Making Sense of Blockchain in Food Supply-Chains

Full Paper

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Abstract

Blockchain is a potentially disruptive and game-changing technology that has created excitement about its potential applications. The agriculture industry in New Zealand is facing increased pressure to be able to accurately track and trace their produce in order to provide higher levels of proof to their customers. This study used a q-methodology approach to examine whether blockchain technology can be the solution to these issues and provides recommendations as to what businesses need to in order to make this a reality. The empirical research revealed four distinct groups within the industry; each with different perspectives of blockchain and its potential. Results also found that while industry experts believe blockchain implementation is inevitable and it will solve the current issues, factors such as high set-up costs and the complexity of technology may be inhibitors. Based on these findings, key recommendations on how the industry should proceed in order to overcome these factors that are preventing adoption are derived. Further research is suggested on how the challenges of food safety and security may be overcome with emerging technologies such as Blockchain, IoT and AI.

Keywords Value Chain, Trust-less Platform, Q-Methodology, Precision Food Systems.

1 Introduction

There is an ever-increasing demand for more effective supply-chain solutions in the Agricultural industry (Rueda, Garrett & Lambin, 2016). The current issue causing this demand in the New Zealand industry is the need for transparency and tracking of produce through the entire supply-chain life-cycle. This need for transparency and traceability has become increasingly important lately with consumers focusing on eating healthy products that have been sourced locally (Dalzier, Guenther & Saunders, 2016). This has created a situation where suppliers are required to be able to track their goods throughout the entire supply-chain, from point of origin right up until the point of sale (CBH Group & AgriDigital, 2017). The majority of the current systems in place currently are outdated and lack the ability to provide this required level of tracking.

Recently, blockchain technology has gained increased exposure and has numerous industries, including Agriculture, excited about its potential to provide improvements to business processes. Blockchain is a decentralized, peer-to-peer database that manages a ledger by means of a network of computers that must agree before a transaction, or record, is added to the ledger. This consensus mechanism makes it very difficult for incorrect information to be included either accidentally or fraudulently. Furthermore, any user on the network of the blockchain may trace back every transaction, which in the context of the Agriculture industry would allow goods to be traced and tracked through the entire production process. This would, therefore, satisfy consumers' requirement for high levels of proof about the origins of their product.

The research question therefore is: *How can blockchain technology best support food supply-chains and what steps need to happen to make this a reality?*

As blockchain technology is still nascent, a full technical plan of how to implement blockchain is not the goal of this research. It is an exploration of the current stakeholder perspectives of blockchain within the agricultural industry, and to develop recommendations to businesses and future research about how to make blockchain implementation a reality. Because of the subjective nature of stakeholder beliefs about nascent technologies, a Q-methodology approach was used to evaluate the industry's perspectives about blockchain technology, since Q-method is a technique that is specialized for the analysis of peoples' subjective beliefs. The analyses of the data are provided as well as interpretation of the meaning behind the results. Finally, recommendations are provided about what steps should be taken in order to implement blockchain for the agriculture industry.

2 Background Review

With the rise of awareness about Blockchain technology in recent years, driven largely by Bitcoin interest, there is a good base of research already conducted on the potential of blockchain to support supply-chains. The most commonly stated potential advantages will be discussed along with the main issues that could prevent adoption.

A common issue with current supply-chains is the inability to trace an item through the multiple steps and systems it has to travel through (Tian, 2018). Blockchain technology enables all users of a particular blockchain network to have a complete, up to date and transparent ledger of all records in the supply-chain at any stage (Korpela, Hallikas & Dahlberg, 2017). This is able to occur because blockchain has the ability for an entire supply-chain to exist on one single collaborative network, eliminating the need for multiple companies and systems to need to communicate and collaborate (Hackius & Peterson, 2017). Additionally, Francisco & Swanson (2017) state that, due to the nature of blockchains, every single user will have an identical record of transactions and will eliminate the risk of double entries or discrepancies between companies sharing the same supply-chain. Furthermore, blockchains also provide the ability to not only know where an item is currently, but also provide an accurate and detailed record of every transaction in the past (Sadouskaya, 2017).

For a transaction to be recorded on a blockchain, the majority of users on the network must form a consensus and agree that it is correct. Once this transaction is agreed upon, it can never be edited or deleted (Apte & Petrovsky, 2016). This means that businesses can provide a high level of proof of where their goods have come from. Additionally, this greatly reduces the time and cost needed to identify errors or fraud and provides secure and accurate data for businesses (Bocek, Rodrigues, Strasser & Stiller, 2017). Furthermore, Tian (2018) found that access to this accurate and secure data can allow companies to spend more time making informed decisions and improving other aspects of their business.

Another facet of blockchains is the ability to layer a smart contract on top of them. A smart contract is similar to a normal contract, however, the main difference is that a smart contract is executed or enforced when certain conditions are met without the need for human interaction or enforcement (Francisco & Swanson, 2017). They have a number of advantages when used in the context of a supply chain; firstly, it removes any ambiguity around the execution of contractual conditions between the parties as the contract is automatically executed on the blockchain when conditions are met (Swan, 2015). Secondly, smart contracts lower costs by removing the need for paperwork and third-party involvement (Sadouskaya, 2017). Finally, smart contracts remove the need for trust between the participating parties which eliminates the risk of loss for either party. This allows more focus to be placed on other aspects of the supply-chain and forecasting decisions can be made with much more confidence (Hackius, Petersen 2017).

Apte & Petrovsky (2016) stated that although blockchains can ensure transactions are unalterable, there is no certainty that entered information or the good itself was altered. Therefore there can be no guarantee that the transactions on the supply chain are entirely congruent with the actual goods they are expressing. However, they counter this by further stating that this will still be an advance from older systems as any falsification needs to be completed in real-time which is much harder to do than altering older records. Bocek et al., (2017) claimed that combining blockchain with existing verification and identifying tools such as RFID and Bluetooth sensors could help to provide a way to ensure only verified and accurate data is entering the supply-chain. This data then cannot be altered because of the properties of the blockchain supporting it.

There are certain common issues to the adoption of blockchain that arise in recent research on the topic. Abeyratne & Monfared (2016) found that blockchain requires a specific IT infrastructure to be in place for every actor within the supply-chain and this may be impractical for remote locations. Furthermore, Korpela et al., (2017) found that due to how new of a technology blockchain is, there lacks a current standard of data and electrical supply chain documents characterisations on the supply chain. These standards will need to be agreed upon and adhered to and this creates another level of complexity and unfamiliarity for new users who are already apprehensive about adopting new technology. Additionally, Sadouskaya (2017) argues that companies spend years developing and refining their supply chains and the potential advantages of blockchain are not worth the challenges that integration would undoubtedly cause. Venegas & Krabec (2016) state that the complexities of integrating blockchain into a company's supply-chain would require these companies to employ specialists and there are simply not enough people with this particular experience.

In order to gain an understanding of the landscape and sentiment of the Agriculture Industry in New Zealand, the KPMG 2018 Agribusiness Agenda Report was used. This report conducted a survey of hundreds of industry leaders and provides an in-depth understanding of the current state of the industry in New Zealand. Academic papers were also researched, however, due to the constantly changing and dynamic state of the Agriculture Industry in New Zealand, these archived papers are often outdated and no longer relevant.

KPMG (2018) found that one of the major themes from the most recent business year was the ever-increasing requirement from consumers to be able to track their goods from origin right to the end of the supply-chain. The "Produced in New Zealand" brand provides a host of certifications such as "fair trade", "non-GMO" and "organic". These certifications refer to expiry dates, storage conditions and origin of the physical product and have to be tracked accurately to ensure trust in the labelling (Author et al. 2019). This has therefore placed further pressure on companies to be able to create a supply-chain where this higher level of proof can be provided. Furthermore, KPMG (2018) found in consulting engagements with industry leaders that this extra pressure to satisfy the consumers' needs has resulted in the supply chain becoming more complex. Traditionally the supply chain was perceived as linear with the consumer not interacting with it until the goods reached the end of the line and became available to them. With the extra level of proof required now, the supply-chain has turned more into a web with the consumer situated in the middle. Every participant within the supply-web now has to cater to the consumer's requirements thus creating a demand for new systems and technology.

Additionally, during these roundtable talks with industry leaders, KPMG (2018) found that these leaders feel that the New Zealand industry is missing out on world-leading innovation that is being used overseas. However, these business leaders also stated they were comfortable with this position. The findings of these talks appear to indicate that leaders within the industry are aware of increasing pressures and changes in the market. However, they appear to be resistant to and uncomfortable with the adjustments that are required to keep pace with both consumer needs and innovations worldwide.

3 Research Design and Method

Q-methodology was selected to investigate the research question because its empirical approach combines the strengths of both qualitative and quantitative methods to gauge a person's subjective beliefs, attitude and viewpoint to a particular subject or issue (Brown 1996). This subjectivity is gauged by participants ranking a series of Q-sort statements, collectively known as a "Q-set". The Q-set is a representative sample of the discourse that is drawn from any number of sources: experts, academic literature, popular and literary media such as television programmes, discussion panels, informal discussions, or pilot studies (Watts & Stenner, 2005). The Q-set represents an extensive diversity of perspectives and opinions on the issue being investigated (Shinebourne, 2009). The most significant difference between Q-methodology and more standard questionnaire and survey approaches is that each item in a Q-sort is dependent on each other because they are ranked by the person during the sorting procedure, which is the means by which Q-method operationalizes a person's subjective perspective (Klaus, Wingreen & Blanton 2010). The Q-sorts are factor-analyzed to determine the similarities between Q-sorts to indicate perspectives with similar subjective viewpoints between participants (van Exel & de Graaf 2005). The power of Q-methodology lies in being able to identify these perspectives and their relationship to the person's motivations, goals, and behavior that other methods are unable to explore (van Exel & de Graaf 2005).

Q-method's uniqueness is derived from its philosophical and theoretical grounding in Concourse Theory. In other words, it's not merely a methodological tool, but part of a larger integrated system of theory and measurement aimed at the exploration of human subjectivity. In other words, a Q-sort is something entirely different than a survey of attitudes or intentions, because of its different philosophical foundations and goals, and therefore should not be implemented without consideration of its role in Concourse Theory (Wingreen and Blanton, 2018).

In its underlying theory, the unit of analysis is the concourse, which is defined as the universe of communicability about a given research topic. According to Concourse Theory, the concourse has structure, and the structure of the concourse is revealed by people's interactions with it. By means of Q-methodology, Q-sorts, and their associated methods of analysis and interpretation, we bring a person's subjective interactions with the concourse into the laboratory, so to speak, where we can observe their interactions with it in a controlled environment. In Concourse Theory, we sample the "concourse", since it is the unit of analysis, and there is no need to sample people as there is when a population of people is the subject of a research question. Since there is an infinity of communicability in any given concourse, a representative sample of the concourse should be designed to fit the specific goals of the research; the resulting sample is the set of Q-sort statements.

People "load" on factors in Q the same way that measured variables load on factors in classical empirical statistical analyses, so Q-method seeks "exemplar" respondents for the same reasons that measured variables are screened for inclusion into classical empirical measured scales. In other words, the point of gathering respondents for a Q-method study is to recruit exemplars in this manner, not to sample a population of people. The Q-sorts thus obtained are then factor-analyzed, and interpreted using abductive reasoning to propose the most likely theoretical explanation of the resulting factors. Using abductive reasoning, generalizations are made about the concourse, based on how the exemplary people interact with the set of Q-sort statements, and these generalizations are the foundation of new theory about the domain of the concourse, because each factor requires its own abductory explanation, and each explanation is essentially its own internally-consistent, subjectively-testable theory of the domain. Hence, Concourse Theory provides a description of nature that accounts for the entwined-ness of theory and measurement, rather than assuming that theory and measurement are independent of each other as they are assumed to be in classical empirical research. According to Concourse Theory, theory *is* measurement, and measurement *is* theory.

Q-method provides several advantages in the context of blockchain technology. Firstly, blockchain has only recently entered the business landscape, it is still a very new technology and therefore there are very few instances of blockchain having already been implemented and used within agriculture to support the supply-chain. Because of this, it would be very difficult, if not impossible to design a study about the current state of blockchain implementations in agriculture. However, it is possible to design a Q-set based on the volume of discourse about its relevance to supply-chains in general, and agriculture in particular. Participants who have only a little knowledge about blockchain but are knowledgeable about the agriculture industry are able to provide Q-sorts that provide insight into the role blockchain may be play in the industry. In theory, the subjective perspectives observed while a technology is nascent should be more-or-less the same perspectives observed when the technology is mature, albeit with more "mature" content in the concourse, and previously unobserved factors may emerge as a technology matures. Furthermore, the traditional survey instrument method prefere3d by IS scholars (cf. Conrath & Sharma, 1992; 1993) that involved measuring participants' knowledge about blockchain would have provided very little useful data as the technology is too new and the participants simply do not have enough understanding.

Additionally, Q-method was chosen with time and resources in mind. Watts & Stenner (2005) state that a Q-methodological study may be carried out with very few people, as long as the people are exemplars of their respective perspectives, without sacrificing the quality of patterns detected within the data. This research was conducted under strict time constraints, and Q-method enabled the data collection phase to be relatively short and simple. Watts & Stenner (2005) argue that the study need not have a very large Q-set, since a set of 33 statements with a ranking distribution of -4 to +4 would provide each participants with roughly 11,000 times as many sorting options are there are people in the world. The act of forcing participants to rank the statements enables Q-method to provide such significant results while using a small set of statements. The only real concern is the extent to which the Q-set is a representative sample of the concourse.

Furthermore, Q-method is an exploratory technique. It cannot prove hypotheses; it can, however, bring a sense of coherence to research questions that have many potentially complex and socially contested answers (Watts & Stenner 2005). This research aims to provide real-life value for the agriculture industry by making sense of all of the hype and excitement surrounding blockchain. Q-method was chosen as it has the ability to find coherence in all of this excitement and talk. Thus it can provide recommendations and insight into how blockchain may improve and support supply-chains in the agriculture industry. These recommendations and insights aim to give people in the industry the confidence and base of knowledge to progress forward with future research or even plans for adoption and implementation. Therefore Q-method enables us to explore a broad range of issues, including the potential advantages, patterns, and themes within the industry.

This project was undertaken in accordance with Agile project management principles. Agile project management is an iterative process that involves completing a series of 'sprints'. Upon completion of a sprint, the current state of the project was re-assessed, this was done to ensure that any changes that need to be made were identified and carried out. The series of sprints that were completed are outlined in the following action steps:

1. Research literature:

Research literature is a primary source for information about the content of the concourse, in our case, the application of blockchain technology to supply chains. For example, Conrath & Sharma (1992) used a combination of the Critical Success Factors (CSF) and Delphi approaches to synthesise dimensions of evaluation from the scholarly literature and obtained from a panel of researchers the measurable indicators of the implementation success for AI-based systems. In a similar vein, an instrument was designed using the resulting 39 indicators or dimensions of quality. And field tested for validity and reliability. We collected 20-30 papers which discussed the current understanding and knowledge about the state of blockchain technology's ability to support supply chains, and the most commonly mentioned potential benefits were noted. A thorough understanding of these possible benefits was vital in understanding which may be applicable to the agriculture industry. Research on other common issues such as potential barriers to adoption was also studied. As the understanding and development of blockchain is changing rapidly, only papers from the last 2-3 years were examined.

Additionally, as previously mentioned, academic papers on the agriculture industry in New Zealand are very hard to come by and are out-of-date very quickly due to the competitive and changing nature of the industry. Therefore, end of year reports from the most recent business year were studied. Common themes and the general landscape of the industry were obtained from these reports. An initial understanding of both of these research topics was important to obtain as it helped guide the development of the Q-statements.

2. Understand current discourse on research topic

This sprint involves gaining an understanding of the discourse on the state of supply-chains in the context of Q-methodology. Discourse refers to the flow of communicability surrounding the particular topic and includes all possible opinions that the respondents may have regarding it (Brown, 1993). The researcher may gain access to the discourse in a number of different ways: interviewing people, participant observation, popular literature, media reports, newspapers and magazines (van Exel & de Graaf 2005). In the context of this project, drawing from procedures long used by IS scholars (cf. Sharma & Conrath, 1992), the discourse was obtained from a combination of informal interviews and industry business reports. These options were chosen with time constraints and resources in mind. The researchers judged that it was possible to obtain a firm understanding of the current discourse from these two resources because every person who participated in this "sprint" was able to identify the main themes and issues within the industry reports about the supply-chain in agriculture. If the discourse had not been as clear and consistent, further resources would have been pursued to gain a clearer understanding.

3. Develop Q-statements

In this sprint, the knowledge and understanding gained from the first two sprints are used to create the set of Q-statements. The Q-set must broadly representative of the entire opinion domain of the project question (Watts & Stenner 2005). In procedures consistent with long established IS research (cf. Conrath & Sharma, 1992; 1993), an initial set of 35-40 statements was developed, and pilot sorts were undertaken in collaboration with the research supervisor in order to trim the set down to a final 24. This initial larger set of 35-40 statements was created first to ensure that the statements adequately represented the state of the discourse. These statements were pilot-tested collaboratively to ensure there were not any obvious omissions. Once completed, the Q-set was refined and reduced in size to 24 statements, and classified into four areas: i) Current state of supply-chains in the Agriculture industry; ii) Benefits of supply-chains in the Agriculture industry; iii) Factors preventing adoption of blockchain in supply-chains in the Agriculture industry; iv) Views on blockchain in the context of the Agriculture industry. These groups of statements were chosen to provide a practical framework both for respondents sorting the statements and to assist the interpretation of the resulting factor types.

4. Develop and distribute Q-sort questionnaire

The online tool, "Qsortware", was chosen to carry out the Q-sort. This tool enables respondents to complete a full Q-sort at their own leisure in their internet browser. An online tool was chosen as the method over an in-person Q-sort due to time and resource constraints. Various online tools were researched and tested and Qsortware was found to the most suitable as it was user-friendly for respondents and it was free to use. Respondents had to fit the criteria of being 18 years or over and having 6 months or more experience in the agriculture industry. These criteria were selected to meet ethical requirements and to ensure responses from people outside of the agriculture industry were not included in the data pool for analysis. Potential respondents were identified via posts on e-business forums and emails to agriculture businesses in New Zealand.

5. Collect and analyse data

Data from the online questionnaires was stored in a cloud server initially and then moved to an offline secure storage area once all the data was collected. The data was then analysed using PQmethod. PQmethod is software that was specifically designed for analysis of Q-sort data and is preferred by many Q-method researchers because it has a full complement of tools to factor-analyze and assist with the interpretation of Q-sorts (Klaus et al., 2010; van Exel & de Graaf, 2005).

6. Interpret results and provide recommendations and insights

In this final step, the factors (also known as "types" in the language of Q-Method) that were acquired during the previous step were then reviewed and interpreted using abductive reasoning. Abductive reasoning proposes the most likely theory for a given observation, which in the context of our research is the reasoning implied by the types revealed in the factor analysis of the Q-sorts. Careful consideration and thought was given to this process as interpreting factor groups is as much an art as it is a science, and is central to the power and efficacy of Q-methodology (Watts & Stenner, 2005).

4 Results and Discussion

Participants spanned a variety of age, job titles and experience within the agriculture industry. A tabulation of the demographic breakdown of all 27 respondents may be found in the Online Annex. As Q-method researchers such as Watts & Stenner (2005), Wingreen & Blanton (2018), etc. categorically state, the representativeness of a Q-sample is not determined by the number of respondents but by the selection of Q-statements.

The Q-sorts were subjected to principal component analysis (PCA) with varimax rotation, which produces a set of factors based on the correlations between Q-sorts (Brown, 1993). The varimax rotation method maximizes both the homogeneity within factors and their uniqueness with respect to other factors (Klaus et al., 2010). Respondents "load" on the factors depending on the priorities expressed in their Q-sorts, which means that multiple participants who load on the same factor will have very similar Q-sorts (Watts & Stenner 2005). Therefore, each factor represents a shared viewpoint amongst participants (Brown, 1993). The software uses an algorithm to identify "factor exemplars" who are the most ideal representatives of each factor (Watts & Stenner, 2005). The demographic information associated with the factor exemplars may also be used to assist the interpretation of the factor (Shinebourne, 2009). It is reiterated that the art of executing and interpreting Q-method research is abductive, judgemental and guided by prior experience (Klaus et al. 2010; Wingreen & Blanton, 2018).

Table 1. Q-statements: Group loadings and explanatory power.

Q-statements	Factor 1		Factor 2		Factor 3		Factor 4	
	z	*rank*	*z*	*rank*	*z*	*rank*	*z*	*rank*
1. Sufficient transparency	-0.68	18	1.34	4	-1.20	21	-0.79	18
2. Sufficient traceability	0.55	7	1.35	3	-0.64	16	-0.21	15
3. Cost effective	-0.55	17	-1.23	22	1.19	3	-0.56	16
4. Provide proof	1.56	2	0.34	11	-1.00	19	0.42	10
5. Meet audit requirements	0.85	6	-0.58	16	1.23	2	0.33	12
6. Not vulnerable to error	-1.73	23	-1.22	21	0.41	11	0.82	7
7. Meet certification requirement	0.36	8	-1.35	24	-0.27	15	1.25	2
8. Lower admin costs	0.06	12	-1.00	18	0.41	10	-0.59	17
9. Removal of 3rd party	0.95	5	0.81	7	-1.41	23	-1.77	23
10. Tracking of goods	0.02	14	-0.24	15	1.42	1	0.80	8
11. Immutability	-0.20	15	1.01	5	1	6	1.13	4
12. Comp advantage	-1.20	22	0.77	8	-1.15	20	-0.83	19
13. Too complicated	-0.44	16	0.34	11	0.24	13	1.19	3
14. Not enough orgs using it	1.87	1	1.35	3	1.00	5	1.30	1
15. Too high set-up cost	0.16	10	0.85	6	1.12	4	0.61	9
16. Open to manual error	0.21	9	-1.34	23	-1.28	22	0.10	14
17. Create extra problem	0.06	11	-0.09	13	-0.10	14	-1.39	22
18. Not meet audit / compliance	-1.87	24	-1.10	19	-0.98	18	-1.81	24
19. Inevitability	1.29	4	0.52	9	0.75	8	0.41	11
20. Excites me	0.05	13	-0.01	12	-0.68	17	0.87	6
21. Talked about often	-0.73	19	-0.24	15	-1.82	24	0.20	13
22. Understanding blockchain	-1.12	21	-0.76	17	0.29	12	-1.18	20
23. Encourage adoption	-0.85	20	1.68	1	0.53	9	-1.21	21
24. Industry is open to innovat^{n}	1.35	3	-1.19	20	0.93	7	0.92	5
Eigevalues	6.84		3.3		2.93		2.76	
R^2 (%)	25		12		11		10	

Table 1 reports the rankings of the Q-sort statements as expressed by the respondents for each factor, from 1, the highest priority, to 24, the lowest. The shaded factor groupings represent the convergence of the high rankings among members of the same group. Z-scores indicate their discriminant values.

More specifically, Table 1 shows the four factors that were selected for analysis and their corresponding Eigenvalues and percentage of variance explained by each factor (R^2). Four factors were chosen for two reasons: (1) The Eigenvalue for factor five significantly dropped off from the others and was barely above the required criteria of a value of one. It also only helped to explain a very small portion of variance in our data compared to the first four factors. (2) Brown (1995) recommends a standard requirement that a factor has at least two factor exemplars; factor five only had one so was not included. The factor matrix may be found in the Appendix.

Table 1 also shows the z-scores and rankings associated with each Q-statement, which is used as the basis for factor interpretation (Shinebourne, 2009). The z-scores and corresponding rankings of statements indicate the strength of their inclusion (ranks 1-6) or exclusion (ranks 19-24) within a factor. A full un-abbreviated set of statements is listed in Appendix A and the factor matrix output in Appendix C. The shaded cells are the top 6 ranked statements for each factor. The interpretation involves creating a series of summarizing accounts that abductively explain the viewpoint being expressed by each factor (Watts & Stenner, 2005).

Factor 1 has four exemplars who explain 25% of the study variance, with an eigenvalue of 6.84. They are younger, with three of the four participants between the ages of 18-30, and one between 31- 45. The average perceived knowledge on blockchain for people representing this type is medium/low, they are on the lower end of experience in the industry, and appear to be in entry-level roles.

From Table 1 we can see the top ranking statements that this group agrees with are: current supply-chains provide consumers with required level of proof; current supply-chains can meet current certifications/audit requirements; removal of 3rd parties is worth risk of adopting blockchain; not enough orgs using blockchain could prevent adoption; blockchain implementation is inevitable; and, the agriculture in the industry as a whole is open to new tech and systems

They are the only type who believe that the supply chains in agriculture should be able to provide consumers with their required level of proof. This can be seen by their #2 ranking for this statement. Does this indicate a youthful naiveté and a lack of understanding about the current pressures facing the industry which is to be expected by a younger and less experienced person? It is possible that this perspective is associated with those in roles of lower seniority who do not have to deal with the realities of the agricultural supply chain.

Members of this type were the only ones to prioritize (#5 ranking) the belief that removal of 3rd parties is one of the top potential benefits of blockchain supporting supply-chains. A possible reason for this belief may be that in their roles they have to interact directly with and contact a variety of other businesses, whereas other participants in executive, management, research or academic based roles may be more involved in their own organisations and have less to do with other companies within the industry. Members of this type also believe blockchain implementation in the industry is inevitable and that the industry as a whole is open to innovation.

Factor 2 explains 12% of the study variance, with an eigenvalue of 3.3, and is represented by three exemplars. Members of this type are all aged between 31-45 and all have development/research type roles. The average perceived knowledge of blockchain technology in this group is Medium and all have 3-10 years familiarity with the agriculture industry. They are not novices.

The top priorities for this type are: current supply chains provide sufficient transparency; current supply chains provide sufficient traceability; immutability of transactions providing a higher level of proof to consumers; not enough organisations using blockchain could be a factor preventing adoption; too high set up costs could prevent adoption; and I would encourage my company to adopt blockchain technology. One of the main factors that differentiate members of this type is that they are not actively working within the industry; they are researchers and scientists who observe and provide information about the industry from the outside.

Because type 2 is composed of roles that operate mainly by observing and researching the industry, they may be able to provide a more accurate and holistic idea of the concourse and themes influencing the industry than people working in just one particular part of the industry. This may be apparent by their very low ranking for "the agriculture industry as a whole is open to new technology and systems" despite all other types ranking this statement highly. Perhaps type 2 is alone in their ability to gauge the entire industry from the outside, while the insiders are incapable of seeing the inflexibility of the industry? Additionally, type 2 is more likely to encourage adoption of blockchain than any other type (ranked #1), which aligns with what we might expect from researchers and scientists who endeavour to be open-minded and willing to challenge the status quo.

Factor 3 is represented by seven exemplars, and explains 11% of the study variance with an eigenvalue of 2.93. Members of this type have 3-10 years familiarity with the industry, and two participants have 10+ years. This type is composed mainly of people with consultant/specialist and executive roles and the perceived knowledge of this type is the highest of the four at slightly over an average of medium. Members of this type span the entire range of ages 18 - 45, and one person being 60+ years old.

Type 3 is represented by experts that work within the industry, by contrast to type 2 who work outside the industry. Unsurprisingly, these two types have contrasting viewpoints surrounding the current state of supply-chains in the industry. Type 3 scored highly on current supply chains providing sufficient transparency and proof to consumers, whereas type 2 scored the lowest on these factors. This is most likely due to type 3 people spending more time on a day to day basis dealing the realities and pressures of agricultural supply chains, whereas type 2 must make their best estimate of these pressures based on their knowledge of the research.

From table 1 we can see that the top priorities for this type are: the current state of supply chains in agriculture are that they are cost-effective; the current state of supply chains in agriculture are that they are able to meet current certification/audit requirements; providing accurate and real-time tracking of goods; immutability of transactions providing a higher level of proof to consumers; not enough organisations using blockchain could be a factor preventing adoption; and too high set-up costs could be factor preventing adoption.

This type is characterized by industry specialists in senior roles, whose viewpoints seem to align most with the literature and concourse described in the beginning of this report. Type 3 three scored very lowly on statements about the current state of traceability, transparency and level of proof in current supply chains in the industry. This may indicate that experts in senior roles seem to have a firmer grasp on the pressures facing the industry, and affirms their need for a better solution. Their high rankings for tracking of goods and immutability also seem to indicate their belief that blockchain provides benefits that may provide this solution.

However, in their view, the low proportion of early adopters and high set-up costs are potential factors that inhibit blockchain from being an appropriate solution. Members of this type express a relatively strong belief that blockchain in industry is inevitable (#8), although it is not often discussed (#24), and does not excite them (#17). This reveals a relatively cautious perspective that is aware of blockchain and the positive changes it could bring to supply-chains in the industry, but the industry as a whole is currently not ready to make a move into adoption.

Factor 4 had eight exemplars that explain 10% of the variance, with an eigenvalue of 2.76. Members of this type are the most mature by a large margin with all but 2 of the group being 45 years or older, they also have the highest average industry experience with half being over 10+ years. This type is comprised mainly of farmers or farm owners and has the lowest perceived blockchain knowledge with the majority reporting low knowledge.

From table 1 we can see that the highest priorities for this type are: meeting certification and audit requirements is a potential benefit worth the risk of adopting blockchain; immutability of transactions is a potential benefit worth the risk of adopting blockchain; blockchain being too complicated is a factor preventing blockchain implementation; not enough organisations using it is a factor preventing blockchain implementation; blockchain technology excites me; and the industry as a whole is open to innovation.

This type is characterized by older people working in mostly hands-on, non-management or executive type roles in agricultural production. They, therefore, have less to do with the actual life-cycle of the supply-chain, as most are farmers who simply supply product at the start of the supply-chain process and have little interaction thereafter. This type has no high or low ranked statements surrounding the current state of supply-chains in the industry, which is unsurprising considering they have little to do with it. They do report that meeting certification and audit requirements are a high priority, which is also understandable as meeting these requirements are an important function of their roles.

Furthermore, this group has the lowest perceived knowledge of blockchain technology so it is therefore unsurprising that they ranked very highly the notion that blockchain is too complicated. Additionally, they expressed the belief that blockchain adoption is hindered because not enough other organisations use it. Interestingly in this group, although they have little stated knowledge about blockchain, they still report that blockchain technology exciting them. This indicates that although it seems too complicated and they may not understand it, there is some willingness from this older generation to learn and be open to it in the future.

In summary, we may discern 4 types of adopters of blockchain technology in the agricultural supply chain:

Type 1 represents the view of new entrants to the industry in more entry-level type roles; and because of this lack a coherent understanding of the current pressures facing supply-chains in agriculture. They have some knowledge about blockchain and believe implementation in the industry is inevitable and that the industry is open to it.

Type 2 represents the view of mid-level service professionals, mostly in research and development type roles. Because they are not actively working within the industry, they seem to lack a correct understanding of the pressures facing supply-chains currently. However, they were the only type whose members believe that the agriculture industry is not open to innovation. This could be due to their ability to gain a more accurate and holistic view of the industry from the outside looking in.

Type 3 represents the view of industry experts in executive and consultant type roles; they appear to have the clearest view on the pressures facing agricultural supply-chains and have the highest perceived knowledge of blockchain. They are aware of blockchain's potential as a solution, however, they are realistic about the factors that could prevent this from happening.

Type 4 represents the viewpoint of a mature collective of veterans who primarily work on or own farms. They have low knowledge of blockchain and supply-chains, however, they appear to be open and willing to learn about it.

5 Concluding Remarks

This study has obtained an understanding of the natural structure of the agricultural supply chain concourse through the four factor groups and the different characteristics and viewpoints each group has expressed. Reasons for the groups' respective viewpoints and opinions have been discussed and justified. These findings may now be utilised to formulate recommendations and strategies that will help enable to provide a realistic view of what needs to happen to make blockchain implementation in the agriculture industry a reality.

A common theme throughout all four types was about how the insufficient number of use-cases for blockchain is a factor preventing adoption. Additionally, high set-up costs preventing adoption was identified by all types. A potential solution to these factors would be collaboration between companies in the industry in a joint blockchain venture. This venture could either be a test/pilot or full-blown implementation. Collaboration would help to minimize individual set-up costs and also lower the risk of other organizations failing to adopt the technology. Furthermore, from our analysis we see that the average knowledge of blockchain is still quite low and people who are experts both in the industry and have knowledge about blockchain are rare and useful. Industry players would be able to share these experts across the venture and combine knowledge bases. This also allows smaller businesses and people with lesser technical knowledge to be involved, such as people represented in type 4, who have limited knowledge within the space, but appear to be open to blockchain but find it too complicated and intimidating on their own.

The results also demonstrate how the viewpoints for each type were associated with to a number of factors: their level of *experience* in the industry, the *strategic orientation* of their role, their *a priori knowledge* of blockchain and their *maturity* in interacting with merging technology. These groups provided a base of understanding and knowledge that has helped to cut through the hype and excitement and provide a structured framework of understanding towards the different perceptions and level of knowledge surrounding supply-chain in the industry. These findings show that professionals in senior and decision-making roles agree that blockchain can provide a solution to the current issues facing the industry. However, outside of this, although openness to blockchain is at a workable level, knowledge of blockchain and the reason why it may be required are both at a relatively low level. Finally, this research has provided an exploration of knowledge about the state of the pressures facing the food industry and the role blockchain has in being the potential solution to this. It has therefore set a platform for future research to explore a more pervasive technical approach to implementation. It provides hope for the agriculture industry to consider the recommendations provided in this study in order to move towards food safety and security with blockchain and augmented technologies such as AI, IoT and Big Data platforms.

References

Abeyratne, S. A., & Monfared, R. P. (2016). Blockchain ready manufacturing supply chain using distributed ledger. International Journal of Research in Engineering and Technology, 05(09), pp. 1-10.

Agridigital & CBH Group (2017). Solving for supply chain inefficiencies and risks with blockchain in agriculture. Retrieved from www.agridigital.io/products/blockchain

Apte, S., & Petrovsky, N. (2016). Will blockchain technology revolutionize excipient supply chain management?. Journal of Excipients and Food Chemicals, 7(3), 910.

Bocek, T., Rodrigues, B. B., Strasser, T., & Stiller, B. (2017, May). Blockchains everywhere-a use-case of blockchains in the pharma supply-chain. In 2017 IFIP/IEEE Symposium on Integrated Network and Service Management (IM) (pp. 772-777). IEEE.

Brown, S. R. (1993). A primer on Q methodology. Operant Subjectivity, 16(3/4), 91-138.

Brown, S. R. (1996). Q methodology and qualitative research. Qualitative Health Research, 6(4), 561-567.

Conrath, D.W. & Sharma, R.S. (1992) "Toward a diagnostic instrument for assessing the quality of expert systems" ACM SIGMIS DATABASE for Advances in Information Systems 23 (1) 37-43.

Conrath, D.W. & Sharma, R.S. (1993) "Evaluation measures for computer-based information systems" Computers in Industry 21 (3), 267-271.

Dalziel, P., Guenther, M., & Saunders, C. (April, 2016). The New Zealand agri-food sector. Auckland: The Policy Observatory.

Hackius, N., & Petersen, M. (2017). Blockchain in logistics and supply chain: trick or treat?. In Proceedings of the Hamburg International Conference of Logistics (HICL) (pp. 3-18).

Klaus, T., Wingreen, S. C., & Blanton, J. E. (2010). Resistant groups in enterprise system implementations: a Q-methodology examination. Journal of Information Technology, 25(1), 91-106.

Korpela, K., Hallikas, J., & Dahlberg, T. (2017, January). Digital supply chain transformation toward blockchain integration. In proceedings of the 50th Hawaii international conference on system sciences.

KPMG (2018). Agribusiness Agenda 2018. Retrieved 29-January-2019 from www.kpmg.com/nz

Rueda, X., Garrett, R. D., & Lambin, E. F. (2017). Corporate investments in supply chain sustainability: Selecting instruments in the agri-food industry. Journal of cleaner production, 142, 2480-2492.

Sadouskaya, K. (2017). Adoption of Blockchain Technologyin Supply Chain and Logistics.

Sharma, R.S. & Conrath, D.W. (1992). Evaluating expert systems: the socio-technical dimensions of quality. Expert Systems 9 (3) p 125-138.

Sharma, R., Wingreen, S., Kshetri, N. & Hewa, T. (2019). "Design principles for use cases of blockchain in food supply chains" Proceedings of the 25th Americas Conference on Information Systems (AMCIS 2019), Cancun, Mexico.

Shinebourne, P. (2009). Using Q method in qualitative research. International Journal of Qualitative Methods, 8(1), 93-97.

Swan, M. (2015). Blockchain: Blueprint for a new economy. New York: O'Reilly Media, Inc.

Tian, F. (2016, June). An agri-food supply chain traceability system for China based on RFID & blockchain technology. In Service Systems and Service Management (ICSSSM), 2016 13th International Conference on (pp. 1-6). IEEE.

Tian, F. (2018). An Information System for Food Safety Monitoring in Supply Chains based on HACCP, Blockchain and Internet of Things (Doctoral dissertation, WU Vienna University of Economics and Business).

Van Exel, J., & De Graaf, G. (2005). Q methodology: A sneak preview. Retrieved 24 January 2019 from https://qmethod.org/portfolio/van-exel-and-de-graaf-a-q-methodology-sneak-preview/.

Venegas, P. & Krabec, T. (2016). Trust the Name: Demonstrating Material Value Added by Management Using Intangible Flows Maps – A Case from the Blockchain Smart Contracts Industry. Available at SSRN: http://dx.doi.org/10.2139/ssrn.2895778

Watts, S., & Stenner, P. (2005). Doing Q methodology: theory, method and interpretation. Qualitative Research in Psychology, 2(1), 67-91.

Wingreen, S. C., and Blanton, J. E. (2018). IT professionals' person–organization fit with IT training and development priorities. Information Systems Journal, 28(2), 294-317.

Weber, I., Xu, X., Riveret, R., Governatori, G., Ponomarev, A., & Mendling, J. (2018). Untrusted business process monitoring and execution using blockchain. Proceedings of the International Conference on Business Process Management (pp. 329-347). Cham, Switzerland: Springer.

Appendix

The Appendices to this paper may be found in https://drive.google.com/open?id=1m-cIQzWF39Vo9GSeVFMBhxm-lsN6rxeb .

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