attempt to improve grower returns. Both supply chains with the support of digital platforms succeed in improving grower returns by increasing transparency in the supply chain, reducing buyers search costs or time, strengthening growers bargaining power and incentivising higher product quality.

5. Thematic Analysis

As explained earlier interviews have been conducted with individuals from three different stakeholder groups in the New Zealand fresh produce supply chain. The data generated from interviews was analysed into codes as shown in Table 1 under 10.2 Thematic Codes, found in the appendices. These codes have been used to establish themes discussed below. The initial theming Table 2 is shown under 10.3 Thematic Themes – Growers, also found in the appendices. There are similar themes from the marketer and retailer discussions so to save repetition these two sectors have been consolidated in discussion below with theming Table 3 shown in 10.4. Thematic Themes – Marketers and Retailers.

Within each overarching theme there are a series of sub themes that have been driven by the questions that were asked in the interview. These sub themes are shown in the Table 2 and 3. These subthemes are the foundations for the discussion and findings below.

There were five Growers who were interviewed from varying business and fresh product types. Attempts have been made to obtain a broad cross section of growers that covers a wide variety of fresh products. The individuals represent businesses that vary in scale from small scale dealing with the pack house and marketer solely, to large scale farming operations that deal with multiple supply chain routes to market and are vertically integrated having a direct relationship with the retailers.

6. Findings and Discussion

This research project has provided a better understanding of the New Zealand FPSC through the analysis of recent literature and a data corpus from semi structured interviews have provided three unique perspectives from growers, marketers and retailers.

The FPSC in New Zealand is a is an efficient system that turns over a significant amount of produce daily. The FPSC feeds a growing population with daily fresh product readily available in a large variety of retail services. The transactions have shifted over the past 20 years from a faceless market floor towards integrated partnerships throughout the entire supply chain. Information is more readily available through technology and growers have better information to support on farm decision making. While technology in the literature reviewed includes exciting propositions with blockchain technology the thematic analysis reflects a general immaturity among FPSC participants. These findings show that while there are efficiencies that can be gained, the overall system runs very efficiently when considering the supply of good quality product in New Zealand with physical challenges that are faced in fresh products.

6.1. Growers

From all data collected there were three main themes that came through in conversations and literature. The main themes were financial incentives, consumer orientation, and relationships. Financial incentives for growers to maximise the productivity of their farm drives them to grow crop that is best suited to the physical characteristics of their property. There is a need to meet consumer demands which growers continually work on to support the brand for their products either driven by regulation or linked to financial incentives. Relationships continue to become more important through the supply chain with strong partnerships forming that generates good information between participants.

Table 1. G*rowers (2022)*

Financial	Consumer Orientation	Relationships
Crop Selection	**Product Differentiation**	**Buyer Selection**
Relationship	**Technology & Traceability**	**Efficiencies**
Challenges	**Environmental & Social**	**Supply Contracts**
Solutions	**Product Challenges**	**Other**
Traceability		
Supply Contracts & Pricing		
Technology		

6.1.1. Financial Drivers

Financial drivers are a challenge and an opportunity for participants throughout the FPSC. It begins when the grower is selecting a property to purchase, a developed orchard that is financially performing at the time of purchase will influence the growers decision. For permanent crops that take time to establish, for example, lemons or apples, growers consider different options before committing to plant and establish a particular crop. This decision based on a multitude of factors however, financially, growers will way up the cost to develop the crop, the time to reach maturity

and the financial returns once the crop is fully producing. Once this decision is made the aggregate supply of the product planted is increased and the grower is reliant on the market forces of the product to produce returns into the future. Markets change over time, when financial returns are strong for a particular crop on farm, we tend to see increase in development of this crop. When overdevelopment occurs there is an oversupply and profitability is reduced. This leads to a reduction of development before potentially removing the crop if profitability falls significantly. There is a reluctance to remove an established crop because there can be a large capital cost and loss of income if the crop were to be changed in the future. Throughout these market cycles growers are constantly trying to maximise their financial returns. The phenomenon is similar in the short-term crops that are rotated multiple times a year, for example, cauliflower or sweetcorn. These crops are planted on the basis that when they are ready to harvest there will be a market and this is typically not guaranteed to the grower, nor is there knowledge of how much of the same product is being planted for the same period. For both permanent and annual crops, there is a significant cost outlay to produce a crop, typically without certainty of the value the crop will have at the time of harvest.

Historically financial drivers encourage growers to produce as much product as they can that meets the quality and size standards that are required (Anon. Pers.Com. 2022). Growers may work with multiple marketers to have visibility of the market price for their product. Communication between growers and their subsequent buyer can be daily with updates of pricing and volume requested. This is changing, growers are aligning themselves closer with a particular marketer or retailer that shares similar values. Grower partnerships with buyers, whether it be marketers or retailers direct, are positive for the entire supply chain. The partnership provides improved certainty of supply to the retailer that allows them to plan and align domestic growing seasons with importing product for off season. This in turn reduces the frequency that imported product and local product offerings overlap causing huge oversupply and very low returns to growers and/or wastage of product. In turn, this reduces the volatility of supply and price.

Competition among marketers and retailers impact financial returns to growers. As some marketers compete over volume, returns to growers tend to diminish which historically has been an ongoing concern in specific fresh produce categories. Increasing costs along the entire supply chain exacerbated by cost of, and access to labour has increased the costs of fresh produce over the past two years which is significantly impacting the price consumers pay and the returns being received at farm level.

There are a multitude of potential solutions to these challenges. Increasing the labour pool available to the whole FPSC would improve the consistency and reliability of the supply chain. Maximising the use of transport and cool chain capacity between depot's would see existing infrastructure utilised to its full potential. Regulation around the import scheduling of fresh product could support the consistency of supply of NZ product ready to be harvested.

The FPSC historically has not been particularly transparent on price and growers have noted relatively large and unsubstantiated differences between the sale price of their product and the consumer price. Growers consider price transparency with their buyer to be very important. While products change hands between intermediaries before reaching the consumer each intermediary takes their specific margin. As a result, growers are often in communication with multiple marketing companies and negotiating the highest price for sale. This gives them visibility of the market and gives them the confidence they are getting the fairest price. Pricing incentives are offered for first grade product. Growers aim to achieve the largest pack out of the product to achieve the first grade however there is inevitably product that doesn't make this grade and falls into the second or lower grade. The problem can be finding a market or use for this lower grade product. We are seeing an

increasing trend of ugly fruit or misshaped fruit that can sometimes be discounted otherwise it can be processed. Often the demand for this produce is significantly less and can sometimes be wasted.

There is huge potential for technology in on farm operations and to add efficiencies to the supply chain. Growers see that technology has been implemented on the supply chain over time and that investment in technology is needed on farm. That said, growers see benefit in technology that can take them closer to the consumer, reduce reliance on labour by automating processes, improve stock visibility throughout the supply chain with a category sharing type platform and finally record and generate big data to support decision making. The biggest concern is the cost of investing in technology with the ongoing risk of disruption. Organizations need to be specific about the problem they are trying to resolve before investing in technology. Market disruption is inevitable at some point and we are already seeing this by way of vertical farms and roof top farms that solve many of the challenges the traditional farming system faces.

6.1.2. Consumer Orientation

Over time information sharing and collaboration has improved. There has been a change in paradigm from producing the largest physical yielding crop, to planting and harvesting crops based on retail data such as harvest programs, quality parameters and optimum size profile. Growers are working to produce a product that has all the characteristics required to satisfy consumer demands, support a great experience in consumption and create a returning customer for the product.

When it comes to picking dates for seasonal crops, imported product can sometimes damage the brand of an entire category. That can cause a consumer to have a poor experience with product just before the local season is coming on. To limit this impact growers would encourage increased customer awareness of imported product versus domestic at the retail level.

The fresh produce supply chain is complex due to the variety of different products that are included and the characteristics of fresh products. The biggest challenge with fresh produce is its perishability. Because of this there is a large amount of pressure on the FPSC to move produce to the consumer as fast as possible. As a result of perishability, seasonal production of permanent crops limit ability to supply market all year round. Consumers demand fresh products for 52 weeks of the year which is not possible when production is seasonal and storage time is limited. To mitigate the seasonality, retailers and marketers select similar product from different hemispheric geographies to address seasonality. Due to the perishability the coordination of planting and picking is essential to manage supply, if product is held from market after picking for too long it will be wasted and be a cost to dispose. To help this, supply programs are a good tool to allow growers to plan and know when to pick for the market as well as for the optimum ripeness.

Growing knowledge and infrastructure tends to be localised in areas where conditions are suited to growing fresh produce. These areas have a geographical advantage in growing and are a consideration for growers when deciding what to produce. Often these areas can be some distance from market, so investment is made in the cool chain to ensure the distance to market has minimal impact on the quality of produce before it reaches the consumer.

Domestic fresh produce traceability is well controlled in New Zealand. Good Agricultural Practices NZ (GAP NZ) regulates the entire supply chain traceability standards. Traceability goes as far as the retailer then loose products may be mixed with other similar origins. Growers don’t see enough value on the farm name and location being traced right through to the consumer, allowing the

consumer to see where the product was produced. With the traceability to supermarket level, the consumer has confidence in the retailer that the product has been traced and if there is an issue the origin of the product can be found quickly. The traceability through to consumer also puts added pressure on the supply chain to handle every product with added care as consumers could associate a negative experience with a particular farm that has nothing to do with the cause of the negative experience, for example the product may have been left in a cool store for too long before sale. There is technology being used that supports traceability for growers that are branding their product, which allows consumers to identify the brand and trace back to the farm. The growers using this technology are operating at scale, supplying retail direct and investing in their own brand.

Social licence is becoming increasingly important (Anon. Pers.Com. 2022), and growers have minimum environmental and social standards that are audited annually under GAP NZ and Risk Assessment on Social Practice (GRASP) framework. Minimum standards are critical to meet for growers to supply any produce to market. While most growers are constantly trying to do the right thing there is no incentive for them to go over and above the minimum standard within the traditional supply chain. As regulations increase growing practices will need to increase to remain current.

6.1.3. Relationships

Historically the fresh produce supply chain was largely based around the market floor which consisted of an ascending/descending order auction system. This required growers to bring their product along to the market on the day it was picked and put it up for auction. This was always a guessing game and typically when the category was in season the price crashed. When the category was off season the price was strong. There was minimal coordination of demand and supply, with no way of knowing when the best time was to plant or pick and supply to market. There has been a shift in practice over the past 20 years to a relationship-based supply chain model where there is alignment and open communication between growers and suppliers. Growers will partner with marketing agencies or retailers when they have trust, normally supported by aligning values, fair pricing and transparency.

Efficiencies can be gained with scale that can be achieved by business growth as seen in some fresh products where there is a dominant market leader. The other way is building relationships with other growers and forming a grower group or cooperative. These are used in many applications in primary industry across the world. Smaller scale cooperatives in fresh produce are able to improve the coordination of supply of product and improve the returns generated by growers. An example of this is Kaipara Kumara where growers have collaborated and produce consistently to meet market expectations.

Interestingly, the FPSC doesn’t tend to rely on supply contracts but more supply agreements which are typically non written and based on expectations. The supply contract is difficult for either party to adhere to due to the number of factors that are outside of their control. Some growers would prefer to have them to offer complete certainty of demand and price. Other growers prefer to have the flexibility and ability to negotiate with marketers.

6.2. Marketers and Retailers

Two officials from NZ fresh produce marketing agencies and two officials from two different retail outlets were interviewed. Both retailers and marketers hold individual relationships with growers and other marketing agencies that makes up their supply base. Historically marketers have supplied retailers produce however in recent years there has been a shift and retailers are forming direct relationships with growers to supply directly.

Supermarkets make up 75% of fresh produce sales in NZ. With only three different supermarket chains, and the emergence of a fourth operating in NZ this is an oligopoly that has a large amount of control over the sector. These large organizations ultimately have a consumer focus. Traditionally when there has been minimal alignment with growers and lack of supply coordination. This has driven a fresh produce trading environment; where supply fluctuates daily and produce buyers are searching for the cheapest product. This tends to disincentivise freshness, quality, and consistent supply as the supplier most desperate to sell, will sell at the cheapest price. This may be lower grade product or been held in a cool store and perishing. We have seen a shift towards partnerships between retailers and growers or marketers, depending on the category, to align supply and demand with more focus on freshness, consistent supply, and price stability. 20% of fresh produce is sold through independent grocers who tend to buy through marketers. These organisations don't have the scale to maintain a direct relationship with growers as daily sale volumes are too small and traditional growers are looking to sell at larger scale. 3-5% of fresh produce is sold to hospitality and processing which again is sold primarily through marketing agencies for similar reasons to the independent grocers. The discussions held with marketers and retailers saw two main themes reflected on which were customer orientation and grower orientation.

Table 2. M*arketers and retailers (2022)*

Consumer Orientation	Grower Orientation
Product Characteristics	**Developing supply certainty**
Supply Challenges	**Relationship Factors**
Efficiency Investment	**Supply Chain Challenges**
Traceability & Technology	**Supply Chain Solutions**
Environmental & Social	**Supply Agreements**
	Technology
	Supply Chain Improvements
	Quality Incentives

6.2.1. Consumer Orientation

Consumer demands influence the entire supply chain. Demand signals are captured at the retail outlet then directed throughout the supply chain which drive short and long term investment decision making. In effect the entire supply chain is oriented towards customer demands.

Consumers demand high quality and fresh produce. The FPSC has been optimised with significant investment in cool chain technology to keep produce fresh for as long as possible and move product from the farm gate to the retail shelf as quickly as possible. This demand requirement causes the FPSC to operate fast paced and hold minimal stock on hand. Supermarket chains turn produce over daily to ensure product freshness. Large scale distribution centres are designed to manage quick

turnaround under optimum preserving conditions. This allows produce to be collated in a central location and distributed back out to individual stores. A supply chain operating at such fast pace naturally has vulnerabilities. This was seen when pandemic lockdowns significantly interrupted supply chains and spikes in demand for products coupled with labour issues resulted in temporarily empty shelves in some categories.

Consumers also demand product for 12 months of the year. Large scale growers and marketers to invest in geographical diversification. This supports an increase in the supply period, with some products being grown year-round across NZ, and reduces the risk of a localised adverse events impacting on the availability of a product. Marketers and retailers also build relationships with overseas suppliers to provide stock for products outside of NZ supply period.

Consumers demand fresh produce at a reasonable price. Efficiency in terms of FPSC requires investment in processes, capability, and infrastructure and this requires scale to cover costs. High inflation of costs in the FPSC are causing the pricing of fresh produce to reach a natural price ceiling. As costs continue to rise, we may see consumers change their choices to purchasing processed or other forms of nutrition. This price ceiling is an inhibiting factor for increased investment unless there is increased output or cost savings that will produce the financial return to support the investment.

On top of efficiencies there are environmental and social objectives that FPSC participants are trying to achieve to uphold their own social licence to operate. These are imperative because they serve to justify market access. The concern is that costs are increasing from inflation and as fresh products reach their price ceiling there is less revenue to cover costs of environment and social innovation.

Traceability throughout the supply chain gives consumers peace of mind that the product they're eating has been handled professionally and if there are any issues the product can be tracked back to the farm it was produced on. Traceability is regulated throughout the FPSC by "Good Agricultural Practices" (GAP) NZ. Some larger organizations have policies for traceability over and above the GAP NZ standards to support their own brand and reputation. Traceability data reaches the supermarket however isn't normally passed onto the consumer. Traceability supports the strength of branded product or the retailer's own brand so there isn't enough value gained by passing this information onto the consumer over the cost that would be required to implement it. Technology would benefit the FPSC where supply chains are more fragmented. Technology that could track and record data throughout the chain for all products would give retailers added certainty of safe and professional handling. This is more important for imported product where there are more intermediaries involved and border crossings that can include fumigations and material temperature changes. We are fortunate in NZ because our domestic supply chain is relatively reliable and short, where participants can communicate easily.

6.2.2. Grower Orientation

Retailers and marketers also realise that just as important as the consumer to purchase product, without growers there is no supply of product. This has resulted in a shift over time of purchasing direct from market floors to building partnerships with growers. Communication and exchange of data and information help influence grower's decisions of what to produce and when which allows them to produce based on consumer demand, along with all other considerations. Retailer's data provide robust information around what demand is for product over a 12 month time scale, which is

reliable. The biggest variable is supply, this is due to not having good information on product supply in fragmented supply chains and the biggest variable, the weather.

Marketers have invested in vertical integration up the supply chain, not to compete with growers, but to create “anchor” product supply that can be built off in partnerships with grower organisations. Further investment in developing model farms for new product varieties where intellectual property is held and there is uncertainty around production. This helps to give other growers and financiers confidence in growing and returns that can be generated. This is supported by intellectual property rights to manage supply in line with demand.

Similar to growers’ perspective, marketers and retailers will align themselves with growers that hold similar values; can provide high quality produce, consistently, year-round if possible and can except reduced volatility in price. This can mean not getting the best price when supply is short, but likewise, maybe not the lowest price when supply is abundant. Incentives are paid for first grade fruit based on normal quality standards, however there is no incentive above the first grade that is incentivised for growers to strive for. That said, retailers are constantly working to reduce their own stock loss that can come about from product that perishes before it is sold. This is a cost to the retailer. If growers can get product direct to retailer fresher with consistency that would potentially reduce stock loss, increase the shelf life and support more positive pricing.

Marketers have access to multiple sales channels which puts them in the best place to manage supply variations outside of normal expectations. Marketers support retailers in times where product is scarce by sourcing stock elsewhere and when supply is abundant, they can utilise other channels to help support better returns to growers and reduce waste product in the FPSC.

Increasing costs stemmed from inflation is also putting pressure on grower returns which is a concern facing retailers and marketers because of the price ceiling (earlier discussed) there is only so high the consumer price can go before it will negatively impact demand. Low access to labour is impacting supply chain costs and reliability. Marketers are investing in automation that will reduce reliance on labour in the future however this is still a long time away.

Technology that could support marketers and retailers in terms of their grower orientation is improved asset management systems that supports a closed loop supply chain. This would enable sharing resources that may have a long lifetime, such as plastic crates, rather than using single use packaging such as cardboard boxes. There is also value in storing information throughout the supply chain that could be supported by IoT and verify product movements, temperature, and other details from when it leaves the farm gate.

Marketers and retailers see the need for leadership from NZ Horticulture and industry sector bodies to support development in supply chain efficiencies. While retailers are focusing on product sales, they need to be aware of potential developments in the supply chain and support optimisation where they can.

7. Conclusions

The main objectives of this study are to gather understanding of the New Zealand domestic FPSC, modern technology supporting supply chains around the world and recommend a more efficient system. While the research conducted has been broad based with a focus on finding a modern technology or systems that could be implemented it is worth noting there is no 'silver bullet' that will drastically improve the efficiency of the NZ FPSC. The FPSC is already a highly efficient system with low wastage tolerances and minimal unnecessary intermediaries. Instead of finding a new system or technology to change the paradigm. The key findings of this report are summarised below.

The current FPSC includes a diverse basket of goods that each have their own characteristics built into their own supply chains. Growing organizations of all different sizes and scale operate within each of these categories. We find that large growing organizations that have invested in vertical integration operate a highly efficient system where they control a large part of the supply chain partnering directly with retailers to supply product year-round. These growers and retailers share a vast amount of information which supports products being delivered to NZ consumers consistently at high quality and reasonable prices.

Sectors that are more fragmented and include large numbers of small-scale growers suffer from a lack of scale and market leadership. They rely on marketers to consolidate product and supply local and/or export markets. Retailers have a lack of visibility in aggregate supply volume which makes it difficult to plan for varying supply events. There are also more intermediaries required that increases the costs within the supply chain. Retailers and marketers are working to build on relationships with suppliers. They incorporate supply agreements, non-contracted, that sets expectations for each party. Expectations include fulfilment of consistent supply with volume-based pricing. This leads to growers growing to consumer demand and implementing planting and picking regimes to suit the market demand. This reduces over supplied product and waste when the price is too low to justify picking and encourages a financially sustainable supply chain.

In fragmented product categories where there is no clear market leadership or dominant entity communication tends to be weaker as participants have more of an internal focus than external. This is could be driven by the general observation that the individual growers product is undifferentiated from the market and the decisions they make will have little to no impact on the overall market for the product. In these product categories communication and partnerships with marketers is also reduced as growers communicate with multiple buyers to get the best price on the day. This makes it difficult at a retail level to understand the total supply volumes with accuracy with double counting of same areas. These discrepancies make it difficult to plan for seasonal supply and can mean import product ends up being over or under ordered, which has price implications for the imported product and local product. This also has flow on effects with product stored for too long or selling out, both of which can lead to a poorer consumer experience.

The literature reviewed included articles referring to blockchain, smart contracts and internet of things technology with information on how this technology is and can be implemented in supply chains for all different types of production and manufacturing. In terms for NZ's domestic FPSC there is a relatively short and reliable supply chain that has less intermediaries with better infrastructure than what is seen in larger counties and especially second and third world countries. This means there is better visibility and communication links between participants. It also means there is less desire to invest in technologies such as blockchain that remove the need for trust in the supply chain. However, when considering imported product there is less traceability and visibility that

increases the need for blockchain technology, supported by internet of things to monitor product throughout the supply chain to give retailers verified information and confidence that product arrives fresh and has been handled appropriately throughout the chain.

The New Zealand FPSC is an efficient system for the current grower make up and it is worth noting that the supply chain for fresh produce is not 'broken'. There are natural vulnerabilities in the chain that are driven from the product characteristics and consumer demands of fresh produce.

8. Recommendations

Based on the research and findings from this study the following recommendations are made to industry bodies and participants in the domestic fresh produce supply chain in New Zealand:

- **Encourage growers with scale to sell direct to retail**
  Where growers have the scale and access to infrastructure. Retailers are increasingly sourcing product directly from growers and tend to pay the consumer price minus their own margin. Retailers focus on partnering with growers with long-term views to build open communication channels. This can reduce number of intermediaries required, benefiting the grower with increased revenue and communication, reducing wastage with direct supply plans, shorter storage periods, increased product shelf life.

- **Cooperate to vertically integrate**
  Where scale is not present cooperative models are a second-best option, this type of model gives smaller growers access to the benefits of scale without the significant capital investment required. This can improve the communication flow with an intermediary operating that is owned by the grower dealing directly with the grower and retailer. Growers can enjoy the benefits of coordinated production and stable pricing while sharing the costs of infrastructure. This does require close communication between growers as there can be tendencies to go outside of the coop for individual gain which can be detrimental to the trust in the cooperative.

- **Increase communication between FPSC participants with accurate data**
  Increased communication and transparency between FPSC participants to share annual crop volumes from fragmented sectors, particularly with permanent crops. Accurate crop data can support marketing and retail planning with variations of supply at a sector level to support the use of import product at the appropriate times, as seen in the kiwifruit and dairy industries.

- **Increase signage and branding on imported vs local product**
  Drive increased consumer awareness with signage and branding on imported vs local produce. Consumers in New Zealand have a preference for local produce over imported produce. Increasing consumer awareness around what is local and what is imported will help differentiate the taste and eating experience between imported and local product seasons.

- **Invest in internet of things and blockchain technology to manage traceability**
  Encourage investment by produce importers in internet of things and blockchain technology on import product to reduce impact on local fruit demand with perished product. In a similar token to the above this would give retailers the visibility and confidence that imported product is in a fresh state and has been handled appropriately throughout the supply chain before it reaches consumers.

9. Limitations & Future Research

This project covers a broad product base that includes a large basket of goods. More detail can be found when focusing on a particular product or category. This has supported a high-level discussion about the aggregate fresh produce supply chain in New Zealand. While this project has focussed on domestic fruit production and consumption, one major application for future research is to understand the relationship between export and domestic sales and how this impacts supply of product to the respective markets.

Literature reviewed was limited to the articles that can be found in the Lincoln University database which has a wide range of information however more literature could be found searching different institutions databases.

Interviews were conducted with a range of participants within the fresh produce supply chain as it is today. Further interviews with other people outside of the supply chain would provide a holistic view from the outside looking in, potentially providing more prospective.

The recommendations produced in this report need to be tested by industry experts before they can be acted on. It is suggested that supply chain participants communicate with one another before significant business changes or investments that may be based on the recommendations of this report.

This project has been completed based on the information available focusing on challenges, processes and practices that are the agenda as of today. Times will change and what is important tomorrow may not be the same as today.

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11. Appendices

10.1. Appendix 1: Interview Questions

Interview Questions:

1. What products do you produce for fresh market?

2. Why did you decide to produce these products?

3. Who do you sell these products to?

4. Why do you sell to this/these buyer?

5. What do you think are the biggest challenges in fresh produce supply chain?
    a. And can you explain why?

    b. Do you have any solutions for these?

6. Is there a better supply chain structure that you think should/could be implemented?
    a. If yes, can you explain how it might work?

    b. If no, can you explain how each actor in your supply chain adds value?

7. Do you feel you get the fairest price for your product(s)?
    a. Why, or why not?

8. Do you have any supply contracts in place?

    a. What is the nature of the conditions in your contract?

    b. Why do you choose to operate under contract?

9. For the products you sell, is there any traceability back to your farm?

    a. Can you explain your view as to whether this would add value?

10. Could you explain if there is any incentive to produce a superior product?

11. Are there any ESG objectives you are trying to achieve?

    a. Can you explain how you think this is recognized by your buyer/market?

    b. How do you think this could be communicated to the market better?

12. Can you explain any opportunities that technology can bring to supply chain management?

13. Do you see a place for blockchain technology in supply chain management?

14. What part of the supply chain do you think should be responsible for fresh produce supply chain management and why?

10.2. Appendix 2: Thematic Coding

Table 3. *Thematic coding (2022)*

Q		Interview Codes	Growers				Marketers		Retailers	
2										
		crops grown for Return on Investment	1		1					
		Inherited the crop/trees	1	1						
		Grow for geographical advantage	1			1				
		Support and industry knowledge in the region	1							
		Crop grown for ease to develop and growing		1						
		Crop grown to fill gap in the market		1						
		Produce based on consumer demand					1	1	1	
		Focus on freshness and quality							1	
		speed to consumer							1	
		fast supply chain has vulnerabilities							1	
		shift from sell anything to strategically investing in certain catagories					1			
		verticle integration, investment in growing systems					1			
		building IP in certain catagories					1			
		consumer demands 12 month supply						1		
4										
		Use marketers for there ability to sell at scale	1	1						
		seasonal production limits ability to supply market direct	1							
		grower marketer relationship, high trust		1						1
		grower marketer relationship has high transparency with pricing		1				1		
		grower packhouse relationship based on price and relationship with marketer		1				1		
		grower marketer relationship based on high communication			1					1
		grower marketer relationship based on higher price incentive			1					1
		grower marketer relationship based on higher quality								1
		direct to supermarkets to sell at scale			1	1			1	
		partnerships with supplier alligning values							1	
		geographical spread							1	
		marketers will sell to anyone					1			
		marketers solve variations in supply					1	1		
5	a									
		challenges accessing labour		1			1		1	
		competing with imported product		1						
		increasing costs along the whole supply chain		1	1		1		1	1
		marketers competing with each other for volume		1	1	1				
		lack of transparency across whole supply chain			1					
		perishable product				1				
		logistic and coolchain				1				
		getting product to final consumer				1				
		historically oversupplied fresh produce					1		1	
		allignment of domestic supply and import supply							1	
		information on scale of fragmented catagories							1	
		lack of historical investment in supply chain efficiencies					1			
		price ceiling in fresh produce					1			
		increase in growing costs						1		
5	b									
		regulate with import embargo during high local supply periods		1						
		greater customer awareness of NZ Grown		1						
		increase labour pool		1						
		achieving scale through grower pool or other means			1	1			1	
		maximise transport capacity				1				
		centralised distribution				1			1	
		partnerships between supply chain actors	1	1		1	1	1	1	
		IP in products					1		1	
		supply/picking programs					1		1	
		strategic crop planning at farm level					1			
6										
		knowing how much to pick and selling prior to picking	1	1	1	1		1	1	
		transparency from packhouse/marketer	1							
		Direct to consumer model, high cost and hard to scale								1
		lower grade outlet			1					
		high technology and big data				1				
		coops that bring growers together to manage supply			1				1	
		direct to retailer model reduces cost					1		1	
		move from auction to supply chain over time					1	1		

Table 3. *Thematic coding (2022) continued.*

	efficiency does creat cost					1			
	retail has a responsibility to invest in capability to sell product					1			
7									
	large difference between farm gate sale and consumer purchase price	1							
	transparency, relationship with buyer	1	1						
	have visability of market price		1	1	1	1			
	retailer competition to drive down prices		1						
	find market for 2nd grade produce		1	1					
	reduce volitility in pricing and supply, demand is relatively constant							1	
	information to suppliers shows effect of variations in supply							1	
8									
	grower enjoys flexibility	1	1						1
	market access is easy to obtain	1							
	minimal grower benefits from supply contracts	1			1				
	high trust		1						
	rely on less formal agreements	1	1	1	1	1		1	1
	prefer to use consistent pricing			1	1			1	1
	would prefer contract to maintain continuity of terms and agreement			1	1				
9									
	tracability to the supermarket	1	1		1	1		1	
	traceability could improve grower competition	1							
	produce traditionally bulk branded	1	1		1				
	tracability is regulated through NZGAP	1	1	1	1				1
	reliance on each actor to continue traceability	1	1						
	have visability of full supply chain		1	1					1
	not enough value for consumers to pay for grower branding		1		1	1			1
	maintain tracability to consumer with brand at scale			1	1			1	
	consumer preference for domestic produce							1	
	need technology to track events throughout supply chain							1	
10									
	incentives based around size and quality	1				1		1	
	marketer advises standards	1							
	packhouses can interpret quality standards differently	1							
	no premium for higher than normal quality standards			1					
	get preferential supply with better, consistant quality			1	1				
	incentive for superior/differentiated product					1		1	
	incentive for freshness, increase shelf life							1	
11									
	follow regulation with NZGAP	1	1	1	1	1			1
	working on ESG objectives				1			1	1
	do the right thing								1
	no incentive for esg practices		1	1	1	1		1	
	social licence is important				1			1	
	consumer not prepares for inconvenience/cost of ESG					1	1	1	
	Critical to maintain standards for market access					1			
12									
	technology available manages traceability			1					
	need technology that can take grower closer to consumer			1					
	technology that removes need for market floor			1					
	reduce labour demand		1		1				
	ordering systems with stock visability		1						
	big data to support decision making				1				
	concern of market diruption				1				
	technology to support traceability and significant events through supply chain							1	
	asset management to enable shared resources in supply chain							1	
13									
	Don't know about blockchain in supply chains		1	1	1				
	value in comms and transferring information					1		1	
	reliable & short supply chain in NZ					1			
14									
	growers have to take responsibility for their product to consumer			1					
	packhouse and marketer should be alligned		1						
	the actor that can make a profit will find the efficiency				1				
	retailers need to be aware and support							1	
	leadership from industry bodies					1			
	partnerships between growers/marketers					1			

10.3. Appendix 3: Thematic Themes – Growers

Table 4. *Thematic theming – growers (2022)*

Financial	Consumer Orientation	Relationships
Crop Selection	**Product Differentiation**	**Buyer Selection**
crops grown for Return on Investment	greater customer awareness of NZ Grown	grower marketer relationship, high trust
Inherited the crop/trees	regulate with import embargo during high local supply periods	grower packhouse relationship based on price and relationship with marketer
Grow for geographical advantage	need technology that can take grower closer to consumer	grower marketer relationship based on high communication
Crop grown for ease to develop and growing	growers have to take responsibility for their product to consumer	lack of transparency across whole supply chain
Crop grown to fill gap in the market	**Technology & Traceability**	**Efficiencies**
market access is easy to obtain	high technology and big data	achieving scale through grower pool or other means
Relationship	tracability to the supermarket	partnerships between supply chain actors
Use marketers for there ability to sell at scale	traceability could improve grower competition	coops that bring growers together to manage supply
grower marketer relationship based on higher price incentive	produce traditionally bulk branded	transparency, relationship with buyer
grower marketer relationship has high transparency with pricing	maintain tracability to consumer with brand at scale	reliance on each actor to continue traceability
direct to supermarkets to sell at scale	technology available manages traceability	**Supply Contracts**
Challenges	**Environmental & Social**	grower enjoys flexibility
competing with imported product	follow regulation with NZGAP	high trust
increasing costs along the whole supply chain	working on ESG objectives	rely on less formal agreements
challenges accessing labour	do the right thing	would prefer contract to maintain continuity of terms and agreement
marketers competing with each other for volume	no incentive for esg practices	**Other**
retailer competition to drive down prices	social licence is important	packhouse and marketer should be alligned
find market for 2nd grade produce	**Product Challenges**	
Solutions	seasonal production limits ability to supply market direct	
regulate with import embargo during high local supply periods	Support and industry knowledge in the region	
increase labour pool	challenges accessing labour	
maximise transport capacity	perishable product	
centralised distribution	logistic and coolchain challenges	
transparency from packhouse/marketer	getting product to final consumer	
Direct to consumer model, high cost and hard to scale	knowing how much to pick and selling prior to picking	
large difference between farm gate sale and consumer purchase price	lower grade outlet	
have visability of market price	find market for 2nd grade produce	
Traceability		
tracability is regulated through NZGAP		
have visability of full supply chain		
not enough value for consumers to pay for grower branding		
Supply Contracts & Pricing		
minimal grower benefits from supply contracts		
prefer to use consistent pricing		
incentives based around size and quality		
marketer advises standards		
packhouses can interpret quality standards differently		
no premium for higher than normal quality standards		
get preferential supply with better, consistant quality		
Technology		
technology that removes need for market floor		
reduce labour demand		
ordering systems with stock visability		
big data to support decision making		
concern of market diruption		
the actor that can make a profit will find the efficiency		

10.4. Appendix 4: Thematic Themes – Marketers and Retailers

Table 5. *Thematic theming – marketers and retailers (2022)*

Consumer Orientation	Grower Orientation
Product Characteristics	**Developing supply certainty**
Focus on freshness and quality	Produce based on consumer demand
speed to consumer	building IP in certain catagories
fast supply chain has vulnerabilities	verticle integration, investment in growing systems
shift from sell anything to strategically investing in certain catagories	**Relationship Factors**
consumer demands 12 month supply	grower marketer relationship, high trust
geographical spread	grower marketer relationship has high transparency with pricing
Supply Challenges	grower packhouse relationship based on price and relationship with marketer
marketers solve variations in supply	grower marketer relationship based on high communication
allignment of domestic supply and import supply	grower marketer relationship based on higher price incentive
price ceiling in fresh produce	grower marketer relationship based on higher quality
centralised distribution	direct to supermarkets to sell at scale
direct to retailer model reduces cost	partnerships with supplier alligning values
Efficiency Investment	marketers will sell to anyone
efficiency does creat cost	**Supply Chain Challenges**
retail has a responsibility to invest in capability to sell product	challenges accessing labour
Traceability & Technology	increasing costs along the whole supply chain
tracability to the supermarket	historically oversupplied fresh produce
tracability is regulated through NZGAP	information on scale of fragmented catagories
not enough value for consumers to pay for grower branding	lack of historical investment in supply chain efficiencies
maintain tracability to consumer with brand at scale	increase in growing costs
consumer preference for domestic produce	**Supply Chain Solutions**
need technology to track events throughout supply chain	achieving scale through grower pool or other means
technology to support traceability and significant events through supply chain	partnerships between supply chain actors
reliable & short supply chain in NZ	IP in products
Environmental & Social	supply/picking programs
follow regulation with NZGAP	strategic crop planning at farm level
working on ESG objectives	knowing how much to pick and selling prior to picking
do the right thing	coops that bring growers together to manage supply
no incentive for esg practices	Direct to consumer model, high cost and hard to scale
social licence is important	move from auction to supply chain over time
consumer not prepares for inconvenience/cost of ESG	have visability of market price
Critical to maintain standards for market access	reduce volitility in pricing and supply, demand is relatively constant
	information to suppliers shows effect of variations in supply
	Supply Agreements
	grower enjoys flexibility
	rely on less formal agreements
	prefer to use consistent pricing
	Technology
	have visability of full supply chain
	asset management to enable shared resources in supply chain
	value in comms and transferring information
	Supply Chain Improvements
	retailers need to be aware and support
	leadership from industry bodies
	partnerships between growers/marketers
	Quality Incentives
	incentives based around size and quality
	incentive for superior/differentiated product
	incentive for freshness, increase shelf life