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The Potential of Blockchain in New Zealand Food & Fibre Supply Chains

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Executive Summary

Blockchain is a digital platform that stores and verifies transactions between users. It is different from other digital databases in the following ways; it allows peer-to-peer transactions rather than relying on an intermediary to facilitate the transaction; the information is distributed throughout the network rather than being held in one central database; data is encrypted so that it is unable to be changed in any way; and any changes to the network require consensus among all participants in the network.

The potential for blockchain is huge, with it now having hundreds of uses across the financial, manufacturing, health, and education sectors. It has created a secure, immutable way to store information on all kinds of assets. This report will focus on the use of blockchain within supply chains. Supply chains are a perfect use case for blockchain technology as they require multiple parties having access to the same information.

This report will cover the fundamentals of how blockchain technology works, it will investigate how blockchain could change supply chains, and it will identify and understand the global trends that are driving the need for this technology. New Zealand is in a great position as a producer of premium food and fibre to capitalise on blockchain technology. We aim to feed the top 40 million consumers, these consumers want more safety and security around their food, they want to know where it has come from, how it was produced; they care about a healthy environment and the sustainability of the planet. For New Zealand businesses, they are looking for ways to protect their reputation, fending off imitation products and maintaining a premium position for products. The transparency offered by blockchain provides this information to every entity in the supply chain.

Transparency is one of the key drivers of blockchain technology, but the other outcome for the New Zealand primary sector is greater supply chain efficiency. With more stream-lined supply chains, there will be a faster turnaround of goods and finance, fewer transaction costs, and ultimately more money back to the people who grow the product.

As an agricultural exporting nation, New Zealand has huge opportunity to lead the world in developing agricultural supply chains that connect, shorten, and sharpen global supply chains. Blockchain has the potential to reshape the way New Zealand agricultural companies market, sell and record the provenance of our products to the globe. If we are to lead the world, then we must invest in understanding this technology now.

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Introduction

Blockchain has the potential to transform agricultural supply chains. Blockchain provides an online documentation system that records the transfer of information or goods at each point in the supply chain, this transaction is contained in a 'block'. Each block contains a timestamp and a link to the previous block, creating an immutable ledger (Kim & Laskowski, 2016). The system ensures both confidentiality and traceability for each trading partner involved in the supply chain (Connolly, 2018). Blockchain has developed over the last decade to be one of the biggest ground-breaking technologies with the potential to impact every industry from financial to manufacturing to educational institutions (Marr, 2018).

It is a digitised approach which facilitates the transfer of physical commodities, finance and associated information. This technology will support provenance and transparency demanded by the premium consumer; it will deliver supply chain efficiencies, returning more money back to the producer; and it will alleviate counterparty risk.

One of the key drivers of blockchain is that it enables complete traceability of a product, providing secure data about where a product is from, how it was grown and whose hands it has passed through. This offers huge opportunity for premium products in a world where consumers want high-quality safe products with visibility of the supply chain.

Supply chains are a perfect use case for blockchain technology, as they require multiple parties having access to the same information. When combined with other software, such as smart contracts, users of blockchain will have the following benefits:

- Buyers and sellers can transact directly,
- Borderless transactions,
- Automated contract execution,
- Superior transparency with secure record trail,
- Low transaction costs.

"Google organised the world's information, Facebook connected people across the globe, and blockchain will organise the worlds assets" (Tai, 2017).

Objectives

The objectives of this study were:

- To understand the fundamentals of how blockchain technology works.
- To investigate how blockchain could change supply chains.
- To identify and understand the global trends that are driving the need for blockchain technology.

Method

The methodology used to complete this study was a combination of literature review and the qualitative data analysis method known as thematic analysis. The literature review allowed evaluation of the current available information on blockchain technology; how blockchain technology works and how it could reshape New Zealand's food and fibre supply chains. The process of thematic analysis involved reading the data to become familiar with its content, and then searching for common themes. In this study, the themes were defined as the key factors that are driving the need for blockchain technology, from both a consumer and a farmer perspective.

The Fundamentals of Blockchain

What is Blockchain?

Blockchain is a digital platform that stores and verifies transactions between users. The transactions, referred to as 'blocks', are recorded on a shared ledger (Lefroy, 2017). When a new transaction is made, this is verified by the parties operating in the chain. Each block is timestamped and connected to all the blocks before and after it. The ledger is replicated on a wide network of computers (nodes), making it impossible to edit or delete, and therefore creating a very secure digital record (Nason, 2018).

There are five basic principles which underpin how blockchain technology works, these are summarised by Casey & Wong (2017) below.

i) *Distributed database*

Each party on a blockchain has access to the entire database and its complete history. No single party controls the data or information. Each party can verify the records of its transaction partners directly, without an intermediary.

ii) *Peer-to-Peer Transmission*

Communication occurs directly between peers instead of through a central administrator.

iii) *Transparency*

Each transaction and its associated value are visible to anyone with access to the network.

iv) *Irreversibility of records*

Once a transaction is entered in the database and the record updated, it cannot be altered because they are linked to every transaction before it (hence the term 'chain'). Various computational algorithms are used to ensure the recording on the database is permanent, chronologically ordered, and available to all others on the network.

v) *Computational Logic*

The digital nature of the ledger means that blockchain transactions can be tied to computational logic and programmed. Users can set up algorithms and rules that automatically trigger transactions between nodes.

Blockchain is an open, decentralised ledger which records transactions without the need for third party authentication (Verberne, 2018). While it originated as an electronic system for cryptocurrency transactions, the technology has the adaptability to be used in numerous other situations.

Why use Blockchain?

The current global economy relies on a third party to verify and record all transactions. These centralised databases support the volume and velocity of transactions, however, due to their centralised electronic nature the information contained within them is notoriously easy to modify and falsify (CSIRO Data61, 2017). New ideas on how to ensure the integrity of data have raised significant interest. The first example of a publicly distributed ledger was the cryptocurrency, Bitcoin. It provided trust because it recorded all the transaction information in a public space and is non-replicable (Marr, 2018). Now it has been identified as having enormous disruptive potential to transform a range of businesses (CBH Group and AgriDigital, 2017). The term blockchain has been widely adopted to refer to distributed ledgers[1].

The World Economic Forum (2018) identifies three key value propositions for blockchain:

- Accuracy – multiple copies (as opposed to a single copy) of the complete historical record of ledger entries that have been verified by consensus.
- Transparency – it is a public record of activity that can be seen by all network participants.
- Disintermediation – it operates using a peer-to-peer network, rather than requiring a specific central organisation.

Blockchain in Agricultural Supply Chains

Blockchain is a digitalised approach to managing supply chains. It will facilitate the transfer of physical assets, finance and all associated information (Lefroy, 2017). It has been identified as the solution to safer, fairer and more transparent supply chains with its use ranging from food production (Chu, 2018; Myler, 2018) to diamonds (Everledger, 2018), to cars (Gohd, 2018).

[1] A distributed ledger (also sometimes referred to as a shared ledger) is a consensus of replicated, shared, and synchronised digital data geographically spread across multiple sites, institutions, or countries. There is no central administrator or centralised data storage. A blockchain is one type of a distributed ledger design.

Globally there has been a movement towards digital economies. Sectors such as finance, professional services and retail were early movers, investing heavily in IT in the 1980s. Whereas other sectors, particularly ones with extensive physical assets have been slower at shifting towards digitization. According to McKinsey Global Institute (2015) agriculture remains one of the world's least digitised industries which leaves it widely open to disruption. However, with disruption comes huge opportunity. Blockchain has gained incredible traction over the last few years, and there is huge potential for agricultural supply chains to utilise this technology.

According to Ohlsson (2018) the main problems affecting the global agri-supply chain that are driving the need for blockchain technology are:

- Consumers don't know where their food comes from,
- Farmers don't get paid for what they deliver, when they deliver, and
- Buyers don't have access to automated supply chain finance.

Consumers are increasingly demanding high-quality, safe products, they want to know exactly where their food comes from and how it was produced (Smellie, 2017). They want to know what they are buying was produced sustainably, with animal welfare, social responsibility, and environmental protection all taken into account. Blockchain is the solution in supporting provenance and traceability (Lefroy, 2017).

In an agricultural supply chain, blockchain technology has the potential to eliminate counterparty risk, ensuring farmers get paid for the food and fibre they produce (Nason, 2018). The fundamentals of the technology mean that there is greater efficiencies and lower transactional costs, ultimately driving more money back to the producer. Further value of blockchain in agricultural supply chains is the ability to do volume reconciliation. As 'trusted' food and fibre brands make a name for themselves, there is the opportunity for fraudulent products to enter the market, hoping to capitalise on the brand. For example, the success of the Zespri brand in China, has meant local kiwifruit sellers are using fake Zespri stickers in attempt to mislead consumers (Boot, 2017). The security of the blockchain system offers a way to identify if more product is entering the market than what is actually grown.

How is Blockchain Different from the Status Quo?

Currently supply chains rely on centralised databases and third-party verification. They are typically paper-base; not-automated; slow and expensive; and most pointedly they allow no visibility up or down the supply chain, with the majority of parties only being able to see one step either side (Figure 1).

A traditional centralised supply chain, as shown below, functions on stepwise interactions between the various stakeholders. Transactions from farmer to buyer, buyer to packer, etc until the product reaches the end consumer. Transactions between the parties are verified by a trusted third party such as a bank. The flow of information up and down relies upon the accurate passing of information between stakeholders and depends on trust from stakeholder to stakeholder. Information can still be altered or communicated inaccurately along the way (Nason, 2018).

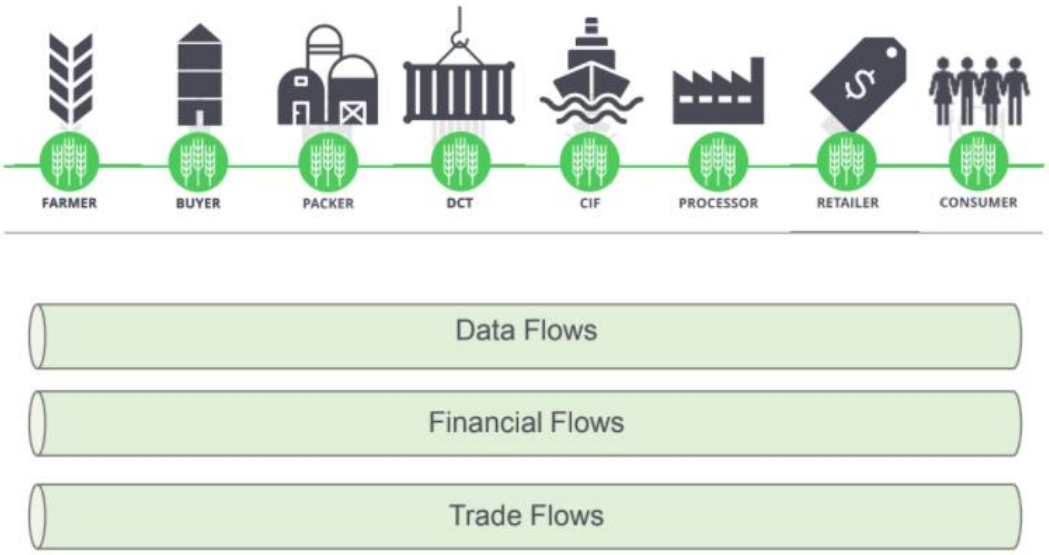

Figure 1: Current supply chains *(Ohlsson, 2018)*

In a blockchain-driven model, as shown below, the supply chain is decentralised with all stakeholders connected via the blockchain network. Transactions and information are stored and verified by all users, and all stakeholders are equally connected (Nason, 2018). The data sharing is now also two-way, so producers at the start of the supply chain can see is happening downstream and get relevant market feedback (Lefroy, 2018).

Figure 2: Blockchain supply chains *(Ohlsson, 2018)*

Blockchain provides the potential for an open platform, with the underlying technology guaranteeing integrity even within the most fragmented supply chains. The key attributes of blockchain technology within supply chains are; the transfer of assets without the need for intermediaries; transactions stored on a ledger that is shared by all users; and the use of smart contracts.

Public versus Private Blockchains

Blockchain is designed to be open source, however, there are both public and private blockchains. The distinction between public and private blockchain is related to who is allowed to participate in the network, who verifies the transactions and who maintains the shared ledger. Public blockchains can be likened to the internet, whereas private blockchains are analogous to the intranet.

Public blockchain is completely open and anyone can join and participate in the network (e.g. Bitcoin), there is often an incentivising mechanism to encourage more participants to join the network. Public blockchains provide radical transparency and allow all participants to view the transaction data recorded on the blockchain (CBH Group and AgriDigital, 2017). The downside of a public blockchain is the large amount of computational power required to maintain a distributed ledger at a large scale. The other downside of a public blockchain is the lack of privacy for transactions (Jayachandran, 2017).

Private blockchains are permissioned, which means that for an entity to be part of the network, the will require an invitation and must be validated by either the network starter or a set of rules put in place by the network starter (Jayachandran, 2017). There is control over who can assess the transactional information, with only a few trusted participants having visibility of the whole network. For example, within private supply chains there can be a blockchain 'owner' (verifier) and parties are invited to partake in the blockchain. This places a restriction on who is allowed to participate in the network, and also controls what information is available to the end-user. For this reason, private blockchains can be considered less transparent, with a lot of trust remaining with the 'owner' of the network.

Private blockchains allow companies to take advantage of blockchain technology by setting up participants who can verify transactions internally and through reducing transaction costs, however there is much debate about whether this system can actually be defined as blockchain. Due to the increased privacy and control with private blockchains they are unlikely to revolutionise the way we transact, they are not providing full transparency and there is a still a risk of security breaches just like in a centralized system. The table below outlines the main differences between public and private blockchains.

Table 1: Differences between public and private blockchains *(Skinner, 2018)*

	Public	Private
Access	- Open read/write	- Permissioned read and/or write
Speed	- Slower	- Faster
Security	- Consensus mechanisms[2]	- Pre-approved participants
Identity	- Anonymous - Pseudonymous	- Known identities
Asset	- Native asset	- Any asset

Smart Contracts

A 'smart contract' is a computer code on top of a blockchain which contains a set of rules by which the parties have agreed to use to interact with each other (Voshmgir, 2018). When the pre-defined rules are met, then the agreement is automatically enforced. The aim of smart contracts is to provide the security and to dramatically reduce the transaction costs typically associated with contracting. It is the simplest form of decentralised automation (Houser, 2018).

Smart contracts are intended to digitally facilitate, verify, and enforce the terms of a contract. Nick Szabo first came up with the idea of a smart contract in 1997 (Wingreen, 2018). They are 'trustless', since the parties involved in a smart contract do not need to trust each other, but instead trust the code of the smart contract and the blockchain's ability to enforce the terms of the contract. They allow credible transactions to occur without the need for third parties. These transactions are trackable and irreversible.

[2] Consensus mechanisms are the process of verifying transactions in a public blockchain. Any computer connected to the internet can validate transactions in a public blockchain, this is done through a process called 'mining' (Miles, 2017). Transactions are bundled together into what we call a block and miners verify that transactions within each block are legitimate. To do this, they must solve a mathematical puzzle known as 'proof-of-work' and a reward is given to the first miner who solves each blocks problem (Blockgeeks, 2018). These verified transactions are then stored in the public blockchain.

A simple example of a smart contract is a vending machine. The rules of the transaction are programmed into the machine. You select a product by pressing a number related to that product, insert your money, the machine acts as a smart contract by checking whether you inserted enough money. If you have, the machine is programmed to release the product. If you inserted too much money, you will get change, and if you didn't enter enough money you will get this back also. Automatic vending machines significantly reduced transaction costs by making human vendors obsolete, and they also expanded hours of service, with round the clock availability instead of limited shop opening hours.

Smart contracts are dependent on the people coding them, they are reliant on people taking into account all of the information available at the time of coding. The pre-set rules are put in place and parties can opt-in if they agree with these terms. While smart contracts have the potential to become legal contracts, they should not be confused with legal contracts accepted by courts or law enforcement. Legal contracts and smart contracts will likely merge as the technology develops and becomes more widely used and accepted (Voshmgir, 2018).

In agricultural supply chains there is a lot of potential to establish smart contracts to execute specific actions when they encounter a specific situation. For example, the pilot project that AgriDigital have been working on with the Australian grain producers, has a smart contract established so that the transfer of the asset (grain) results in simultaneous transfer of funds (CBH Group and AgriDigital, 2017). By having automated exchange of goods for finance, this has the potential to rapidly improve efficiencies of agricultural supply chains, and removes significant risk regarding payment.

Security of Transaction

As the name blockchain implies, it is a chain of 'blocks', with the blocks containing all the records of transactions. Each block is connected to all the blocks before and after it, making it impossible to tamper with. Other inherent characteristics of blockchain that provide security include; the records on the blockchain are secured through cryptography, network participants have a private key which is assigned to the transactions they make and act as a personal digital signature (Miles, 2017). If a record is altered, this digital signature becomes invalid and the network will know something has happened.

As blockchains are not contained in a central location, they do not have a single point of failure and cannot be changed from a single computer. It would require huge amounts of computing power to

access 51% of a certain blockchain and alter them all simultaneously. The bigger the network, the more tamper-resistant it will be.

Drivers of Blockchain Technology

Global Food and Fibre Trends

The New Zealand primary sector is only able to feed approximately 40 million people. As a result of this, the focus is on producing quality not quantity. New Zealand aims to be a niche producer of premium quality, safe and sustainable food, fibre, and timber (KPMG, 2017). The consumer we are targeting is prepared to pay a premium for these products, in return for product history information. Due to a shift in social and cultural trends, more information surrounding the product is required to be available to the consumer.

Producing for the premium paying consumer, relies on us evolving the way in which we produce food and fibre, but also relies on us creating different ways to market our products as new tools and solutions become available. Blockchain is a possible solution in providing consumers the information they want about the products they are buying.

There is an ever increasingly global requirement for food. Traditionally there has been a demand for natural proteins but with the introduction of alternative protein sources (plant protein and synthetic meat) more emphasis is needed to be put on the benefits of a naturally grown product. It will be the sustainability and provenance of these natural products that appeal to the consumer. However, consumers need this information about the product for it to be considered premium. This information is essential to the international marketing of our products, it is what differentiates it and creates value.

It will be essential to integrate digital technology into all aspects of a farming system for it to operate sustainably. By collecting data and using it to make informed decisions, it will enable farmers to improve yield while reducing inputs. The data that is collected will form the first block in a chain of data, all of which will ultimately provide the consumer assurance of the provenance of their products.

The KPMG Agribusiness Agenda (2017) has stated that putting the consumer at the centre of what we do is increasingly important. It is the authenticity of the product story and the way this appeals to the consumer that will determine the value we are able to secure from what we grow. As consumer expectations continuously increase, blockchain technology will assist in making this connection from producer to consumer.

Trust

Blockchain allows verification to occur either by a trusted party in the case of a private blockchain (Jayachandran, 2017), or by 'consensus' in a public blockchain (Miles, 2017). The overarching driver behind the need for blockchain technology is trust (Higginson, Lorenz, Münstermann, & Olesen, 2017). Previously we have relied on third party authentication to ensure trust within the system.

In order for us to transact we must trust the people we are dealing with, currently this trust is manufactured. We use banks, trading houses, and clearing houses as intermediaries to facilitate, verify and record the transaction from one individual or business to another. Blockchain will allow us to transact from peer-to-peer because it will change the way in which we trust (Etwaru, 2017).

For supply chains, this will vastly improve efficiencies, driving more money back to those who actually grow the product. The Commonwealth Bank of Australia (CBA) have been collaborating with a US bank to help a US-based cotton business sell cotton to Australia. They are integrating blockchain with sensor technology. Instead of waiting for payment from CBA under the usual manual letter of credit, the cotton business was paid automatically through sensor-based, physical tracking of the shipment in real time. Blockchain was able to provide greater certainty, reduced errors and speed up a process that usually takes days (Cooney, 2017).

Food Safety

As previously mentioned, global consumers are becoming increasingly conscious about where their food comes from and how it was produced, as knowing this kind of information ensures the safety of food. In countries such as China, a high-end purchasing decision is often preceded by a significant amount of research into the origin of the product. Research into whether the source is trusted or if the product is actually safe for consumption.

These trends provide significant opportunities and risks. For New Zealand opportunity arises because most of our products are considered to sit in the premium, value-add space. New Zealand products are thought of as safe and healthy, whereas Chinese consumers have limited trust in local brands. As brands and countries become increasingly associated with being trusted and safe, then the risk of the fraudulent, counterfeited products entering the market increases. The risk for New Zealand is that fraudulent products will undermine the true value and quality of our products and the reputation of our companies and country. Blockchain is the solution to both issues. This

technology can provide information about the production of food to the end consumer as well as provide consumers the assurance that the product is genuine.

China has had several major food safety issues, including the contamination of infant formula with the toxic industrial chemical melamine. Melamine was found to have been deliberately added at milk-collecting stations to boost the protein content of raw milk. The milk contamination caused kidney damage, with six deaths and an estimated 300,000 babies becoming sick (Huang, 2014). The Sanlu Group, one of the largest dairy producers in China, was identified as responsible for this contamination. The incident damaged the reputation of China's food export, as well as their booming domestic dairy industry. Following this issue, the demand for 'safe' infant formula products meant that imported product from New Zealand and Australia became highly valuable. The transparency and tamper-proof nature of products underpinned by blockchains allows consumers to buy with confidence. It also can eliminate imitation products entering the market, ensuring consumers of the integrity of our New Zealand products.

Fonterra is one of the first companies to trial Alibaba's 'Food Trust Framework', the pilot involves shipping Anchor dairy products to Chinese consumers who purchase them on Alibaba. The Framework uses blockchain technology and product tagging with unique QR (quick response) codes. The technologies are designed to authenticate, verify, and record the transfer of goods, with the overall aim of achieving end-to-end supply chain traceability and transparency (World Retail Publishers, 2018). The outcomes of implementing this Framework and adopting these technologies are enhanced consumer confidence, protection of food company's reputations, and creating a trusted environment for cross-border trade.

Blockchain can also enhance food safety by rapidly identifying food contamination issues, including cross-contamination, spread of food borne diseases, and recalls. There have been numerous examples where food recalls have been inefficient and slow due to a lack of information about the product and its origins, and as a result they have come at a huge cost. Without genuine transparency, food recalls are a lengthy and expensive ordeal. For example, in September 2016, the US Food and Drug Administration (FDA) advised consumers to stop eating bagged fresh spinach because of customer complaints. It took 14 days to identify the region the spinach came from, and took 28 days until the specific source of contamination was identified. During this time five people died and 200 became ill. All fresh spinach products were removed from shops which came at a cost of US $175 million (Connolly, 2018). Due to the high level of traceability in blockchain, food can be

traced back to its origin in seconds, and all other possible cross-contaminations can be identified. Being able to locate and deal with any contaminated food immediately, safeguards consumers, reduces waste, and protects producers from suffering unnecessary losses.

Walmart, one of the largest retailers in the world, is now harnessing blockchain to catalogue huge amounts of data which will help manage food recalls. With traditional methods, it can take several weeks to trace an item from shipment through to retailer. With a blockchain database, Walmart can find all the details about how and where the food was grown and who it was inspected by right down to individual packages in seconds (Cooney, 2017). This enables strategic product withdrawals, giving confidence to the consumer, and saving Walmart significant costs.

Transparency and Traceability

The globalisation of the world means that the commodities we consume have been through a journey; of people, places, and materials (Pilkington, 2016). Consumers globally want to ensure the safety of their food by knowing where it has come from and how it was produced, but furthermore they also want to ensure what they are buying was produced in an environmentally sustainable and ethical way – looking after people, animals, and the planet. A recent study showed that 8 out of 10 consumers in the UK check the origin of their food when making a purchase (Elementar UK, 2017).

There is a need to have verified products, backed by ethical assurance standards. Currently assurance standards are reliant on a step-wise system with information passed on from one entity in the supply chain to another, which carries a high risk of information getting changed or lost. In the wool supply chain, The New Zealand Merino Company has an assurance brand 'ZQ', this covers environmental sustainability, animal welfare and social responsibility, to ensure it is ethically produced wool. Unless there is good technology in place that accounts for factors such as wool volume reconciliation, then there is a risk that more ZQ wool is traded globally than what is currently grown.

The Australian Ethical Merino Growers Co-Op Ltd plan to use blockchain technology to take advantage of the international market opportunities which are underpinned by the global Responsible Wool Standard (RWS). Using a simple data system, farmers can record all their on-farm data such as vaccinations, animal health, stock movements, pesticide applications etc. Combining on-farm data with all the supply chain data, it will provide total transparency of the production of Merino wool. The blockchain will be built from the Merino growers perspective and with the use of

blockchain technology they can bring together standardised on-farm practices and supply chain data, and link this with a QR code to provide RWS confirmation to the end consumer (Sim, 2018).

The United Nations created a diamond certification program known as the Kimberley Process, with the aim of keeping blood diamonds (diamonds that are mined in war zones and used to finance conflict) off the market by certifying and tracking the origin of each diamond (Greiner, 2018). The tracking was on paper which left it vulnerable to fraud and alteration. The company Everledger, has created a blockchain-based platform which records unique identifying data on individual diamonds, creating digital thumbprint which can be stored on a blockchain. As the diamond changes hands, these details are added to the chain, enabling all parties to know the exact origin and location of the product at all times.

Participants along supply chains are looking for digital solutions to verify where food comes from, attract premiums, and protect against counterfeit goods. Ian Proudfoot, KPMG Global Head of Agribusiness, has recently said all companies in New Zealand's agricultural industry should be looking at blockchain. While it will initially provide a novel way for supply chains to operate, it will eventually become the way in which we all transact. He has estimated most farmers will need to provide information into a blockchain within two years (Christian, 2018). A recent example of needing protection against counterfeit products was in the New Zealand Manuka honey industry. This is a high-value, coveted product, so companies tried to capitalise on the potential to make money by selling fraudulent Manuka honey with synthetic UMF. For New Zealand companies like Zespri, blockchain could offer supply chain provenance and traceability, increasingly demanded by consumers. Eventually the technology would be able to provide information about the origin and quality of the produce in real time. This is particularly important to Zespri who has face significant issues around counterfeiting, particularly in China (Howard, 2017). At this current time Zespri is already passing on certain information about product origin and attributes as European consumers demand it.

Provenance is UK company using blockchain technology and smart tags, to track physical products and verified attributes from origin to point of sale (Provenance, 2018). Ultimately, helping brands to build their reputation. One of the first use cases was tracing yellowfin and skipjack tuna fish in Indonesia from catch through to consumer in the UK, Japan and US. This enabled digital proof for sustainably-sourced, slavery-free products. They have worked with numerous businesses, from food and drink companies through to high retail fashion brands.

Lower Costs and Added Value

The agricultural sector has a lot to gain from utilising blockchain technology. Lower costs are achieved through greater efficiency, lower transaction costs and better access to information (Connolly, 2018). The information provided through the blockchain is reliable, documents and certificates are trusted and many other transactional processes can be automated, all of which contribute to greater efficiency (Henderson, Knoll, & Rogers, 2018). As we decrease the need for manual verification, we can get faster turnaround. The security of the system means payments can be executed upon delivery, eliminating the need for third-party payment processing.

Further efficiency is created because blockchain can speed up the movement of food through the supply chain network which is critical for perishable goods. It also allows for fast, targeted, removal of products that are not fit for consumption. Both of these factors reduce food waste.

The visibility of the blockchain means that small agribusinesses and farmers have price transparency, and a better understanding of consumer demands will allow for better forecasting. Analysis of current, reliable data will help identify opportunities globally for agribusiness companies. If there is cooperation between industry and government then this can achieve greater regulatory agreement and overall improve efficiencies.

Data from Precision Farming

There is starting to be a deluge of data produced from precision-farming applications, as farm systems are linked to sensors and digital networks. There is the potential to integrate a blockchain solution with data-gathering devices that use 'Internet of Things' technology. This data can be automatically uploaded to a block, giving buyers access to live on-farm data, this might include status of livestock or produce for verification and pricing which will increase efficiencies. Blockchain provides a simple, effective way to access and utilise this data.

Challenges and Issues with Blockchain

a) Incorrect data entry

While information might be incorruptible once it has entered the chain, there are minimal safeguards to prevent incorrect entry of data in the first place. Random security checks within the blockchain may offer a means to identify the error or fraudulent entry, however, the long-term solution will be automation of data entry.

b) Matching physical assets to digital assets

Smart contracts rely on digital assets being moved along a blockchain and exchanged simultaneously for payment. It will be critical to match the physical asset to the digital during this process, it is likely this will be done through sensor technology.

c) Real-time payments

If we are to establish smart contracts with real-time payments, it will be essential to find a stable currency to trade in. At present time the smart contracts that AgriDigital offer exchange digital asset for funds, these funds sit in 'digital wallet' but must be moved off the blockchain and exchanged for Australian dollars to realise their value.

d) Energy consumption

Another issue raised has been the energy consumption used in public blockchains. The consensus mechanisms (i.e. proof-of-work) used to verify the transactions on the blockchain require computers to solve complex mathematical riddles. This process means that computers are racing to validate the next block of transaction data, and as more computers are involved in this network, the math problems get harder to crack and require even more processing power (Zhao, 2018). Businesses can run private networks, where they only allow a certain number of trusted participants to be part of the network and therefore require significantly less energy to run. However, these provide less transparency and are still considered as centralised databases.

e) Standards and interoperability

While private blockchains require significantly less energy than public blockchains, there are issues around standards and interoperability. If we are to encourage free access, competition, and open innovation, then global supply chains should be run on public blockchain which no entity controls. The transactional data should be cryptographically recorded in open ledgers, however, closed private ledgers will arise, as companies want to protect market share and profits. There needs to be interoperability across private and public blockchains which will require standards and agreements.

There are also further issues around the legislative environment. For example, currently complex regulations govern rights of ownership and possession along the world's shipping routes. These laws and the human-led institutes that manage it, will need to come together with the digital, automated and denationalised blockchains, which will be a challenge. It will be essential that governments

globally support this new way of trade, but the industry will have to agree on best practices and standards of technology and contracts across international borders and jurisdictions.

Alternatives

If it is the provenance and integrity of products that matter most to consumers, there are other technologies being developed which can provide this. Around 75% of consumers globally have identified that brand origin is one of their key purchase drivers. One company, Oritain uses advanced science to trace products back to their true origin. It is not a traceability system that relies on the likes of barcodes, but instead relies on the inherent properties of the product to identify where it is from. This process can happen regardless of the journey of that product.

Oritain can identify the origin of products because plants and animals are influenced by their environment and what they eat or drink. The natural concentrations of trace elements and isotopes within each environment can be measured to trace a product (Oritain, 2018). This kind of technology, using trace element and isotope markers can significantly protect a brand's reputation; it protects businesses from fraud, uses an actual product test rather than relying on packaging which is prone to counterfeiting, and enables business to tell their product story. New Zealand Manuka honey is a sought-after product and is recognised for its health benefits, making it one of the most counterfeited products in the world. The science used by Oritain can identify differences between batches of honey, and therefore verify if honey originates where it claims to come from. The technology Oritain offer provides a solution without having to have information on the entire product journey.

Conclusion

The New Zealand primary industry is in a strong position to capture value from blockchain technology. No longer is blockchains use solely focused on cryptocurrencies, it has the potential to transform the way buyers and sellers connect. Regardless of where they are in the world, it allows fast, secure, transparent, low-cost, peer-to-peer transacting.

The practical applications of blockchain in the primary sector are growing. Blockchain provides seamless trade at low cost, with complete transparency. It has huge value in a world where consumers are concerned about food safety and provenance, and provides value for businesses seeking solutions for managing food waste and supply chain inefficiencies.

Participants the whole way along supply chains are looking for data rich, digital solutions to help:

- Provide food security
- Verify where food came from
- Protect against counterfeit goods
- Preserve or attract premium
- Reduce supply chain inefficiencies

The ability to securely record and store data on a blockchain makes it perfect for providing food provenance information to the consumer, along with market insights back to the farmer. The use of smart contracts will see that farmers get paid for what they produce, as soon as they deliver it. Smart contracts will also remove some of the 'middle men' from the supply chain which will see reduced transaction costs, and more value back to the producers.

There is a lot of potential to eliminate the inefficiencies we have in traditional agricultural supply chains. Due to the strength New Zealand has in agricultural exports, this leaves us with huge opportunity to lead the world in developing agricultural supply chain solutions that connect, shorten, and sharpen global supply chains. Blockchain has the potential to reshape the way New Zealand agricultural companies market and sell our products to the globe.

Recommendations

Blockchain offers huge potential to deliver a competitive edge for New Zealand producers. Through increased transparency and traceability, we will be providing consumers the information they want about their food and fibre. By providing the information the consumers want, we put ourselves in a position to capture premium value on our products. We have the opportunity to create more efficient supply chains, driving more money back to the producer.

While it is hoped we can be in a position to capture premiums through using blockchain technology, Ian Proudfoot, KPMG has predicted that in the next few years large companies will only accept products if they have the integrity that blockchain offers (Christian, 2018).

One of the main limitations currently is the fact there is no perfect ledger platform. Currently, more development is needed for applications that want to offer blockchain technology. For example, applications that wish to offer 'smart contracts', the exchange of physical goods for money throughout the supply chain, then it will be necessary to have a stable digital currency to trade in. For any organisation, blockchain technology should not be a goal but a tool deployed to achieve a specific purpose. There are alternatives such as Oritain which can scientifically prove the origin of product, but does not provide any information on the product journey. Businesses need to be clear about the outcome they are wanting to achieve.

It is important that New Zealand agribusiness companies look to invest in this technology, it has the potential to transform the entire global agricultural supply chain. We risk losing strategic ground if don't invest to understand technology such as blockchain. To do this successfully, collaboration between supply chain partners is critical; all entities must be prepared to put their transactional information (time, volume, value) onto a blockchain. The move to blockchain supply chains must be driven by industry and supported by the government.

Blockchain might be the technology solution to enabling the New Zealand primary sector to capture more margin. It is the tool to authenticate our provenance story.

References

Blockgeeks. (2018, May 30). *Proof of Work vs Proof of Stake: Basic Mining Guide*. Retrieved from Blockgeeks: https://blockgeeks.com/guides/proof-of-work-vs-proof-of-stake/

Boot, S. (2017, May 10). *Counterfeits, Name recognition a challenge for Zespri in quest for Chinese market dominance*. Retrieved from Sharechat: http://www.sharechat.co.nz/article/2c6aca91/counterfeits-name-recognition-a-challenge-for-zespri-in-quest-for-chinese-market-dominance.html

Casey, M., & Wong, P. (2017, March 13). *Global Supply Chains Are About to Get Better, Thanks to Blockchain*. Retrieved from Harvard Business Review : https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain

CBH Group and AgriDigital. (2017). *Solving for supply chain inefficiencies and risks with blockchain in agriculture.* Australia: AgriDigital.

Christian, G. (2018, May 4). Blockchain wants farmer input now. *Farmers Weekly*. New Zealand: NZX.

Chu, W. (2018, March 8). *Carrefour extend Blockchain use to dairy and meat product ranges*. Retrieved April 2018, from Food navigator: https://www.foodnavigator.com/Article/2018/03/08/Carrefour-extend-Blockchain-use-to-dairy-and-meat-product-ranges

Connolly, A. (2018, March 23). *What are the implications of blockchain technology for food & agriculture?* Retrieved April 2018, from LinkedIn: https://www.linkedin.com/pulse/what-implications-blockchain-technology-agriculture-aidan-connolly/

Cooney, K. (2017, July 20). *Blockchain the Transformer*. Retrieved from NZ Herald: https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11891859

CSIRO Data61. (2017). *Distributed Ledgers: Scenarios for the Australian economy over the coming decades.* Australia: CSIRO.

Elementar UK. (2017, June 26). *8 in 10 consumers check the origin of their food when purchasing products*. Retrieved from New Food: https://www.newfoodmagazine.com/news/42541/8-10-consumers-labelling/

Etwaru, R. (2017, May 15). Blockchain: Massively Simplified. Morristown, New Jersey, USA.

Everledger. (2018). *Do you know your diamond?* Retrieved April 2018, from Everledger: https://diamonds.everledger.io/

Gohd, C. (2018, March 12). *Cars on the Blockchain? Six Ways Automakers Could Employ the New Technology*. Retrieved April 2018, from Futurism: https://futurism.com/cars-blockchain-six-ways/

Greiner, L. (2018, January 22). *How to put the bad guys out of business with blockchain*. Retrieved from Financial Post: http://business.financialpost.com/technology/blockchain/how-to-put-the-bad-guys-out-of-business-with-blockchain

Henderson, K., Knoll, E., & Rogers, M. (2018, March). *What every utility CEO should know about blockchain*. Retrieved from McKinsey & Company: https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/what-every-utility-ceo-should-know-about-blockchain?cid=other-eml-alt-mip-mck-oth-1804&hlkid=8bb420a64d444915ac5fb7f8cd4fd9c6&hctky=1306796&hdpid=1ee2d406-c940-469b-a2d4-7df99

Higginson, M., Lorenz, J.-T., Münstermann, B., & Olesen, P. B. (2017, March). *The promise of blockchain*. Retrieved from McKinsey & Company : https://www.mckinsey.com/industries/financial-services/our-insights/the-promise-of-blockchain

Houser, K. (2018, March 2). *Uh Oh: Blockchain May Not Be as Secure as We Thought*. Retrieved from Futurism: https://futurism.com/blockchain-security-smart-contracts/

Howard, R. (2017, December 11). *Zespri looking at block chain*. Retrieved from AgriHQ: https://agrihq.co.nz/#

Huang, Y. (2014, July 16). *The 2008 Milk Scandal Revisited*. Retrieved from Forbes: https://www.forbes.com/sites/yanzhonghuang/2014/07/16/the-2008-milk-scandal-revisited/

Jayachandran, P. (2017, May 31). *The difference between public and private blockchain*. Retrieved from IBM: https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/

Kim, H., & Laskowski, M. (2016). *Towards an Ontology-Driven Blockchain Design for Supply Chain Provenance.* Toronto: Schulich School of Business.

KPMG. (2017). *Agribusiness Agenda 2017 - The recipe for action.* Auckland: KPMG.

Lefroy, W. (2017, October). *Blockchain: Changing Interaction in the F&A Supply Chain from Paddock to Plate*. Retrieved April 2018, from Rabobank:

https://research.rabobank.com/far/en/sectors/farm-inputs/Blockchain_changing-interaction-in-the-FandA-supply-chain-from-paddock-to-plate.html

Lefroy, W. (2018, February 14). (M. Schwass, Interviewer)

Marr, B. (2018, February 16). *A Very Brief History Of Blockchain Technology Everyone Should Read*. Retrieved April 2018, from Forbes: https://www.forbes.com/sites/bernardmarr/2018/02/16/a-very-brief-history-of-blockchain-technology-everyone-should-read/#385c40c47bc4

McKinsey Global Institute. (2015). *Industry Digitization Index* . McKinsey & Company.

Miles, C. (2017, December 12). *Blockchain security: What keeps your transaction data safe?* Retrieved from IBM: https://www.ibm.com/blogs/blockchain/2017/12/blockchain-security-what-keeps-your-transaction-data-safe/

Myler, L. (2018, February 16). *Farm-To-Table: How Blockchain Tech Will Change The Way You Eat*. Retrieved April 2018, from Forbes: https://www.forbes.com/sites/larrymyler/2018/02/16/farm-to-table-how-blockchain-tech-will-change-the-way-you-eat/#76bd3d12c454

Nason, J. (2018, April 3). *How blockchain can beef up cattle supply chains*. Retrieved from Beef Central: https://www.beefcentral.com/features/ntca-conferences/how-blockchain-can-beef-up-cattle-supply-chains/

Ohlsson, B. (2018). Blockchain: How will this technology impact the primary sector? *MobileTECH.* New Zealand.

Oritain. (2018). *The Science* . Retrieved from Oritain: https://oritain.com/how-it-works/the-science/

Pilkington, M. (2016). Blockchain technology: principles and applications. In *Research Handbook on Digital Transformations* (pp. 225-247). Cheltenham : Edward Elgar Publishing .

Provenance. (2018). *Provenance For Business*. Retrieved from Provenance: https://www.provenance.org/how-it-works

Sim, T. (2018, March 31). *Blockchain technology coming to Merino flocks in May*. Retrieved from Sheep Central: https://www.sheepcentral.com/blockchain-technology-coming-to-merino-flocks-in-may/

Skinner, C. (2018, May 30). *Blockchains & Distributed Ledger Technologies*. Retrieved from BlockchainHub: https://blockchainhub.net/blockchains-and-distributed-ledger-technologies-in-general/

Smellie, J. U. (2017, December 14). *Blockchain: could it revolutionise food & agri supply chain?* Retrieved from Business Scoop: http://business.scoop.co.nz/2017/12/14/blockchain-could-it-revolutionise-food-agri-supply-chain/

Tai, B. (2017, September 21). *The Promise of Blockchain*. Retrieved from Futurism: https://www.youtube.com/watch?v=cMhYFnNpdlc

Verberne, J. (2018, February 1). *How can blockchain serve society?* Retrieved from World Economic Forum: https://www.weforum.org/agenda/2018/02/blockchain-ocean-fishing-sustainable-risk-environment

Voshmgir, S. (2018, May 25). *Smart Contracts*. Retrieved from BlockchainHub: https://blockchainhub.net/smart-contracts/

Wingreen, S. C. (2018). Blockchain and Corporate Governance: The Curious Case of the DAO. *University of Canterbury, Blockchain Symposium.* Christchurch.

World Economic Forum. (2018). *Blockchain Beyond The Hype.* Switzerland: WE Forum.

World Retail Publishers. (2018, May 10). *Alibaba pilots product trial on blockchain traceability system*. Retrieved from World Retail Pulishers : http://apparelmagazine.co.nz/worldretailpublishers/news/alibaba-pilots-product-trial-on-blockchain-traceability-system/

Zhao, H. (2018, February 23). *Bitcoin and blockchain consume an exorbitant amount of energy.* . Retrieved from CNBC: https://www.cnbc.com/2018/02/23/bitcoin-blockchain-consumes-a-lot-of-energy-engineers-changing-that.html