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Master Thesis

Thesis Master of Science

Would you like to bid higher for additional information? Examining consumers’ willingness to pay for blockchain proven goods in the Norwegian food industry

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Program:

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Executive Summary

This study focuses on the effect blockchain technology has on consumers' willingness to pay, when used to record and present food provenance information. This was done through an experimental auction, where consumers bid on food products that differed on the method additional food provenance information was conveyed (labels or blockchain), within one of three food categories (pork, fish, or chicken). Through multiple regression analyses, results indicate that customers have an increased willingness to pay towards products that have additional information regardless of the method of conveyance. This result is evident in all three categories, but variation in ratios is observed. Moreover, results disclose that labels enhance willingness to pay to a greater extent than blockchain, but is only significant within one of the three food categories. Lastly, knowledge about blockchain is positively correlated with willingness to pay, however this is not statistically significant. A discussion and interpretation of results are undertaken, further implications for business practices are identified, and proposals for further research are introduced.

Disclaimer: The data collection for this thesis was conducted during the Coronavirus pandemic, where strict government restrictions regarding public health were in place. Therefore, the results of this study may have been impacted by this extraordinary context.

Keywords: Blockchain Technology; Food Provenance; Willingness to Pay; Technological Use Cases; Customer Trends; Experimental Auction; Animal Welfare; Food Safety; Traceability

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1.0 Introduction

In this era of increased digitalization, evolving technologies offer novel ways to produce and deliver different types of information for various types of businesses and consumers; the food industry included. Alongside these new opportunities, there are also emerging new demands among the different actors along the supply chain. A meta-trend that has grown in popularity is the desire for knowledge and understanding of the provenance of the products we purchase; from furniture, to cosmetics, to foods (Ernst & Young, 2007). As the global market grows larger, it becomes harder to keep track of where these products originate from and the methods in which they are handled during production and transportation (Wilson, 2014). In order to better manage these processes and their outputs, a trustworthy system that is more secure and tamper-proof, as well as more efficient for supply chains is needed.

After its origination in the financial industry in 2008, we now see an increasing use of blockchain technology for business purposes, especially in the food and agriculture industry (Hyperledger, 2018). The use of blockchain technologies enables every player in the supply chain, including the end-user to be able to see detailed information regarding the food product of interest. This thesis explores the importance of different types of provenance information regarding three types of food products, and how the presentation of this information, either through labels or verified through blockchain technology, affects consumers' willingness to pay.

1.1 Motivation

As of 2020, suppliers and end-consumers have an increasing demand regarding provenance information of products being purchased. With this increasing demand, as well as an increasing scepticism among end-consumers, being able to provide trustworthy information is seen as a critical success factor across several industries (Hackius & Petersen, 2017). This is particularly true in the food industry, which is seen as needing substantial safety and traceability for products being sold. Due to a rather complex supply chain consisting of many important actors, often located in different geographical areas, the need for minimal friction points in addition to trust and transparency is crucial. With this in mind, a technology able to provide such information could potentially affect the competitive arena to benefit all players operating with healthy circumstances.

As mentioned, with a growing scepticism regarding food due to long travel distances, and worldwide scandals, we now see fast-growing segments asking for provenance information. Consequently, we also see worldwide players such as Walmart, putting pressure on their suppliers with demands regarding the traceability of their products (Hyperledger, 2018). The benefits of blockchain enables end-consumers to easily evaluate the quality of their food, its travel route, and much more through a simple QR code (Murphy, 2016, cited in Kamath, 2018; Mishra, Mistry, Choudhary, Kudu, & Mishra, 2020). With this intersection of food and technology in mind, we believe that the current focus of traceability in 2020 tends to be *"what information can be shown"* instead of *"what information do end-consumers want to see"*. This distinction leads to our main motivation for the topic. Is it possible to affect end-consumers willingness to pay by ensuring that the information provided to them regarding the food product they are purchasing is valuable and trustworthy? Furthermore, does the medium used to convey this information, through labelling or through the use of blockchain technology play a role?

1.2 Research Question

The purpose of this thesis is to investigate how providing end-consumers blockchain-proven information regarding a set of different products affects their willingness to pay. Therefore, our main research questions are:

How are different forms of product information valued by consumers in the food industry? Does the use of blockchain technology as a form of food provenance influence consumers' willingness-to-pay?

To be able to answer these research questions, our methodology consists of an experimental auction followed by a post-experimental survey. The process of designing and performing the experimental auction is described in detail in section *3.2 Methods of Data Collection*.

1.3 Contribution of our Research

The Marketing Science Institute has deemed ‘cultivating the customer-technology interface’ as one of the foremost research priorities of 2018-2020, with a particular focus on how new technology fundamentally alters the purchase experience of customers (Mela, 2018). Prior research on blockchain has been dominated by the technical implementation and development of the technology, while there has been limited research focusing on the commercial application. This paper adds to this dialogue by focusing on the customer-technology interface in the business context of food security and provenance.

Despite blockchain technology being high on the agenda for every major industry in the world, the benefits of blockchain are still not well known among end-consumers. This thesis includes a broken down and educational presentation of the technology and its main benefits, which can be beneficial for several people, but especially for end-consumers who have a particular interest in food provenance. Finally, as this study explores consumers’ willingness to pay for blockchain proven goods, it addresses one of the four challenges that remain for businesses in the decision to integrate blockchain technology in their operations; consumer data access and willingness to pay (Rogerson & Parry, 2020).

1.4 Thesis Structure

This thesis is following a standard ITMRD-structure starting with an introduction, followed by the theoretical background, methodology, results and a final discussion. The introduction states our motivation and background for the chosen topic as well as our main research question and potential contributions. The next chapter of the thesis creates a theoretical foundation for further investigation, based on existing literature on the field. The main focus of this chapter is blockchain technology and the importance of traceability in the food industry. The theoretical foundation created in our literature review will, in the end, support our discussion and conclusion. Further, in section 3, our chosen research methodology will be presented and discussed. This includes argumentation for the chosen research strategy and design, sampling, as well as collection and analysis of collected data. In section 4, we will present our findings and results from our data collection. Finally, the last section will include a discussion based on our findings, theoretical contribution, implications for business practice, limitations, and suggestions for further research.

2.0 Literature Review

To get a better understanding of the benefits of blockchain and its impact on the food industry, we have investigated several aspects of the existing literature in the field. In this chapter, crucial literature to answer our research question will be presented. Due to the complexity of the chosen topic, we have decided to focus on four main elements. Firstly, we present what blockchain is at its core, as well as its evolution. Secondly, we focus on the implications and use cases of blockchain, mainly in the food industry. Thirdly, we highlight the importance of food provenance, before finally focusing on factors that may influence consumers' willingness to pay in the context of the food industry.

2.1 What is Blockchain

Blockchain is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets, tangible or intangible, in a business network. Virtually anything of value can be tracked and traded on a blockchain network, reducing the risk and cutting the costs for all involved (Gupta, 2018). Blockchain owes its name to the way it stores transaction data — in *blocks* that are linked together to form a *chain*. As the number of transactions grows, so does the blockchain. Blocks record and confirm the time and sequence of transactions, which are then logged into the blockchain within a discrete network governed by rules agreed on by the network participants. Each block contains a *hash* (a digital fingerprint or unique identifier), timestamped batches of recent valid transactions, and the hash of the previous block. The previous block hash links the blocks together and prevents any block from being altered or the insertion of a new block between two existing blocks. In this way, each subsequent block strengthens the verification of the previous block and hence the entire blockchain (Gupta, 2018).

In order to achieve the risk reduction and cost cutting promised by blockchains, four key characteristics are present; consensus, provenance, immutability, and finality. The consensus characteristic dictates that for a transaction to be valid, all participants of the network must agree on its validity. Provenance asserts that participants know where the asset came from and how its ownership has changed over time. Immutability refers to the inability of participants to tamper with a transaction after it has been recorded on the ledger. If a transaction is in error, a new transaction must be used to reverse the error, and both transactions are then visible. Finally, the finality characteristic states that a single, shared ledger provides one place to go to determine the ownership of an asset or the completion of a transaction (Gupta, 2018).

These characteristics of blockchain networks are particularly valuable at increasing the level of trust among network participants, through the provision of cryptographic proof over a set of transactions; as transactions cannot be tampered with and are signed by the relevant counterparties, any corruption is readily apparent. This self-policing can mitigate the need to depend on the current level of legal or government safeguards and sanctions to monitor and control the flow of business transactions. This trust in the technology is built upon five main attributes (Gupta, 2018). The first is that it is distributed and sustainable, where the ledger is shared, updated with every transaction, and selectively replicated among participants in near real time; as it is not owned or controlled by any single organization, the blockchain platform's continued existence is not dependent on any individual entity.

The second attribute is its security, privacy, and indelibility. Permissions and cryptography prevent unauthorized access to the network and ensure that participants are who they claim to be. Confidentiality is maintained through cryptographic techniques and/or data partitioning techniques to give participants selective visibility into the ledger. After conditions are agreed to, participants cannot tamper with a record of the transaction and errors can only be reversed with new transactions. Thirdly, blockchains are transparent and auditable. The mirrored access for all participants means that transactions and identities can be validated and verified without the need for third-party intermediaries. Transactions are time-stamped, ordered, and can be verified in near real time. Fourthly, blockchains are consensus-based and transactional; all relevant network participants must agree that a transaction is valid, which is achieved through the use of consensus algorithms. Each blockchain network can establish the conditions under which a transaction or asset exchange can occur. Finally, as business rules and smart contracts (that execute based on one or more conditions) can be built into the platform, blockchain business networks can evolve as they mature to support end-to-end business processes and a wide range of activities, making them orchestrated and flexible.

A blockchain network specifically created for business provides several benefits. Transaction times for complex multi-party interactions are reduced from days to minutes and transaction settlements are faster as verification by a central authority is made redundant. Less oversight is needed because the network is self-policed by network participants, all of whom are known on the network. Additionally, the duplication of effort by various parties is eliminated because all participants have access to the shared ledger. There is tighter security against tampering, fraud, and cybercrime and if a network is permissioned, it enables the creation of a members-only network with proof that members are who they say they are and that goods or assets traded are exactly as represented. Furthermore, through the use of IDs and permissions, users can specify which transaction details they want other participants to be permitted to view. Permissions can be expanded for special users such as auditors who may need access to more transaction detail. The shared ledger that serves as a single source of truth also helps to improve the ability to monitor and audit transactions. Finally, the pure digitization of assets streamlines transfer of ownership and transactions can now be conducted at a speed more in line with the pace of doing business, suggesting increased operational efficiency.

2.2 The Evolution of Blockchain

As of 2020, several million people have heard the somewhat abstract word *blockchain*. More specifically, this buzzword was most strongly associated with the financial industry. In fact, almost every major financial company is doing research on blockchain at the moment (Gupta, 2017). Bitcoin, the decentralized peer-to-peer digital currency was the first well-known example of blockchain technology. From its introduction in 2008, the tremendous opportunities for this disruptive technology were evident, and the revolution regarding its commercial applications has just begun (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016). In 2020, blockchain is being used in a wide variety of industries in different ways, but to better understand how and where it began, we first need to look to the financial industry.

Blockchain was first developed to address the need for an efficient, cost-effective, reliable, and secure system for conducting and recording financial transactions (Gupta, 2018). In the modern transaction system, several professionals have pinpointed current shortcomings, such as time between transactions and settlement, need for third-party validation, and reduced access to bank accounts (Gupta, 2018). To be able to address such issues, the world needed a faster transaction system that could provide trust and transparency.

Bitcoin was the most disruptive solution to the problem, introduced in 2008 as a digital currency that was operationalised on blockchain technology, launched by an unknown person or agency called Satoshi Nakamoto. The main difference between bitcoin and the traditional currency issued by banks is that bitcoin does not have a central monetary authority. It is not stamped Euro or Norwegian Kroner, but it is mined by computer power. Since its surge in popularity in 2009, blockchain has evolved from a relatively primitive base for digital currency to a transformative, symbiotic technology that most likely will have a substantial impact on the remaining miles of the digital transformation (Rosenoer, 2019). Because of this evolution, the value-creating benefits of blockchain are now better known to professionals across industries which opens up the technology for new and valuable use cases. However, the core of blockchain is still the same, a trust-based framework supplemented by versatile and dynamic interfaces with a dynamic collection of exceptional data (Rosenoer, 2019). When this data is enhanced by machine learning and advanced analytics, businesses are able to transform and automate existing value chains and capture substantial value with new business ecosystems.

Blockchain facilitates implementations that go beyond cost-cutting, workflow optimization, and common definitions of a redesign of products and services. As of 2020, the technology is highly used to extend existing businesses by limiting dependence on intermediaries, while others are leveraging its *track-and-trace* functionalities. We can also observe relevant use cases in the retail industry. Walmart is using blockchain with its suppliers to better respond to food safety issues (Rosenoer, 2019). Through the use of blockchain, Walmart is now able to track a particular product in its supply chain in only 2.2 seconds - versus the 7 days it took prior to their application of blockchain (Rosenoer, 2019). Such examples of administrative time savings are seen in several industries that traditionally use paper-based processes. Predicting the direction blockchain will develop in the future is rather difficult, but by examining its evolution over the past 10 years, its applications will only continue to grow.

2.3 Implications and Use Cases

As mentioned, blockchain is being utilised in an increased number of industries, and when considering implementation and use cases, blockchain technology seems suitable for business for a number of reasons. The first explanation regarding its suitability is based on the four key concepts of blockchain; shared ledger, permissions, smart contracts, and consensus. With a shared ledger, that every network participant can access, you eliminate the duplication of effort that is typical for more traditional business networks (Gupta, 2018). This is due to the transaction only being recorded once. When it comes to permissions, a blockchain can either be permissionless or permissioned. If the blockchain is permissioned, each network participant has a unique identity, which enables the use of policies regarding transaction details. With such policies, more information can potentially be stored on the blockchain and participants can specify what type of information they will allow other participants to see. Policies like these could make it easier for organizations to comply with data protection regulations (Gupta, 2018).

The concept of consensus focuses on agreements regarding trust, knowledge, and verification of transactions. For the transaction to be given what`s called proof of stake, the validators must hold a certain percentage of the network`s total value (Gupta, 2018). As a blockchain consists of different types of consensus, it is of high importance that businesses have pluggable consensus, to better fit the consensus mechanism to the specific industry. Blockchains last key concept is smart contracts, which is an agreement that governs a business transaction. The agreement is stored on a blockchain and is automatically executed as a part of a transaction. Each and every one of these key concepts is seen in regard to use cases in different industries. The following sections focus on commercially novel and relevant use cases.

2.3.1 The Shipping Industry

Over the last number of years, the shipping industry has started to realise the potential blockchain technology offers. Some of these benefits, which have been taken from learnings in the financial industry are; (1) the ability to manage cross-border transactions across banks in different geographical locations through a single interface, (2) greater visibility and transaction status, as well as tracking over time, and (3) a consistent, timely, and accurate picture across all accounts independent from location (Gupta, 2018).

As supply chain and logistics involve various network actors, often located in different geographical areas, traceability is a major challenge. This poses a challenge regarding how product provenance and transportation details can be monitored. When facing such problems, blockchains can provide an alternative solution while at the same time removing intermediaries and providing self-verifiable data for shipment tracking (Christodoulou, Christodoulou, & Andreou, 2018). The shipping industry is largely affected by paperwork due to the number of actors and goods crossing borders. As an example, shipping refrigerated goods from East Africa to Europe requires stamps and approvals from around 30 people and organizations that must interact with each other on over 200 occasions (Hackius & Petersen, 2017). Added together, the transaction costs of trade-related paperwork processing is estimated to be between 15 - 50% of the costs of the physical transport (Hackius & Petersen, 2017; Popper & Lohr, 2017). To tackle this problem, IBM and Maersk joined forces in 2015, creating a blockchain solution supposed to connect the vast global network of shippers, carriers, ports, and customs (Hackius & Petersen, 2017). Even though this collaboration is still evolving, the project has been able to launch several pilots. These pilots include having a standardised interface that allows all partners involved to have full visibility of the container status in real-time (Allison, 2017). Consequently, the food industry supply chain can greatly benefit due to reduced transit times and costs across borders.

2.3.2 The Food Industry

IBM is a pioneer in the field of blockchain where complex supply chains are involved, such as that of the food industry. Clients of IBM`s blockchain technology have entered into collaboration on solutions that could potentially elevate the quality of food supply, the speed of movement of goods internationally, and much more (Gupta, 2018), implying an increase in technology, knowledge, and initiative of securing food safety. In fact, the forecasted annual growth of blockchain implementation in supply chain management is expected to be 87% and projected to increase from $45 million in 2018 to $3.314 billion by 2023 (Chang, Iakovou, & Shi, 2019). IBM´s Food Trust allows players throughout the different steps of the food supply to help each other enhance visibility and accountability of food products by sharing a record of food origin details, processing data, and shipping details (Gupta, 2018). One specific case of this in action is the collaboration between the IBM Food Trust, Atea, and the Norwegian Seafood Association; wherein norwegian salmon providers upload data surrounding their products to a blockchain. This record includes relevant information from production, processing, distribution, retailing and consumption (Allison, 2020). This is beneficial to consumers as it provides information that ensures the safety and quality of the food. Finally, the use of blockchain also has the ability to lower the transaction costs of food recall for suppliers, which is reported to total ~$10 million annually - not including loss of sales, illnesses, deaths, and damage to their brand (Gupta, 2018).

Food safety, in the context of this study, refers to the condition of processing, managing and storing food in hygienic ways (Creydt & Fischer, 2019), aiding in the prevention of illness. Ensuring food safety and the quality of products in this era of mass globalisation is increasingly difficult due to the growing global flow of goods. Blockchain technology provides an efficient and improved solution that is able to extensively trace food products to ensure its safety and authenticity, by enabling suppliers to identify contaminated products, risks, and frauds as early as possible. However, these benefits may have a greater impact in regions of the world with more challenging environments and circumstances. As Norway is the main country of interest for this study, and is considered one of the world's best countries regarding food quality and safety (Global Food Security Index, 2020), consumers may not perceive the theoretical benefits of the technology as valuable.

In order to create a trustworthy and well-functioning blockchain for food provenance, cooperation between two important and highly relevant industries is required. The agriculture and the food supply chains are already interlinked in the sense that products from agriculture are used as inputs into a multi-actor supply-chain, ending with the consumer as the final client. However, a more seamless collaboration between the two is necessary to ensure accurate recording of information at all points of the supply chain. In order for all of this information regarding the process to be seen by end-consumers a mobile phone or another connected device could be used to scan a QR code associated with a specific food item. This code would then provide detailed information regarding all players associated with the product, from the producer and provider through to the retailers (Kamilaris, Fonts, & Prenafeta-Boldύ, 2019). The question is, how can the information that is entered onto this blockchain be ensured as valuable, and does the availability of this information affect end-consumers' willingness to pay?

2.4 The Importance of Food Provenance

The usage of blockchain in the food industry addresses issues stemming from the importance of food provenance for all actors along the supply chain. The benefits to farmers, producers, and wholesalers are clear; the ability to identify faulty products or contaminated batches of food and quickly recall them, as well as increase transparency and operational efficiency, to name a few. However, the implications of blockchain technology with regards to food provenance from the consumers perspective has not been explored in as much detail.

Traceability of ingredients in food supply chains has become crucial in a world in which markets are global, heterogeneous, and complex, and in which consumers expect a high level of quality. Gaining control of this food supply chain is required in order to fulfill the increasing demand of consumers on safety and quality of products, triggered by several food scandals, for instance; the Belgian polychlorinated biphenyl/dioxin incident (Bernard et al., 2002); the bovine spongiform encephalopathy (BSE) crisis (Wales, Harvey, & Warde, 2006); the Melamine-laced milk products (Xiu & Klein, 2010); the peanut butter Salmonella outbreak in 2008-2009; and the E. coli illnesses caused by contaminated flour in 2016 (Yiannis, 2018). These food scandals have led to an increase in consumers' sensibility regarding food safety, quality, and sustainability, as well as resulting in stricter national and international regulations and stricter food safety and quality controls (Borrell Fontelles & Nicolai, 2004). However, despite the increasing efforts to more strictly regulate the required food control measures, regulatory frameworks between countries and regions still diverge widely and food safety issues and crisis situations still occur relatively frequently on a global level (Chammem, Issaoui, Dâmaso De Almeida, & Delgado, 2018). For example, in 2019, a search of the key words “food safety” on the website of the New York Times resulted in three articles per month about this topic (Behnke & Janssen, 2020). Thus, the food safety incidents and crisis situations have not only brought increased regulations, but also created an increased awareness of consumers. Food traceability is nowadays regarded as an important aspect in ensuring the safety and quality of the food products (Liu, Kerr, & Hobbs, 2012; Resende-Filho & Hurley, 2012) and increases the confidence and satisfaction of consumers.

Although many believe food labels to purely convey the nutritional information associated with a food product, labels may also include information about food brands, descriptive food names, health benefits, origin, organic identity, production methods, and ethics involved in production (Meyerding, 2016; Samant & Seo, 2016). There are a variety of studies that illustrate the market potential of carbon footprint labels (Laroche, Bergeron, & Barbaro-Forleo, 2001; lal Bhardwaj, 2012; Vanclay et al., 2011), organic food labels (Hempel & Hamm, 2016; Janssen & Hamm, 2014), and the Fairtrade label (Andorfer & Liebe, 2015; Ladhari & Tchetgna, 2015; Rousseau, 2015). Furthermore, the information that is obtained from these label claims appear to influence consumers’ product perceptions, in addition to their prior experiences associated with the product (Rozin, Pelchat, & Fallon, 1986). The introduction of blockchain proven goods offers companies a new method of conveying food provenance information. Companies such as Project Provenance Ltd. are attempting to utilise blockchain technology to change the way consumers receive and interact with food products. However, uncertainty remains as to how beneficial this new form of information provision is for consumers, as well as the information itself.

As noted, the benefits traceability provides to the producers and suppliers in the supply chain seem extremely promising; however, a discussion of the importance of food provenance for end consumers needs to be had. In 2005, Hobbs, Bailey, Dickinson, & Haghiri, found that in an experimental auction, consumers were willing to pay non-trivial amounts for a traceability assurance, although these results are stronger for beef than for pork. However, quality assurances with respect to food safety and on-farm production methods for beef were more valuable to consumers than a simple traceability assurance. Therefore, bundling traceability with additional assurances is likely to be of more value to consumers (see also Dickinson and Bailey, 2002).

The experimental auctions showed that consumers are likely to place a higher value on quality verification systems in which traceability facilitates the provision of additional quality assurances, rather than on traceability alone. Thus, quality assurances appear to be more valuable when backed by a traceability capability (Hobbs et al., 2005). Furthermore, in a recent study conducted by IBM, 71% of those surveyed who indicated that traceability is very important, said that they are willing to pay a premium for brands that provide it (Haller, Lee & Cheung, 2020). In relation to our study and prompted by the findings presented by Hobbs, we argue that regardless of the method used to convey information to consumers, a positive impact on their willingness to pay should be observed:

> **H1$_a$**: *Animal welfare, Food safety,* and *Traceability* conveyed through labels has a positive impact on *willingness to pay*.
>
> **H1$_b$**: *Animal welfare, Food safety,* and *Traceability* conveyed through blockchain technology has a positive impact on *willingness to pay*.

2.5 Factors Influencing Willingness to Pay

In a meta-study done by Cicia, Cicia, & Colantuoni (2010), they argue that the common denominator in the literature on meat traceability is that comparable attributes are ranked differently across studies, and sometimes even contrast each other. This can eventually affect the reliability of willingness to pay estimates. An arguably important variable regarding willingness to pay is the base-price used in the particular study. This factor is thought to influence the premium price, in the sense that the additional amount of money that consumers may be willing to pay for credence attributes depends on the original price of the product (Cicia et al., 2010). The base price is crucial due to two elements. Firstly, a higher price is per se a quality cue which can affect the perceived need of additional information to ensure food quality; secondly, a higher base price will lead to a lower percentage increase in willingness to pay as a consequence of a greater incidence on the total expenditure (Cicia et al., 2010).

Another arguably important factor that can affect customers' willingness to pay is the type of meat at hand. This is often due to different degrees of trust about rearing systems and control along the production chain (e.g. use of hormones, disease, disease incidence potentiality) (Cicia et al., 2010). Dickinson & Bailey (2002) found, as in line with several other researchers on the topic, that subjects show a high willingness to pay for traceability-provided characteristics such as, additional meat safety and humane animal treatment guarantees. Furthermore, a potential implication is presented stating that producers might be able to implement traceable meat systems profitably by tailoring the verifiable characteristics of the product to consumers' preferences (Dickinson & Bailey, 2005).

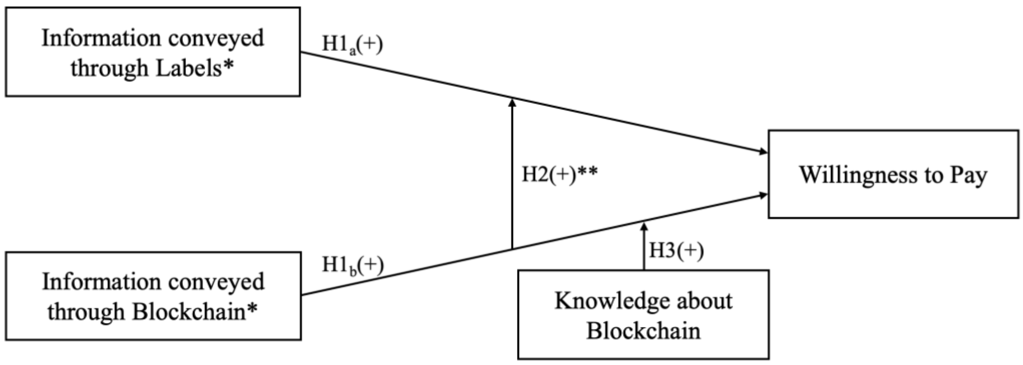
Hobbs et al. (2005) state that the complexity and variety of traceability systems suggest that a system allowing traceability is not simply a binary variable (i.e., either in place or not). Instead of two possible outcomes, there are degrees of traceability. Golan et al. (2003) identify three characteristics by which a traceability system can differ: breadth, depth, and precision. By *breadth* Golan et al. (2003) refers to the amount of information recorded (e.g. animal wealth, additives, feed ingredients, and processing methods). How far forward or backward the supply chain system tracks is defined by the traceability systems *depth*. The system's *precision* refers to the degree of assurance with which the system can pinpoint the movement to a specific product (e.g. tracing to a specific animal or specific farm). By following through on Dickinson & Bailey's (2005) presented implications and ensuring that the system offers breadth, depth, and precision, we believe that customers' willingness will increase. As more information can be stored, verified, and presented on a blockchain rather than on labels, our second hypothesis is that:

> **H2**: *Information conveyed through blockchain technology has a stronger positive impact on willingness to pay compared to the labels.*

In a survey published by the US-based bank HSBC, 59% of the consumers who answered the survey had never heard about blockchain. Furthermore, only 20% of the respondents who had heard about blockchain said that they understand what it is (Zaho, 2017). This knowledge about blockchain implies that they have a greater understanding of the benefits that this technology offers them as consumers. Therefore, as we consider blockchain to be a highly beneficial yet complex technology, we expect that knowledge and understanding of blockchain creates a stronger relationship with willingness to pay. Thus, our third hypothesis is:

> **H3**: *The relationship between information being conveyed through blockchain and consumers' willingness to pay will be positively stronger for respondents with a greater depth of knowledge of blockchain.*

This study seeks to advance prior research by examining how blockchain technology as a form for recording food provenance information potentially increases customers willingness to pay compared to more traditional package labels. The conceptual framework (Figure 1) of this study illustrates the following: (1) how labels guaranteeing animal welfare, food safety, and traceability affects willingness to pay, (2) how blockchain proven food affects customers willingness to pay, (3) how information conveyed through a blockchain affects willingness to pay differently from labels, and (4) how knowledge about blockchain technology affects customers willingness to pay. Blockchain proven goods, in the context of this study, is defined as a food product that offers food provenance information regarding animal welfare, food safety, and traceability, through the use of blockchain technology, thus ensuring transparency and credibility.



* The information conveyed through labels ($H1_a$) and Blockchain ($H1_b$) includes *Animal Welfare*, *Food Safety*, and *Traceability*
** H2 is not a moderator but a two-group hypothesis

Figure 1. Conceptual Framework

3.0 Research Methodology

This section describes the study design and methodology and clarifies the testing procedure of the hypotheses. The hypotheses were tested using data generated from the same study.

3.1 Study Background

Through our study, we aimed to examine whether having food provenance information conveyed through blockchain technology influences consumers willingness-to-pay, and how the amount of knowledge one has on the topic affects this relationship. We also intended to identify how different forms of product information are valued by consumers, when presented to them in various ways.

In order to test for the hypotheses described in section *2.0 Literature Review*, we decided to utilise a qualitative quasi-experimental design where all data collected was primary data. Specifically, we conducted a between-subjects Vickrey second price experimental auction, followed by a post-experiment survey. A quasi-experimental design was chosen as we wished to replicate a real-life situation while isolating the effect of stimuli, which is done through enhanced control of external factors (Gripsrud, Olsson, & Silkoset, 2016). We were therefore able to examine the direct effect that the method used to convey information has on consumers' willingness to pay. The post-experiment survey served to identify the underlying drivers of customers willingness to pay, as well as discern whether consumers' knowledge of blockchain influences this effect. The data collected from these two methods were then analysed through a number of t-tests and linear regression models, to test for the stated hypotheses.

3.2 Methods of Data Collection

Data Sample

The data consists of 180 participant responses collected from 12 experimental auctions and post-experiment surveys conducted in Norway from April to May 2020. This sample size was decided upon to ensure enough respondents to secure satisfactory statistical power. By having a desirable number of respondents, the chance of creating false positive hypotheses is reduced, and the quality of the final outcome is increased. Due to the circumstances surrounding COVID-19, we saw the need to use non-probability convenience sampling and recruited participants by distributing the signup form for the experiment on our social media platforms.

3.2.1 Vickrey Second Price Experimental Auction

Data Collection - Tools, Procedures, and Materials

We used a Vickrey second price auction, which is consistent with previous experimental auctions measuring willingness to pay (e.g. Hobbs et al., 2005; Shogren, Shin, Hayes, & Kliebenstein, 1994). In this auction format, bidders are asked to submit sealed bids, and the bidder who submits the highest bid is awarded the item up for auction and is required to pay the amount of the second highest bid. This type of auction is different from a first price auction where the bidder who submits the highest bid is awarded the object up for auction and pays their bid value. In a first price auction, the rational bidding strategy is to bid somewhat lower than your true willingness to pay value to ensure profit (Levin, 2004), whereas the rational strategy in the second price auction format is to bid ones true valuation of the product (Vickrey, 1961).

The 180 participants were evenly split into one of three food categories; pork, fish, or chicken, where each of these food categories had a blockchain or a Label condition. This resulted in a total of six conditions, each consisting of 30 participants. In order to run the auctions smoothly, each auction was made up of 15 participants, resulting in a total of 12 auctions being performed. In order to ensure a sample size of 180, experimental auctions were only performed when all 15 participants were present. A summary of this distribution is provided in Table 1. The procedure of the auction was equal independent of category and condition.

Table 1. Summary of Experimental Auction Conditions

Condition	Base Product	Condition	Number of Respondents
1	Pork Chops	Labels	30 (2x15)
2	Pork Chops	Blockchain	30 (2x15)
3	Salmon Fillets	Labels	30 (2x15)
4	Salmon Fillets	Blockchain	30 (2x15)
5	Chicken Fillets	Labels	30 (2x15)
6	Chicken Fillets	Blockchain	30 (2x15)

To perform the experimental auction in line with restrictions given by the health authorities in Norway, we utilised the online meeting app Zoom. Zoom enabled us to gather the group sizes required to carry out the experiment in a virtual meeting room, while also reducing the barriers for participants to participate by having minimal download requirements. Registration to join the experiment was done through a secured online Excel sheet where participants anonymously selected a participant number from a list (Appendix A). After selecting a participant number, all respondents answered a three-question survey providing information about their chosen participant number, group, and email address. Participant e-mail addresses were only used to distribute log-in information for the actual experiment, which was sent to them 20 minutes prior to their scheduled meeting time (Appendix B). The email also served as a reminder to ensure attendance of the desired number of participants in each meeting.

Once the participants were entered into the meeting room, we offered a thorough introduction of what to expect from the auction, how responses were to be recorded, and how to request for help if it was required. In order to replicate a real-life purchasing situation, participants were asked to imagine they were on a trip to the supermarket and should treat the following situation as if they were going to purchase the products at the end of the experiment. Each respondent was then shown a product depending on the condition they were assigned to; either a package of pork chops, salmon fillets, or chicken fillets, with the product's nutritional information and price (Appendix C). The price of the products were calculated in advance, and was the average price of the food product across different stores in Norway. Respondents were then told that regardless of other purchases that they would have made, they were going to purchase the product at hand for the announced price. However, on their way to the check-out counter, they were given an opportunity to participate in an auction, where they could bid on a similar product that had additional food provenance information.

Depending on the condition the participant was assigned to, the product up for auction that they were shown had either; a set of three labels representing *Food Safety*, *Animal Welfare*, and *Traceability*; or a QR code leading to a category specific webpage (Appendix E) developed by us on Google Sites. Participants were told that the information on the website was verified through blockchain technology. The label descriptions detailing *food safety*, *animal welfare*, and *traceability*, were taken from Hobbs et al. (2005), whereas the description for the

QR code was developed by us. Table 2 details the label descriptions and QR codes given to the respondents.

Table 2. Label Description for all Categories

QR Code / Label	**Description**
QR Code	Webpage showing details of the product regarding *Traceability*, *Animal Welfare*, and *Food Safety*. Traceability was presented by showing the number of locations included in the supply chain, as well as the journey of the product (from farm to store). Animal welfare was presented through descriptives, recorded injuries, as well as ingredients and materials. Food safety was presented by showing the journey of the product, as well as additives and preservatives.
Label Food Safety 	The Green "Food Safety" label means that "we know that the chicken/pork/fish in this package was processed in a farm federally inspected by the Norwegian Food Inspection Agency. This label also means that the processing plant follows a food safety program that is above the standard, even if they are federally inspected".
Label Animal Welfare 	The Orange "Animal Welfare" label means that "information is available on certain enhanced processes and procedures used to produce this package of chicken/pork/fish, and this is over and above what one would know from typical chicken/pork/fish products (e.g., this chicken/pork/fish product has extra assurances that the chicken/pork/fish was raised in a state-of-the-art facility, the chicken/pork/fish was fed high-quality feed and was processed in a low-stress environment—this is part of humane animal treatment)".
Label Traceability 	The Blue "Traceability" label means that "this package of chicken/pork/fish can be traced back to the specific farm/fish farm on which the chicken/pork/fish was raised".

Each auction consisted of ten rounds of bidding where participants were asked to place bids corresponding to the amount, they would be willing to pay to exchange their base product with the one up for auction. As some respondents may not have seen additional value in products with additional information, zero and/or negative bids were permitted. Prior to each new round of bidding, the second highest bid (defined as the new market price) from the previous round was announced. The announcement of the new market price each round and utilising multiple rounds of bidding, provides a corrective mechanism that assists participants' understanding of the experiment. Ultimately, this led to stabilisation in the participants' bids over the ten rounds of bidding (Hobbs et al., 2005).

Respondents were asked to bid the total value of what they would be willing to pay, for instance with a fish base price of 43 NOK, if the participant believed that the product up for auction was worth 2 NOK more, they would then submit a bid of 45 NOK. Bids from each respondent were private and sent through a private chat, which then was recorded in Excel (Appendix F). This meant that the participants were unable to see the bids of others during the entirety of the auction minimizing competitive and inflated bids. Finally, after all ten rounds of bidding, one round was chosen randomly as binding, where the participant with the highest bid had to pay the price of the second highest bid to exchange their product. The equal chance that any of the rounds of bidding could be chosen provides participants with the incentive to bid honestly every round. This encourages participants to bid their true valuation of the product and reduces the risk of strategic bidding behaviour.

3.2.2 Post-Experiment Survey

The link to the post-experiment survey was given to the participants after the completion of the auction with the aim of identifying the underlying drivers of customers willingness to pay, as well as to discern whether consumers' knowledge of blockchain influences this effect. As the survey was distributed to those that took part in the auction, we achieved a response rate of 100%, with all 180 participants completing the survey. The survey consisted of 18 questions, two of which were to identify the respondents’ group and participant number, the next four related to participant demographics, seven questions pertained to consumers’ awareness and concerns over food safety, and the remaining five concerned consumers’ awareness and knowledge of blockchain (Appendix G).

The demographic questions asked participants about their gender, age, education, and income. The questions surrounding consumers’ awareness and concerns over food safety were adapted from a similar study about consumers' willingness to pay conducted by Hobbs et al. (2005). These questions focus on the history of food poisoning within their families, the amount of news articles they have seen regarding foodborne diseases, and their confidence in the Norwegian food inspection agency. Additionally, how much they value additional information regarding traceability, food safety, and the processes used to produce food was measured. Finally, to assess participants' knowledge of blockchain technology, questions of their awareness of blockchain in general and in the food industry were asked, as well as their exposure to blockchain articles, and their confidence in their own knowledge of blockchain. However, the two questions regarding consumers' confidence in their knowledge of blockchain were omitted from the analysis due to the uncertainty surrounding the questions; specifically, for participants that had not heard of blockchain in general or in the food industry. It was unclear whether respondents were to answer that they had high confidence in their lack of blockchain knowledge, or if they had no confidence in their knowledge of blockchain due to never having been aware of it prior to the experiment. When necessary, we used a 5-point Likert scale, as this gave respondents a natural middle option and did not force them to answer positively or negatively in either direction.

3.2.3 Validity of Chosen Methodology

Internal Validity

In order to minimise external influences on the participants during the study and therefore potential alternative explanations for our results, all participants were asked to remove any distractions prior to the start of the auction. To minimise the chance of hypothesis guessing from the participants during the experimental auction and therefore reducing the construct validity of the study, the survey was distributed after the final round of bidding.

Furthermore, the experimental nature of the study and through the quasi-laboratory setting used, we managed to ensure a relatively clean control setting which ensured that we had a high chance of manipulating cause and observing effect. Several manipulations were done to ensure proper measurement of our dependent variable (willingness to pay); 1) all respondents were given the same information before the auction (Appendix D), 2) all labels and packages looked the same and conveyed the same information, 3) all web pages looked the same and conveyed the same information, 4) brands and logos were removed from labels and web pages to control for potential prior associations and preferences, 5) the experimental auction was identical across all conditions and auctions, and 6) information given to the respondents throughout the experiment was from a pre-made script, ensuring uniform information and minimization of experimenter bias. As willingness to pay is a rather complex construct which includes multiple important dimensions, it is reasonable to believe that our study has some lack of content validity.

External Validity

Due to the fact that our sample only consists of Norwegian residents as well as the fact that we obtained our sample through convenience-based sampling, the generalisability of our study outside of the Norwegian population is reduced. This study was also conducted during the peak of COVID-19, potentially putting extraordinary pressure and uncertainties on participants, particularly relating to finances and health. Ultimately, this could lead to results different from what to expect in a normal economic situation.

Ecological Validity

COVID-19 also poses a threat to the ecological validity of the study, as the methodological approach is more artificial than what would be expected in a real-life purchase situation. As such artificial situations do not include actual payments, there may be discrepancies between the participants willingness to pay bids and their actual purchase behaviour in real-life. In an attempt to combat this, respondents were asked to practice mental imagery of the purchase scenario during the experimental auction. Additionally, the respondents were told that in this fictitious scenario, regardless of what happened during the auction, they would be purchasing their base product for the stated price.

3.2.4 Compliance with Legal and Ethical Regulations

In order to comply with both Norwegian and BI regulations regarding data collection, any surveys presented to respondents during the entirety of this study neither required, nor collected any personal data that could be used to directly identify or attribute their answers back to them. Furthermore, as far as we are concerned, the research presented in this paper is GDPR compliant.

3.3 Method of Analysis

Prior to conducting any analysis, the bid data from the experiment and the survey responses were consolidated onto a single document. During this consolidation process, we created additional variables that identified the food category and condition each participant was a part of, the base price of the food category, the average bid of each participant over all ten rounds, as well as only the last five rounds of bidding, and finally, the percentage change of the participants bids from the base price. All data analysis was done using IBM SPSS Statistics 26 software.

In order to test for significance of the various hypotheses, a total of three different statistical tests were performed. Six one-sample t-tests were used to determine whether there was a significant difference between the bids of the participants and the base price of the products, within the condition they were assigned. Additionally, three independent sample t-tests were done to ascertain whether there was a statistical difference between labelled bids and blockchain bids, within each food category. Finally, multiple linear regression models were created to understand how the two different methods of conveying food provenance information could influence consumers' willingness to pay, when taking into account a number of variables. This method of regression was specifically chosen as the dependent variable is continuous. We conducted three more specific regression analyses on the data by including a selection variable of each individual food category to better understand any differences between the three.

Statistical Model - Linear Regression

The dependent variable of the regression analysis was the respondents average bid over the last five rounds of bidding, depicted as a percentage change from the base price. Therefore, for the purpose of all regression analyses the dependent variable has been converted to participants' marginal willingness to pay for the product up for auction. This percentage change in each condition is considered as their marginal willingness to pay as it is a relative change to the base price of the product. However, for ease of discussion regarding the analysis, we continue to refer to the effect on the dependent variable as an effect on consumers' willingness to pay. We excluded data from the first five rounds of bidding from any further analysis as we expected all bids to have stabilized by round six. This is due to the possibility that participants may have submitted erroneous bids or misunderstood the instructions of the experiment within the first five rounds of the auction. Additionally, as the three food categories had different base prices (one in each category), we opted to use the average percentage change from the base price of the last five rounds to be able to better analyze and compare the data across the categories.

In order to make an evaluation regarding the drivers of customers' willingness to pay, the following full regression model was estimated.

$$\begin{aligned}\text{Average Bid (\% change)} \\ &= \alpha + \beta 1\ (\text{GROUPCATFISH}) \\ &+ \beta 2\ (\text{GROUPCATCHICKEN}) \\ &+ \beta 3\ (\text{CONDITIONDUMMY}) + \beta 4\ (\text{FOODPOIS}) \\ &+ \beta 5\ (\text{FOODPOISSEVERITY}) + \beta 6\ (\text{ARTICLESFOOD}) \\ &+ \beta 7\ (\text{CONFIDENCEFOODSAFE}) \\ &+ \beta 8\ (\text{VALUEFOODSAFE}) + \beta 9\ (\text{VALUETRACE}) \\ &+ \beta 10\ (\text{VALUEPROCESS}) + \beta 11\ (\text{HEARDOFBC}) \\ &+ \beta 12\ (\text{ARTICLESBC}) + \beta 13\ (\text{BCFOOD}) \\ &+ \beta 14\ (\text{GENDER}) + \beta 15\ (\text{AGE}) + \beta 16\ (\text{EDUCATION}) \\ &+ \beta 17\ (\text{INCOME})\end{aligned}$$

The independent variables as well as details and expectations regarding each variable are listed in Table 3 below. Two dummy variables represent the different products given to the respondents during the experimental auction: respondents given a fish product (GROUPCATFISH), and respondents given a chicken product (GROUPCATCHICKEN). Respondents given a pork product are used as the reference category. To distinguish between respondents that received the labels conditions from respondents given blockchain conditions, a dummy variable (CONDITIONDUMMY) was created. Coefficients on the created dummy variables will give an indication of whether the respondents are willing to pay a premium for blockchain proven goods over traditional labels. The dummy variables will also indicate whether the potential premium differs between the three food categories. Based on the level of details that a blockchain can provide we expect respondents to value blockchain proven goods more, and therefore have positive coefficients for the condition-related dummy.

To measure respondents' awareness and concerns over food safety, four variables were created: FOODPOIS, FOODPOISSEVERITY, ARTICLESFOOD, and CONFIDENCEFOOD. Direct experience with food poisoning for either the respondent or close family of the respondent were measured through the dummy variable FOODPOIS. It is reasonable to believe that respondents who have experienced food poisoning are willing to pay a premium for additional information, hence the expectation of a positive coefficient for FOODPOIS. The severity of the food poisoning was measured through a 5-scaled variable and we expect a positive correlation between severity and willingness to pay. Exposure to news, articles, and reports regarding foodborne diseases could potentially affect willingness to pay both positively and negatively. An important determiner for the expected direction and magnitude is the tone of the article. As we assume that the majority of articles being read are negative in nature due to the current situation with COVID-19, and that negative events are more newsworthy in general, we expect this coefficient to be positive. Respondents confidence in the Norwegian food inspection agency is measured through the variable CONFIDENCEFOOD. As discussed in the literature review, Norway is considered to be an extremely safe country regarding foodborne diseases. Having this in mind, we expect the mean of CONFIDENCEFOOD to be high, and an increase in confidence to be negatively correlated with willingness to pay.

To measure the extent that respondents’ value additional information regarding food safety, traceability, and processes, three variables were created: VALUEFOODSAFE, VALUETRACE, and VALUEPROCESS. We expect a positive correlation between the amount respondents’ value additional information, and their willingness to pay. Additionally, we expect the magnitudes of each information variable to differ between categories. For example, it is possible that due to recent documentaries surrounding specific types of meat, such as ‘Griseindustriens hemmeligheter’, Norwegian consumers may value additional assurances regarding their pork more than the other food types (Kumano-Ensby & Fjeld, 2019). As mentioned by Hobbs et al., (2005), the reliability of stated preferences is often questioned. There is a tendency that respondents do not act upon their stated preferences in actual purchase situations. However, due to the design of the data set, we are able to test the strength of the relationship between participants' recorded preferences and their actual willingness to pay.

Three variables were created to measure respondents' knowledge regarding blockchain technology: HEARDOFBC, ARTICLESBC, and BCFOOD. HEARDOFBC is a dummy variable that indicates whether the participant was aware of blockchain prior to the experiment. Due to the complexity of blockchain, we expect respondents who are given a blockchain proven product and have heard about blockchain to pay a premium over respondents who have not heard about blockchain. It is also expected that knowledge about blockchain is correlated with the number of articles read by the respondents (ARTICLESBC). Hence, we do expect a positive correlation between articles read and willingness to pay for a blockchain proven product. BCFOOD is a dummy variable separating respondents into the ones who have heard of blockchain in the food industry and those who have not. By knowing about the potential benefits that blockchain can have on the food industry, the coefficient is expected to be positive. The three variables measuring respondents' knowledge about blockchain makes it possible to test for the effect presented in the conceptual framework.

Four demographic variables were included in the regression model: GENDER, AGE, EDUCATION, and INCOME. For the variables gender and age, there are no prior expectations regarding the coefficients. However, due to the fact that technology in general as well as blockchain is an increasingly used topic in education, the EDUCATION coefficient is expected to be positive. It is reasonable to say that wealth is positively correlated with purchasing power. Hence, there is an expectation that a higher income would lead to higher willingness to pay.

Table 3. Description of IV´s in the Regression Model

Variable Name	Description	Measurement	Expected Direction
GROUPCAT FISH	Condition: Fish	**Dummy variable**: 1 = Fish	+
GROUPCAT CHICKEN	Condition: Chicken	**Dummy variable**: 1 = Chicken	+
CONDITION DUMMY	Separate respondents given labels and blockchain	**Dummy variable**: 1 = Blockchain	+
FOODPOIS	Participant or family member experienced food poisoning	**Binominal**: 1 = Yes 0 = No	+

FOODPOIS SEVERITY	Severity of the food poisoning experienced	**1-5:** not severe, a little severe, moderately severe, severe, very severe	+
ARTICLES FOOD	News articles/reports read/heard regarding foodborne diseases in the last 6 months	**1-5**: <10, 11-20, 21-30, 31-40, >40	+
CONFIDENCE FOODSAFE	Confidence in the Norwegian food inspection agency	**1-5**: no confidence, a little confidence, a moderate amount of confidence, a lot of confidence, a great deal of confidence	-
VALUE FOODSAFE	Value knowing additional assurances about food safety	**1-5**: do not value, value a little, value a moderate amount, value a lot, highly value	+
VALUETRACE	Value knowing the exact farm that produced the animal	**1-5**: do not value, value a little, value a moderate amount, value a lot, highly value	+
VALUE PROCESS	Value knowing processes used by farmer to produce the animal	**1-5**: do not value, value a little, value a moderate amount, value a lot, highly value	+
HEARDOFBC	Participants awareness of blockchain technology	**Binominal**: 1 = Yes 0 = No	+
ARTICLESBC	News articles/reports read/heard regarding blockchain in the last 6 months	**1-5**: 0, 1-10, 11-20, 21-30, >30	+
BCFOOD	Participants awareness of blockchain technology in the food industry	**Binominal**: 1 = Yes 0 = No	+
GENDER	Gender of participant	1 = Male, 0 = Female	?
AGE	Age of participant	**Free text**: age in years	?
EDUCATION	Highest level of education attained by participant	**1-5**: less than high school, high school graduate, undergraduate degree, master's degree, doctorate	+
INCOME	Income of participant	**1-5**: >100,000, 100,000-300,000, 300,000-500,000, 500,000-700,000, >700,000	+

4.0 Data Analysis

This section describes an exploration of the collected data. Additionally, a course of action and reasoning behind sample demographics, t-tests, and regression analyses is given.

4.1 Data Cleaning

To get an overview of the data obtained, we performed several descriptive analyses. In order to identify any outliers, the participants' average willingness to pay over the last five rounds was analysed through boxplots (Figure 2). Four values were found to lie outside the interquartile ranges (IQR) of the different conditions. We then used the 1.5xIQR rule (Khan Academy, n.d.) in order to determine which of these were indeed outliers. Ultimately, a total of three outliers were identified in the Fish Blockchain and Chicken Label conditions. This was based on their submitted bids during the auction, as they fell outside the lower and upper limits determined by the 1.5xIQR rule (Table 4). We proceeded all further analysis with a sample consisting of the remaining 177 participants.

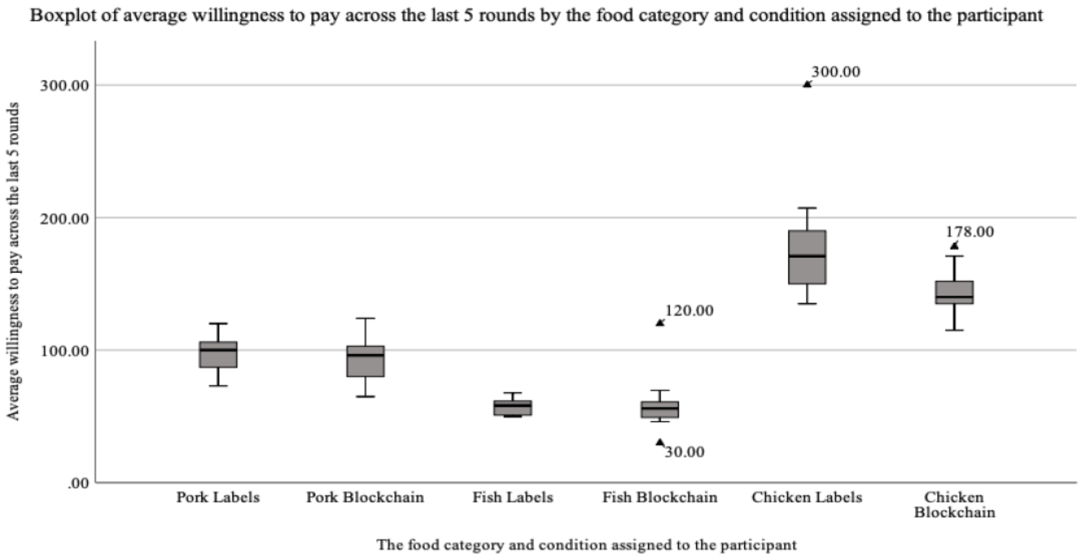


Figure 2. Boxplot Last Five Rounds of Bidding

Table 4. Validation of Outliers - 1.5xIQR Rule

Condition	**Q1**	**Q3**	**IQR**	**1.5 x IQR**	**Lower Limit**	**Upper Limit**
Fish Blockchain	50.000	61.200	11.200	16.800	33.200	78.000
Chicken Labels	150.000	192.000	42.000	63.000	87.000	255.00
Chicken Blockchain	132.600	152.700	20.100	30.150	102.450	182.650

4.2 Sample Demographics

Our sample consisted of 62.70% male and 37.30% female participants all residing in Norway. The participants were between 19 and 84 years old, with a mean age of 28.31. All respondents have obtained a high school degree with 84.20% having obtained an undergraduate degree or higher. Additionally, 60.50% of participants have an annual income of less than 300,000 NOK.

The majority of participants (71.80%) have either experienced food poisoning themselves or have had a close family member that has experienced it, with 26.00% of cases perceived as severe or very severe. Additionally, 74.00% of participants have not read or heard more than 10 pieces of news regarding Foodborne diseases. Furthermore, 80.20% of participants have *a lot of* (52.50%) or *a great deal of* (27.70%) confidence in Norwegian food inspection agencies.

A comparison between the types of information valued by participants reflects the findings of Hobbs et al. (2005), as participants valued additional assurances about food safety the highest ($\bar{x}$ = 3.310, SD = .898), followed by information regarding animal welfare ($\bar{x}$ = 3.200, SD = 1.035), with traceability information being regarded as the least valued ($\bar{x}$ = 2.640, SD = 1.13).

Regarding blockchain technology, 74.00% of participants are aware of its existence, however only 21.50% of participants have read/heard more than ten news/articles regarding blockchain in the past 6 months. Furthermore, only 39.50% of all participants have heard of blockchain technology being used in the food industry. A summary of all sample demographics is found in Table 5.

Table 5. Summary Sample Demographics

Characteristics	**Characteristic Specification**	**Frequency**	**Percentage**
Gender	Male	111	62.700
	Female	66	37.300
Mean Age		177	28.310
Education	Less than High School	0	0.000
	High School Graduate	28	15.800
	Undergraduate Degree	93	52.500
	Master’s Degree	55	31.100
	Doctorate	1	0.600
Income	< 100.000	55	31.100
	100,000 - 300,000	52	29.400

	300,000 - 500,000	24	13.600
	500,000 - 700,000	25	14.100
	> 700,000	21	11.900
Food Pois	Yes	127	71.800
	No	50	28.200
Food Pois Severity	Not severe	76	42.900
	A little severe	23	13.000
	Moderately severe	45	25.400
	Severe	23	13.000
	Very severe	10	5.600
Articles Food	< 10	131	74.000
	11 - 20	25	14.100
	21 - 30	6	3.400
	31 - 40	5	2.800
	> 40	10	5.600
Confidence Food Safe	No confidence	1	0.600
	A little confidence	2	1.100
	A moderate amount of confidence	32	18.100
	A lot of confidence	93	52.500
	A great deal of confidence	49	27.700
Value Food Safe	Do not value	1	0.600
	Value a little	31	17.500
	Value a moderate amount	75	42.400
	Value a lot	52	29.400
	Highly value	18	10.200
Value Trace	Do not value	30	16.900
	Value a little	55	31.100
	Value a moderate amount	52	29.400
	Value a lot	29	16.400
	Highly value	11	6.200
Value Process	Do not value	6	3.400
	Value a little	42	23.700

	Value a moderate amount	59	33.300
	Value a lot	50	28.200
	Highly value	20	11.300
Heard of BC	Yes	131	74.000
	No	46	26.000
Articles BC	0	64	36.200
	1 - 10	75	42.400
	11 - 20	20	11.300
	21 - 30	9	5.100
	> 30	9	5.100
BC Food	Yes	70	39.500
	No	107	60.500

4.3 One Sample t-tests

To be able to explain how different methods of presenting information affects willingness to pay, and thereby begin answering hypotheses $H1_a$, $H1_b$, and H2, graphics in Excel were produced and one sample t-tests over the last five rounds of bidding were conducted. Figures 3, 4, and 5 visualize how participants' willingness to pay evolved over ten rounds of bidding. The numbers shown in the figures are the average percentage increase of the participants' bids relative to the initial base price of the product. Consistent with Hobbs et al. (2012), the figures illustrate that the bids begin to stabilise around their true willingness to pay by the sixth round as respondents seem to have fully understood the auction procedure. Due to participants' lack of understanding and potential bid errors during the first five rounds, we have decided to exclude this data in further analysis.

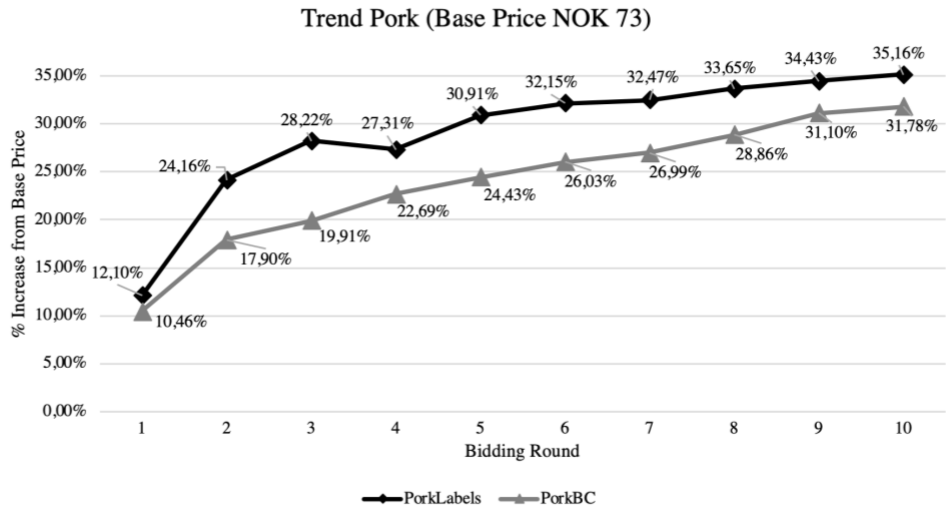


Figure 3. Average Willingness to Pay Bids: Pork

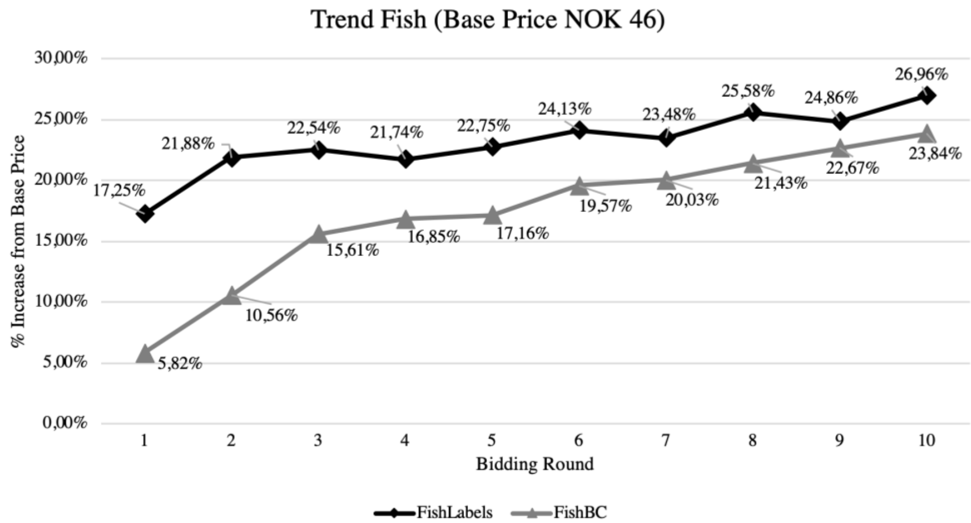


Figure 4. Average Willingness to Pay Bids: Fish

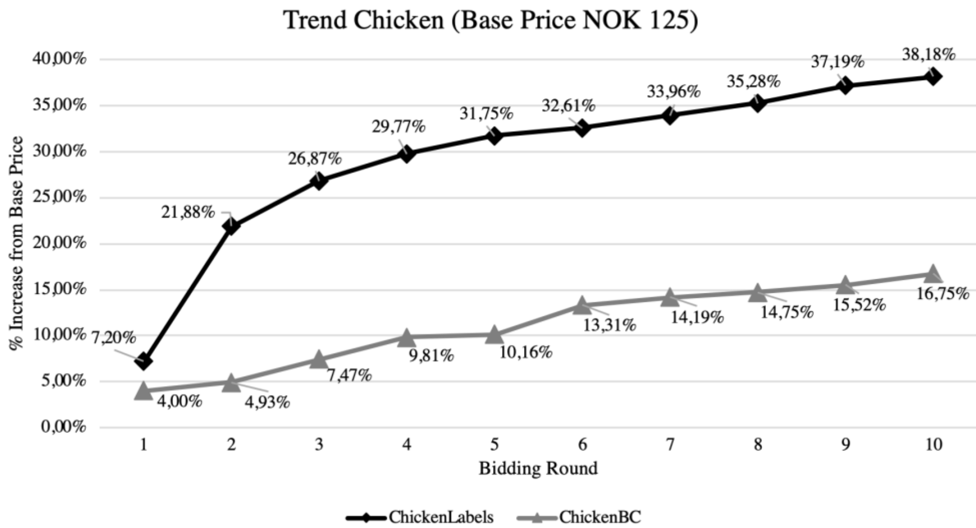


Figure 5. Average Willingness to Pay Bids: Chicken

The three figures show that having information regarding animal treatment, food safety, and traceability, presented through labels or through blockchain technology, increases customers willingness to pay from the standard base product. In order to test whether this difference is statistically significant for each condition, a one-sample t-test was performed on the participants' average bids over the last five rounds (dependent variable) against the base price of each of the products (Table 6). All results were statistically significant, indicating that consumers' bids within all conditions were indeed positively different than the base price of the products, thus supporting $H1_a$ and $H1_b$ for all three categories.

Table 6. One Sample t-test of Average Bids over the Last Five Rounds

Condition	**Base Price (NOK)**	**Mean (NOK)**	**Standard Deviation**	**t-value**
Pork Labels	73	97.507	12.894	10.410***
Pork Blockchain	73	94.133	16.640	6.956***
Fish Labels	46	57.500	5.703	11.045***
Fish Blockchain	46	55.893	7.251	7.219***
Chicken Labels	125	169.303	21.478	11.108***
Chicken Blockchain	125	144.269	15.278	6.792***

* Significant at 0.1; ** Significant at 0.05; *** Significant at 0.01

Figures 3, 4, and 5 further illustrate that regardless of the category, respondents are willing to pay more for a product when the information is conveyed through labels than through blockchain technology. However, in order to properly evaluate H2, three independent samples t-tests were conducted within the individual food categories to compare consumers' percent change in willingness to pay for the label and blockchain conditions. Within the Chicken category, the 29 participants who received the labels condition (M = 35.443, SD = 17.182) compared to the 30 participants who received the blockchain condition (M = 14.901, SD = 12.335) demonstrated a significantly higher willingness to pay, ($t(57) = 5.289$, $p = .000$). However, the t-tests within Fish ($t(56) = .942$, $p = .350$) and Pork ($t(58) = .878$, $p = .384$), do not show a significant difference between the bids for labelled and blockchain proven products. As H2 refers to a significant positive increase of blockchain proven goods over labelled goods, these findings result in the rejection of H2.

Table 7. Independent Samples t-test on Individual Food Category

Condition	N	Mean (%)	Standard Deviation	t-value
Pork Labels	30	33.571	17.662	.878
Pork Blockchain	30	28.951	22.795	
Fish Labels	30	25.001	12.397	.942
Fish Blockchain	28	21.506	15.763	
Chicken Labels	29	35.443	17.182	5.289***
Chicken Blockchain	30	14.901	12.335	

* Significant at 0.1; ** Significant at 0.05; *** Significant at 0.01

4.4 Full Linear Regression

In order to better understand what drives the observed effect on consumers' willingness to pay, we applied a linear regression analysis. The linear regression model allows us to examine how the different variables concerning consumers' awareness and concerns over food safety, consumers' awareness and knowledge of blockchain, and participant demographics independently influence consumers' willingness to pay. The dependent variable of the linear regression is the average willingness to pay of the participants, represented as the percentage increase over the products base price. We decided to use this dependent variable in order to ensure that the data could be compared across the three food categories, as they had different base prices. The regression analysis is run as a two-tailed test as our hypotheses contain specific predictions about the direction of the difference between the labels and blockchain conditions, yet we are also interested in the possibility that the opposite outcome could be true.

Multicollinearity was controlled for by evaluating variance inflation factors and collinearity tolerance. As seen in Table 8, all VIF values are below the critical value of 4 (O`brien, 2007) with the highest registered value being 1.906. Additionally, all collinearity tolerances are above the critical value of .50 (Janssens, De PelsMacker, Wijnen, & Van Kenhove, 2008) with the lowest registered value being .525. In the ANOVA results given in the model summary, we can see that the full model is significantly different from a null model at a 1% level. When looking at the adjusted R_2, we can see that our model explains 15.70% of the variation in our dependent variable. Considering the fact that willingness to pay is a rather abstract and complex term, and the fact that the model consists of 17 independent variables, we consider our adjusted R_2 as satisfactory.

Table 8. Full Regression Model Results

	B **Effect Size (%)**	***SE B***	**β**	**t-value**	***p***	**Tolerance**	**VIF**
Constant	23.822	11.990		1.987**	.049		
GROUPCAT FISH	-6.420*	3.275	-.168	-1.960*	.052	.650	1.539
GROUPCAT CHICKEN	-4.535	3.227	-.119	-1.405	.162	.664	1.507
CONDITION DUMMY	-10.727	2.616	-.300	-4.101***	.000	.898	1.114
FOODPOIS	2.951	3.593	.074	.821	.413	.587	1.704
FOODPOIS SEVERITY	.902	1.312	.065	.688	.493	.542	1.846
ARTICLES FOOD	-1.195	1.211	-.072	-.987	.325	.899	1.112
CONFIDENCE FOODSAFE	.526	1.777	.022	.296	.768	.883	1.132
VALUE FOODSAFE	-.028	1.889	-.001	-.015	.988	.537	1.863
VALUE TRACE	2.260	1.485	.142	1.522	.130	.548	1.825
VALUE PROCESS	2.551	1.657	.147	1.540	.126	.525	1.906
HEARDOFBC	-3.142	3.792	-.077	-.829	.409	.555	1.802
ARTICLES BC	2.343	1.529	.139	1.533	.127	.579	1.728
BCFOOD	.913	3.223	.025	.283	.777	.618	1.617
GENDER	-4.818	2.701	-.130	-1.784*	.076	.900	1.111
AGE	-.204	.146	-.121	-1.400	.163	.638	1.567
EDUCATION	.089	2.084	.003	.043	.966	.761	1.314
INCOME	-.420	1.108	-.032	-.379	.705	.671	1.490

R_2 = .239; Adjusted R_2 = .157
* Significant at 0.1; ** Significant at 0.05; *** Significant at 0.01

In the full regression model, we can see that CONDITIONDUMMY is the only coefficient that is significant at a 1% level. The standardised coefficient of CONDITIONDUMMY is -.300 with an effect size of -10.73% indicating that customers given a blockchain proven good are willing to pay less than the respondents given labels. This result further reinforces the rejection of H2, as consumers are willing to pay more for labelled goods than blockchain proven goods.

The constant, the coefficient GROUPCATFISH, and the demographic variable GENDER are all significant at a 10% level. The coefficient for GROUPCATFISH indicates that respondents given fish are willing to pay 6.42% less than the respondents given pork ($\beta = -.168$, $p < 0.1$). The coefficient for GENDER indicates that females are willing to pay 4.82% more than the males in our sample ($\beta = -.130$, $p < 0.1$). The rest of the demographic variables, EDUCATION ($\beta = .003$, n.s), AGE ($\beta = -.121$, n.s), and INCOME ($\beta = -.032$, n.s) were not statistically significant. All other variables were not statistically significant, however due to the nature of the study, we find some of the effect sizes relevant to report. Additionally, explanations for unexpected variable directions are reported.

The results from the regression analysis indicates that respondents given a pork product, were willing to pay 4.54% more than respondents given a chicken product (GROUPCATCHICKEN: $\beta = -.119$, n.s). Comparable with Hobbs et al., (2005), we can see that respondents value knowing the processes used by the farm to produce the animal (VALUEPROCESS: $\beta = .147$, n.s) more than knowing the exact farm that produced the animal (VALUETRACE: $\beta = .142$, n.s). These coefficients indicate that both types of information affect willingness to pay positively. VALUEFOODSAFE indicated a slight decline in willingness to pay of .03% and was not statistically significant ($\beta = -.001$, n.s). Variables regarding food poisoning (FOODPOIS: $\beta = .074$, n.s) and its severity (FOODPOISSEVERITY: $\beta = .065$, n.s) were not significant. Nevertheless, by having experienced food poisoning, the respondent's willingness to pay increased by 2.95%, and if the poisoning was more severe, the willingness to pay increased by .90%. These results were in line with expectations prior to the analysis.

The number of articles/reports and news read about foodborne diseases was expected to increase respondent's willingness to pay. This was due to the assumption that the majority of articles/reports posted in today's media on the topic has a negative angling due to the COVID-19 situation. Nevertheless, the number of articles/reports has a negative effect on willingness to pay, but not enough to be statistically significant (ARTICLESFOOD: β = -.072, n.s). Regarding respondents' confidence in the Norwegian food inspection safety, coefficients indicate that increased confidence in the Norwegian food inspection agency leads to an increased willingness to pay with .53% (CONFIDENCEFOODSAFE: β = .072, n.s). This result was a contradiction to our expectations. Nevertheless, this can potentially be explained by the fact that respondents believe that the information provided on the labels and the blockchain is certified by the Mattilsynet and therefore lead to a positive correlation between confidence and willingness to pay.

Coefficients measuring respondents' knowledge about blockchain, indicates mixed results. Willingness to pay declined with 3.14% for the respondents who had heard about blockchain (HEARDOFBC: β = -.077, n.s). BCFOOD confirms that if the respondents have heard about the use of blockchain technology in the food industry, willingness to pay tends to increase with .91% (β = .025, n.s). It is important to emphasize that these values are not by any means statistically significant, but their magnitudes are still of interest. The coefficient ARTICLESBC indicates that for the well-read respondents, willingness to pay tended to increase by 2.34% (β = .139, n.s).

To further investigate H3, another regression model was run on participants assigned to the blockchain condition of the auction (Table 8), to examine the effect of participants' blockchain knowledge (HEARDOFBC, ARTICLESBC, and BCFOOD) on their bids for blockchain proven goods. The direction, magnitude, and significance of these three variables in the full regression, are also reflected in the more specific blockchain regression (HEARDOFBC: β = -.160, n.s; ARTICLESBC: β = -.083, n.s; BCFOOD: β = .058, n.s). Participants who have heard about blockchain had a lower willingness to pay of 7.23%, however if the participants were aware of the use of blockchain in the food industry they were willing to pay 2.13% more than those that were not. Finally, those that are more well-read or up to date on blockchain news are also willing to pay 1.37% more.

Thus, it appears that it is not enough just to have heard of blockchain, but the more specialised knowledge one has on blockchain, the more they are willing to pay, partially supporting H3.

Table 9. Regression Analysis Blockchain Condition

	B **Effect Size (%)**	***SE B***	**β**	**t-value**	***p***
Constant	8.995	16.523		.544	.588
GROUPCATFISH	-6.322	4.862	-.162	-1.300	.198
GROUPCATCHICKEN	-12.964	4.905	-.338	-2.643**	.010
FOODPOIS	-3.769	5.531	-.094	-.681	.498
FOODPOISSEVERITY	1.975	2.214	.138	.892	.375
ARTICLESFOOD	-.705	1.772	-.043	-.398	.692
CONFIDENCEFOODSAFE	2.150	2.572	.091	.836	.406
VALUEFOODSAFE	-.226	2.894	-.011	-.078	.938
VALUETRACE	5.173	2.355	.339	2.196**	.031
VALUEPROCESS	1.073	2.356	.064	.455	.650
HEARDOFBC	-7.233	6.015	-.160	-1.203	.233
ARTICLESBC	1.372	2.092	.083	.656	.514
BCFOOD	2.126	4.708	.058	.451	.653
GENDER	-4.303	4.050	-.115	-1.062	.292
AGE	-.083	.262	-.037	-.316	.753
EDUCATION	.557	3.108	.021	.179	.858
INCOME	-.835	1.637	-.062	-.510	.612

R_2 = .320; Adjusted R_2 = .167
* Significant at 0.1; ** Significant at 0.05; *** Significant at 0.01

4.5 Categorical Regression Analysis

Further regression analyses were performed on the individual food types in order to better identify any differences that may be present between the three product categories. As the dataset was split into three (Fish, Pork, and Chicken), the two dummy variables, GROUPCATFISH and GROUPCATCHICKEN, have been omitted from these regressions. Standardised betas are used in order to identify which variables have the strongest effects within each category, and for better comparison across the three. Prior to identifying the individual findings within each food category, it is important to note some limitations to the following analysis. One of which is the especially poor fit of the Pork model (Adj R^2 = 0.003), meaning the model does not accurately explain the variances within the dependent variable. Secondly, is the lack of significant independent variables across all three models, potentially reducing the reliability of the comparison between the three food types. Regardless, interesting observations and conclusions will be reported.

Table 10. Summary of Categorial Regression Analyses

	β Fish	**β Pork**	**β Chicken**
Constant	(-.118)	(.247)	(1.504)
CONDITIONDUMMY	-.211 (-1.323)	-.120 (-.735)	-.578 (-4.419***)
FOODPOIS	-.146 (-.850)	.197 (1.065)	.005 (.034)
FOODPOISSEVERITY	.165 (.904)	.096 (.515)	-.082 (-.515)
ARTICLESFOOD	-.100 (-.672)	-.161 (-1.164)	-.116 (-.802)
CONFIDENCEFOODSAFE	.100 (.619)	.077 (.498)	-.030 (-.248)
VALUEFOODSAFE	.297 (1.787*)	.004 (.018)	.025 (.142)
VALUETRACE	.103 (.590)	.311 (1.666)	.020 (.119)
VALUEPROCESS	-.017 (-.101)	.136 (.646)	.201 (1.176)
HEARDOFBC	-.125 (-.641)	-.132 (-.771)	-.082 (-.424)
ARTICLESBC	.247 (1.438)	.083 (.487)	.086 (.479)
BCFOOD	-.008 (-.043)	-.105 (-.588)	.255 (1.580)
GENDER	-.173 (-1.199)	-.131 (-.894)	-.066 (-.505)
AGE	-.075 (-.423)	-.042 (-.240)	.013 (.083)
EDUCATION	.234 (1.582)	.026 (.162)	-.081 (-.553)
INCOME	-.382 (-2.005*)	.003 (.017)	.124 (.849)
Adjusted R^2	.123	.003	.260
Number of Observations	58	60	59

* Significant at 0.1; ** Significant at 0.05; *** Significant at 0.01
Notes: t-values are in parentheses

Similar to the full regression model, CONDITIONDUMMY is negative in all three models, with Chicken exhibiting the strongest magnitude (Fish: β = -.211, n.s; Pork: β = -.120, n.s; Chicken: β = -.578, $p < .01$). ARTICLESFOOD also reflected the full model in all three food types, indicating a decrease in participants willingness to pay as they tend to read more articles/news (Fish: β = -.100, n.s; Pork: β = -.161, n.s; Chicken: β = -.116, n.s). The three variables used to measure the extent to which respondents' value additional information regarding food safety, traceability, and processes (VALUEFOODSAFE, VALUETRACE, and VALUEPROCESS) all display positive coefficients across the three models, apart from the variable VALUEPROCESS in the Fish model (β = -.017, n.s). Additionally, variable VALUEFOODSAFE in the Fish model was also found to be significant (β = .297, p < .10). The variable ARTICLESBC (Fish: β = .247, n.s; Pork: β = .083, n.s; Chicken: β = .086, n.s) is positive across all three food types, while the variables HEARDOFBC (Fish: β = -.125, n.s; Pork: β = -.132, n.s; Chicken: β = -.082, n.s) and GENDER (Fish: β = -.173, n.s; Pork: β = -.131, n.s; Chicken: β = -.066, n.s) are negative across the three.

Certain coefficients of the three regression models run in direct contrast to the others. The FOODPOIS variable is negative for Fish (β = -.146, n.s), but positive for both Pork (β = .197, n.s) and Chicken (β = .005, n.s), as is the INCOME variable (Fish: β = -.382, p < 0.10; Pork: β = .003, n.s; Chicken: β = .124, n.s). The Chicken model indicates findings that contradict the other two food types in a negative direction for the variables of FOODPOISSEVERITY (Fish: β = .165, n.s; Pork: β = .096, n.s; Chicken: β = -.082, n.s), CONFIDENCEFOODSAFE (Fish: β = .100, n.s; Pork: β = .077, n.s; Chicken: β = -.030, n.s), and EDUCATION (Fish: β = .234, n.s; Pork: β = .026, n.s; Chicken: β = -.081, n.s). Simultaneously, the Chicken model also indicates a contrasting positive effect of the variables BCFOOD (Fish: β = -.008, n.s; Pork: β = -.105, n.s; Chicken: β = .255, n.s) and AGE (Fish: β = -.075, n.s; Pork: β = -.042, n.s; Chicken: β = .013, n.s) to the other two food types.

Table 11. Summary of Hypotheses Results

Hypotheses	Expectation	Outcome
H1a: *Animal welfare*, *Food safety*, and *Traceability* conveyed through labels has a positive impact on *willingness to pay*.	Support	Supported***
H1b: *Animal welfare*, *Food safety*, and *Traceability* conveyed through blockchain technology has a positive impact on *willingness to pay*.	Support	Supported***
H2: *Information conveyed through blockchain technology has a stronger positive impact on willingness to pay compared to the labels.*	Support	Rejected
H3: *The relationship between information being conveyed through blockchain and consumers' willingness to pay will be positively stronger for respondents with a greater depth of knowledge of blockchain.*	Support	Partially Supported

5.0 General Discussion & Implications for Business Practice

The main purpose of this study was to investigate whether using blockchain technology as a form of food provenance had an effect on consumers' willingness to pay. The following research questions have been the foundation for the study:

How are different forms of product information valued by consumers in the food industry? Does the use of blockchain technology as a form of food provenance influence consumers' willingness-to-pay?

Prior to conducting this study, we held the assumption that blockchain proven goods would increase consumers' willingness to pay. In order to test this assumption, a comparison to other methods of conveying food provenance information (food labels) was done. Four hypotheses were formulated, and when analysed in relation to one another, helped in answering the research questions above. The following section will expand on the results of the experiment and attempt to substantiate the findings in order to utilise them in a business setting.

General Discussion

In line with our expectations, we could see a substantial increase in respondents' willingness to pay for both products with labels and blockchain. Hence, both $H1_a$ and $H1_b$ were supported. These findings reflect Hobbs et al. (2005) and Dickinson & Bailey (2002) as having a quality verification system that facilitates the provision of additional quality assurances about traceability, animal welfare, and food safety increases willingness to pay. Despite the fact that both labels and blockchain proven goods affect willingness to pay positively, there are still observed differences between the two conditions across categories. The results of our analysis indicate that labels have the largest effect on chicken, and the lowest effect on fish. This shows a tendency that the category of interest potentially affects willingness to pay. An interesting finding is that the differences in percentage increase is correlated with what we perceive to be the health risk of eating a bad product from the specific category. Hereby, eating a bad chicken product could lead to a more severe food poisoning compared to eating a bad fish product, hence the higher percentage increase in chicken compared to fish. In comparison with categorical differences, external differences such as preferences towards product categories and brands could potentially affect customers willingness to pay. It is reasonable to believe that having multiple respondents with strong preferences of the product at hand, potentially affects the results in various directions.

Contradictory to our expectations, information conveyed through blockchain technology did not have a significantly greater positive impact on willingness to pay compared to the labels. In fact, for certain products, it appears to have a significantly negative effect. One potential explanation for this may be due to the familiarity of labels as a method of conveying food provenance information, whereas blockchain is a new, unproven technology that has not yet been established in the market. The combination of the availability and familiarity heuristics offer insight into why this may be the case. Tversky & Kahneman (1973) note that these heuristics lead to consumers favouring familiar places, people, or things over those that are novel, due to the ease of recall. Therefore, consumers would be willing to pay more for the information conveyed through labels, which they are familiar with, while not as much when a new, unproven technology is used.

Another possible explanation lies in the theory provided by Malhotra (1984), wherein consumers that receive too much information experience an information overload. This creates two major obstacles to decision making: the inability to locate what is relevant due to sheer volume and overlooking what is most critical among relevant data. Golan et al.'s (2003) identification of the three characteristics by which a traceability system can differ: breadth, depth, and precision, suggest that blockchains would be well perceived in relation to labels due to the ability to provide more breadth, depth, and precision. However, it may be that the sheer amount of information that was shown on the blockchain would have led to an information overload in participants and their judgment of the product may have been impacted. This may have led to a lower willingness to pay, while labels simply satisfy the breadth, depth, and precision that is required by consumers.

For our last hypotheses, investigating if customers' knowledge regarding blockchain technology moderates their willingness to pay, we observed opposing results compared to prior expectations. There are a number of possible explanations as to the negative willingness to pay of consumers that have heard of blockchain.

The first is the argument noted in section *2.5 Factors Influencing Willingness to Pay*, that not all those who have heard of blockchain understand exactly what it is. This lack of knowledge of the intricacies of the technology means that consumers who have only heard of it in passing are not fully aware of the benefits provided by its implementation. A second explanation could be the strong association between blockchain and cryptocurrencies, reinforcing this idea that consumers are not educated of the benefits it offers in broader business practices. This argument is supported by the increase in willingness to pay when consumers have read or heard more about the technology, and when the participants have heard of the use of blockchain within the food industry. More broadly, this demonstrates that educating consumers about the specific benefits new technology (in this instance, blockchain) offers within the bounds of specific industries, may negate the negative effect that simply being aware of blockchain entails.

Implications for Business Practice

In general terms, we encourage companies in the food industry to focus on providing end-consumers with information regarding animal welfare, food safety, and traceability. Specifically, for blockchain, there does not appear to be any further benefits to be found for end-consumers in the food industry. However, there are several benefits that argue for it to be implemented in the supply chain of the food industry. Firstly, as supply chains get more complex and global, blockchain technology can limit dependence on intermediaries by providing *track-and-trace* functionalities. This can enhance wholesalers' control over potential safety issues among their suppliers, and ultimately increase the quality of their end product. A prime example of such benefits is Walmart's ability to track particular products in a couple of seconds compared to several days before the implementation of blockchain technology. Secondly, blockchain technology can lead to great benefits regarding administrative time savings, improving the efficiency of the transport process. As the quality of food often corresponds to the time taken from farm to table; an indication of freshness, we propose that the food industry implements blockchain technology as a method of increasing the quality of the food.

Our study shows that if respondents have higher knowledge about blockchain in a specific field, their willingness to pay increases. This effect is strengthened if respondents have read a larger number of articles about blockchain. Hence, we recommend companies to educate their customers about how blockchain is beneficial for their specific industry. An increased level of knowledge among your customers could lead to several positive effects; firstly, an increase in customers willingness to pay. Secondly, by conveying information and being a provider of education on the field, businesses can enhance the perceived quality of the firm by practicing what they preach.

It is also important for managers to understand the product they are selling, or more broadly, the type of category that they are operating in when implementing a blockchain. This understanding is crucial when considering that blockchain is able to reduce the perceived risk of purchasing a product, if the consumer base is educated about blockchain within the bounds of the industry. The level of perceived risk of certain products or industries; whether that be functional, physical, psychological, financial, or time-loss (Maziriri & Chuchu, 2017), could help determine whether a customer-facing blockchain is worth the investment. Industries with higher risk thresholds may benefit greatly from reassuring consumers of the safety of their product, whereas industries with lower risk thresholds may not benefit to the same extent. However, it is important to reiterate that the infancy of blockchain technology makes it inferior to more established methods of conveying information, such as labels. In order to strengthen the likelihood of successfully implementing blockchain, managers should then focus more on providing information regarding processes used to produce the product rather than on traceability and food safety assurances.

As a final note regarding blockchain in business; it is clear that predicting the direction this technology will take going forward is rather difficult, however the exponential growth blockchain has seen over the last few years leads us to believe it can and should have a significant role in the future. The role it plays may not be as a method to change consumer purchase behaviour or to increase their willingness to pay, but rather as a support technology for supply chains, in order to ensure the products being provided are real and of a certain quality.

6.0 Limitations and Further Research

This section includes limitations regarding sampling, methodology, and data collection, in addition to further research regarding replication alternatives, extensions of the study, and other relevant concepts to explore.

Limitations

Despite our best efforts, there are certain limitations to this study that need to be acknowledged. The first of which is the sampling method that was implemented; a form of non-probability convenience sampling. The first limitation of this sampling technique is that a convenience sample can lead to the under- or over- representation of particular groups within the sample. In the case of this study, we observe an over-representation of young adults with low income. As the sample is not chosen purely at random, the inherent bias in the technique means that the sample is unlikely to be representative of the general population. The study could have also benefited from a larger dataset, particularly in the appropriation of the sample sizes of each individual condition. If each singular condition, for example Pork blockchain, had more than the 30 participants, the regression analysis results would have been more precise. Additionally, the three more specific regression analyses would be more accurate and the comparison across the three even more informative. Finally, certain individual attributes were not taken into account during the experiment that may have influenced the results. For instance, if participants had dietary restrictions or followed a particular diet (veganism for instance), that would influence their willingness to pay for food products that do not align with their values. Screening questions regarding these restrictions, would have made the findings more relevant for consumers of the particular food groups.

It is also worthwhile discussing potential limitations regarding methodology used for data collection. As experimental auctions are a rather distinctive way of collecting responses, it is reasonable to assume that the respondents were first introduced to the method during our experiment. Despite actions taken to reduce potential misunderstandings during the experimental auction, it is still possible that certain respondents misunderstood minor details regarding the process. It is also worth discussing the competitive element that is inherent in an experimental auction. As the respondents bid against each other, auctions may provide a competitive environment where participants wish to 'win', resulting in inflated bids for some respondents. This could ultimately lead to respondents bidding over the actual willingness to pay and therefore exceed what they would have been willing to pay for the product at hand in real life. An additional important aspect regarding the environment of the experiment is that it was done digitally and not physically, and further, the respondents were not asked to pay what they ended up bidding. Hence, it is plausible that respondents did not feel like they actually were using money and therefore bid inflated values.

Evaluating the design of our experimental auction in retrospect, we see certain elements that should have been controlled for. Firstly, the respondents given labels were not told exactly who produced them and could possibly have perceived them as being made by the Norwegian Food Inspection Agency (as they are mentioned in the description of the labels). This lack of detail may have resulted in an increased perceived trust towards the product, as it is evident that the sample has a great deal of confidence in the Norwegian Food Inspection Agency. Whereas, we created a fictitious company called 'Proven Foods AS' as the provider of the blockchain proven goods. This could potentially skew the perceived trust in the two conditions leading to differences in the participants' willingness to pay. Secondly, we did not control for preferences of the products at hand among respondents.

Hypothetically, if a specific condition included several respondents with extreme preferences in either direction, this could lead to weaknesses in our final data. Lastly, we did not make the product categories directly comparable based on product size. Although we decided to base package sizes for the three food products on what you normally find in supermarkets to increase the ecological validity of the study, another alternative may have been to have had all product sizes being equal (e.g. 500 grams). This would have allowed for a more comparable analysis between the three food categories and reduce the impact that package sizes may have had on participants. However, this limitation is partly accounted for by using a percentage increase from the base price.

Further Research

To better understand the potential of blockchain technology in the eyes of consumers, a replication of this study in a physical store may account for the limitations that were acknowledged above and increase the ecological validity. In order to build on the findings of the current study, changing the context to include other products or industries may offer insight into where blockchain proven goods are valued the most by end-consumers. For instance, prior research indicates that fields such as luxury and collectable products could benefit greatly from this technology. Additionally, research of blockchain proven goods in the context of e-commerce environments may offer valuable insight going forward, considering the changing landscape of retail goods. Furthermore, a replication of this study can be done in other countries and cultures, in order to compare how differences in consumers perceptions of food safety and risk influence their willingness to pay.

Finally, other potential variables to consider, if this study were to be replicated or built upon further could be; the effect of implementing blockchains from branded products or from third-party agencies; the effect of brands and how prior associations may influence their acceptance of blockchain technology for specific products; and how different customer segments react to the introduction of blockchain proven goods.

Additional concepts that may be worth exploring are the implementation of blockchain within the food industry, as well as the financial consequences of implementing such technology. Focusing on the benefits provided by blockchain technology to supply chains, an interesting concept would be to find the optimal method of integrating a blockchain surrounding current practices. Analysing real life case studies, as well as theoretical solutions would offer interesting insights and discussion to the future implementation and application of blockchain. Additionally, analysing the financial implications for companies that have already invested in blockchain technology versus others that have not may provide argumentation for the use of blockchain in broader business cases. One particular aspect that would be interesting to examine, is whether blockchain projects are able to self-finance, meaning that the returns are able to cover the investment costs. A final recommendation regarding blockchain research in general, is to explore how multiple blockchains from a range of providers can interact with one another on a global scale.

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8.0 Appendices

Appendix A

Excel Registration

Thank you for helping us out with our master thesis! We highly appreciate your contribution.
English: **If you wish to participate please follow the steps below (scroll DOWN to see all 3 steps).**
Norwegian: **Ønsker du å delta, vennligst følg stegene under (scroll NED for å se samtlige (3) steg)**

Step 1:	Please read the description of the experiment process below
	Vennligst lest beskrivelsen under

English	The experiment you are signing up for concerns how people evaluate **food safety** and will happen in a meeting application called Zoom (similar to Skype). You do not have to download anything as a link will be provided to you 20 minutes before the experiment begins. **You will need a computer to take part in the experiment** and will be expected to participate in an experimental auction and answer a short survey. It is very important that you remember to meet up in Zoom at your scheduled time slot. The estimated time per group is approximately **20 minutes**.
Norwegian	Eksperimentet du nå skal delta i har som formål å forstå hvordan folk verdsetter **matsikkerhet** og vil skje gjennom møte-appen Zoom (omtrent som Skype). Du trenger **ikke** å laste ned noe ettersom du vil få tilsendt en link 20 minutter før eksperimentet starter. **Du vil trenge en PC for å delta på selve eksperimentet** og din deltakelse går ut på å være med i en eksperimentell auksjon og besvare en kort spørreundersøkelse. Det er svært viktig at du husker å møte opp i Zoom til avtalt tid. Estimert tid per gruppe er **20 minutter**.

Step 2:	To join, please put an X in your desired time slot in the "Taken" column found in the tables below. There are 10 groups to choose from, each with different meeting times. Each meeting has 15 slots and will be ran only if all the spots are taken. Remember your Group and Participant number as you will need these to confirm your participation in Step 3.
	For å registrere deg på ønsket tidspunkt, vennligst skriv inn **X** i kolonnen ***"Taken"***. Du kan velge mellom 10 forskjellige møtetidspunkter. Hvert møte har 15 plasser og vil kun bli gjennomført hvis alle plassene er tatt. Vennligst husk **gruppenummer** og **deltakernummer** til steg 3 **nedenfor**.

Group 1		**Group 2**		**Group 3**		**Group 4**	
Date: 26.04.2020		**Date: 26.04.2020**		**Date: 27.04.2020**		**Date: 27.04.2020**	
Time: 1500-1520		**Time: 1600-1620**		**Time: 1300-1320**		**Time: 1400-1420**	
Paricipant Number	**Taken (X)**	**Paricipant Number**	**Taken (X)**	**Paricipant Number**	**Taken (X)**	**Paricipant Number**	**Taken (X)**
Participant 1	x	Participant 1	x	Participant 1	x	Participant 1	x
Participant 2	x	Participant 2	x	Participant 2	x	Participant 2	x
Participant 3	x	Participant 3	x	Participant 3	x	Participant 3	x
Participant 4	x	Participant 4	x	Participant 4	x	Participant 4	x
Participant 5	x	Participant 5	x	Participant 5	x	Participant 5	x
Participant 6	x	Participant 6	x	Participant 6	x	Participant 6	x
Participant 7	x	Participant 7	x	Participant 7	x	Participant 7	x
Participant 8	x	Participant 8	x	Participant 8	x	Participant 8	x
Participant 9	x	Participant 9	x	Participant 9	x	Participant 9	x
Participant 10	x	Participant 10	x	Participant 10	x	Participant 10	x
Participant 11	x	Participant 11	x	Participant 11	x	Participant 11	x
Participant 12	x	Participant 12	x	Participant 12	x	Participant 12	x
Participant 13	x	Participant 13	x	Participant 13	x	Participant 13	x
Participant 14	x	Participant 14	x	Participant 14	x	Participant 14	x
Participant 15	x	Participant 15	X	Participant 15	X	Participant 15	x

Step 3:	To confirm your participation, please follow the link below. This link is accessed by clicking on the link **once**, and then clicking on the **smaller link** that appears in the upper left corner of the link you just clicked.
	For å bekrefte registreringen din vennligst trykk **én** gang på linken under. Det vil da vises en mindre link i venstre hjørne av linken du nettopp trykket på. Trykk deretter på den **LILLE** linken for å komme til registreringssiden.

Sign-up confirmation/Registrering:	https://bino.qualtrics.com/jfe/form/SV_eDlOUy2bsaBn0kR

Appendix B

Sign-up to Enter Zoom Meeting

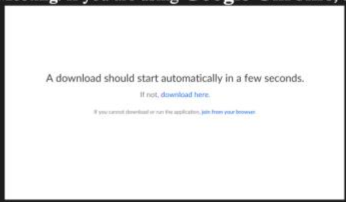
Hi **Participant 1**

If you have a problem joining the session please call 004746906267

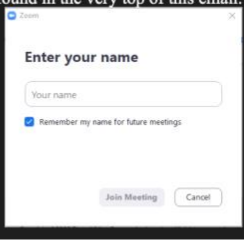
You are a member of **Group** 14. Thank you for taking part in this experiment, we highly appreciate your attendance. If you are familiar with Zoom, please open the link as normal. If you have not used Zoom before please follow the **five (5)** steps below. You will **not need** to sign up with an email and password at any point. Please read **all steps** before starting with step number 1. When finishing all steps below, you will enter a **waiting room** and will be let into the actual meeting **5 minutes** before the meeting start.

1. Click this link to get to Zoom.
   https://binorwegianbusinessschool.zoom.us/j/63435275087

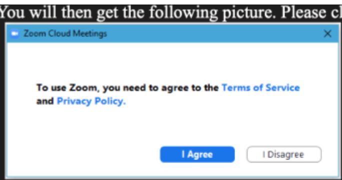
2. When clicking the link, this picture will appear. If you are using **Safari** or **Internet Explorer**, click **download here** and then **run** to get to **Zoom Cloud Meeting**. If you are using **Google Chrome**, click **join from your browser**.



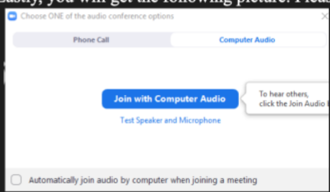
3. Next, you are asked to type in your name. We now want you to type in you **participant number**. This is done to ensure anonymity. Your participant number is found in the very top of this email.



4. You will then get the following picture. Please click **I Agree.**



5. Lastly, you will get the following picture. Please click **Join with Computer Audio**.



The link to the post-experiment survey is here:
https://bino.qualtrics.com/jfe/form/SV_2f1XYhNFOqaUfVX

Please do not click on this until you have completed the experiment.

See you soon!

Appendix C

Packages

Næringsinnhold per 100g	
Energi (kJ)	932 kJ
Energi (kcal)	224 kcal
Fett	16.0 g
-Mettet fett	3,0 g
-Enumettet fett	5,9 g
-Flerumettet fett	5,0 g
Karbohydrater	0 g
Sukker	0 g
Protein	20,0 g
Salt	0,11 g

* av referanseverdi veiledende daglig inntak

Pr 100 g laks 2,4 g Omega-3. (EPA/DHA): 1200 mg

NÆRINGSINNHOLD
PR. 100G

Energi	(445 kJ / 105 kcal)
Fett	(1 g)
› Enumettede fettsyrer	(0,4 g)
› Flerumettede fettsyrer	(0,2 g)
› Mettede fettsyrer	(0,3 g)
Karbohydrat	(0 g)
› Sukkerarter	(0 g)
Protein	(24 g)
Salt	(0,2 g)

INGREDIENSER

Kyllingfilet

Næringsinnhold	
ENERGI	1006 KJ/242 KCAL
FETT	18 G
METTEDE-FETTSYRER	6,5 G
ENUMETTEDE-FETTSYRER	8,1 G
FLERUMETTEDE-FETTSYRER	2,6 G
KARBOHYDRAT	0 G
SUKKERARTER	0 G
PROTEIN	20 G
SALT	0,1 G

Appendix D

Experimental Auction Script

Introduction

Hi everyone and thank you once again for agreeing to participate in our research experiment today. My name is Eirik and sitting behind me is my thesis partner Jørgen. So, today you will be participating in an experimental auction and a short survey that is about researching people's opinions on food safety. During the experiment we would appreciate your complete, undistracted attention. So we would very kindly like to ask that you do not open any other applications on your computer, chat with other participants, or engage in other distracting activities while the experiment takes place, which is expected to last a total of 20 minutes. Please feel free to ask any questions in whichever language you would like to receive the answers in (Norwegian or English).

Due to these Corona-times, the entire experiment will take place through this Zoom session, it was originally meant to be a physical study but as we know that is not possible. In order to ensure everybody has an understanding of the Zoom software we will briefly explain the functions that are important to effectively running the experiment.

- Participant Names / Direct Chat
    - Questions can also be done through this feature

The instructions period may be a little long and detailed but the experiment itself will actually go quite fast. We will now start with a brief instruction period. During this instruction period, you will be given a complete description of the experiment and how to record relevant information throughout. If you have any questions during the instruction period please send a direct message (using the Zoom function) and your question will be answered out loud so everyone can hear. If any difficulties happen to come up during the experiment, please send a direct message and an experimenter will assist you privately through the direct chat function. So, let us begin:

To start the experiment we need everyone to practice a little mental imagery. We need you to imagine that you are in the supermarket and one of the products you are purchasing today is a packet of X. Please take a minute to examine the packet and send us a direct chat with the word "Done" when you are ready to continue. Regardless of what happens you will be purchasing this product today for U amount of Kroner.

- On the way to the checkout, there is an auction taking place where you have the chance to bid on another packet of X. As seen on your screens now. As you can see, this packet has been awarded with the labels of "Animal Welfare", "Food Safety", and "Traceability". Now I will explain what these labels stand for.
    - The Green "Food Safety" label means that "we know that the X in this package was processed in a X farm federally inspected by the Norwegian Food Inspection Agency. This label also means that the

processing plant follows a food safety program that is above the standard, even if they are federally inspected”.

- The Orange “Animal Welfare” label means that “information is available on certain *enhanced* processes and procedures used to produce this package of X, and this is over and above what one would know from typical X products (e.g., this **X** product has extra assurances that the X was raised in a state-of-the-art facility, the X was fed high-quality feed and was processed in a low-stress environment—this is part of humane animal treatment)”.
- The Blue “Traceability” label means that “this package of X can be traced back to the specific X farm on which the X was raised”.
    - All of this information regarding labels is available in the chat if you wish to read them over again.
- On the way to the checkout, there is an auction taking place where you have the chance to bid on a packet of X that has been processed on blockchain technology. This means that information regarding “Animal Welfare”, “Food Safety”, and “Traceability” and more, is available to be seen through the QR code attached to the product. The information on this code can be seen by holding the camera of your phone up to the QR code, and following the website link that pops up.

Please take a second to look at the product that is up for auction and send us a direct chat with the word “Done” when you are ready to continue.

In order to exchange the packet you are holding with the packet up for auction, you will be bidding against the other participants in this Zoom meeting. There will be 10 rounds of bidding, however only one of these rounds will be considered as the binding auction. This means that any of the 10 rounds can be chosen as the winner. The round to be chosen as binding will be decided at the end of the process through a random draw. This means that what you bid each round should be what you are truly willing to pay as the difference between your product and the one on offer. If you win the bid, you will be asked to pay the amount of the second highest bid and not your actual bid price. Before each round begins we will tell you the value of the second highest bid of the previous round. You are allowed to bid under, the same, or over the starting price if you so wish. When you bid please put the amount in terms of the total value: for instance if you believe the product up for auction is more valuable than your current package by 5 Kroner, you would bid the amount of U+5 Kroner.

Each round you will be asked to write down the amount of your bid. You will send this to us through the direct chat function, and after being recorded, the second highest bid price will be told to everyone. After this, the second round of bidding will begin. The process will be repeated until all 10 rounds of bidding are completed. After the experimental auction is completed, we will send you all a link to the short survey that you need to fill out.

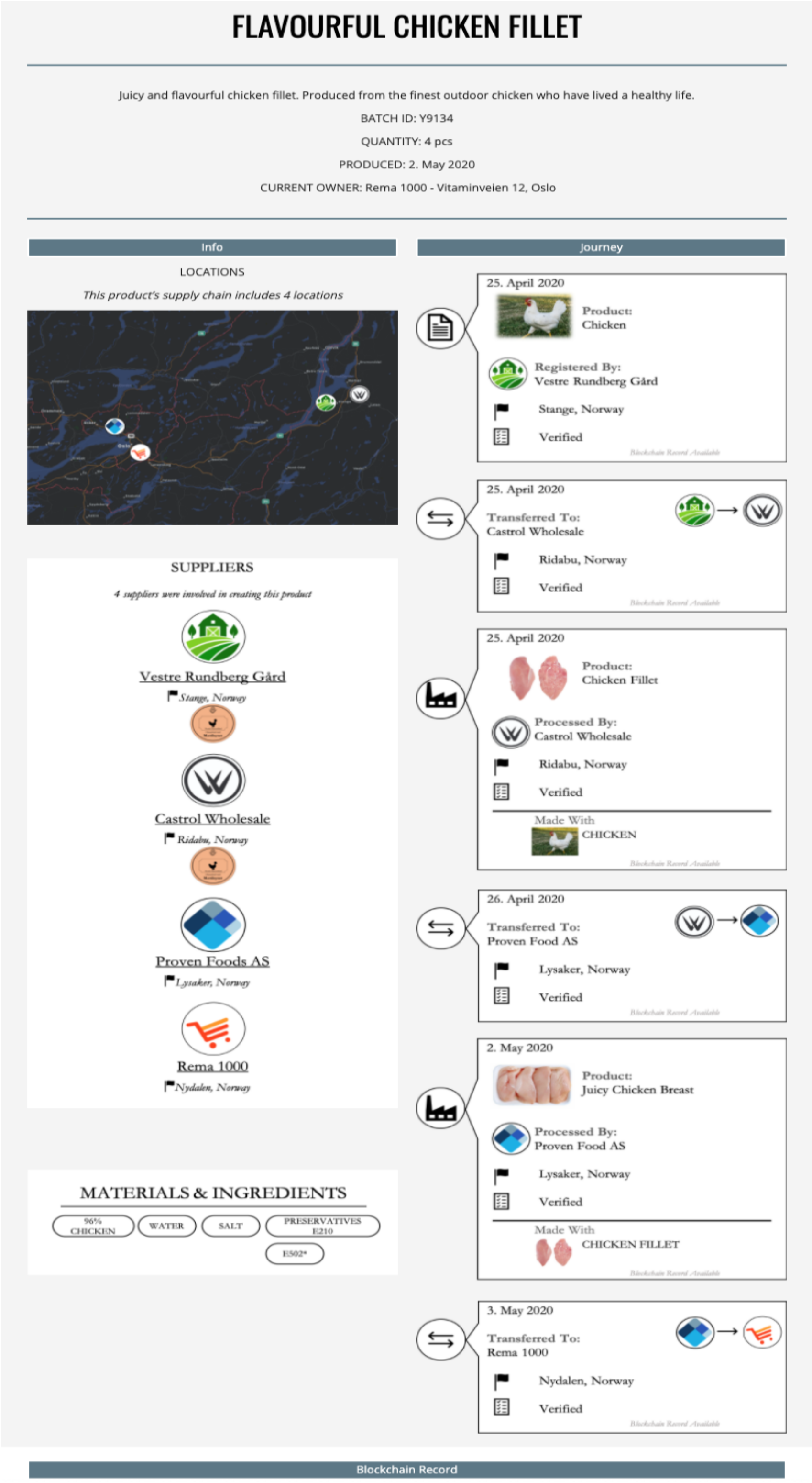
Appendix E

Web Pages

Pork URL: https://sites.google.com/view/provenfoodaspork/home

Fish URL: https://sites.google.com/view/provenfoodasfish/home

Chicken URL: https://sites.google.com/view/proven-food-as/home



Appendix F

Auction Scores - Example

	Rounds											
	Market Price	Market Price	Market Price	Market Price	Market Price	Market Price	Market Price	Market Price	Market Price	Market Price		
	XX	65	65	60	60	61	65	60	65	61		
Participant	1	2	3	4	5	6	7	8	9	10	Avg all rounds	Avg last 5
1	48	50	55	50	50	50	50	50	50	50	50.3	50
2	48	55	60	63	64	65	67	68	69	70	62.9	67.8
3	46	50	50	50	50	50	50	55	55	55	51.1	53
4	50	50	50	50	50	50	50	50	50	50	50	50
5	55	55	55	55	55	55	55	55	55	55	55	55
6	46	50	50	50	49	49	50	50	50	55	49.9	50.8
7	56	56	58	58	56	57	57	57	58	62	57.5	58.2
8	46	55	55	56	55	58	60	60	60	62	56.7	60
9	65	65	55	55	60	55	57	60	60	59	59.1	58.2
10	52	52	52	52	52	65	52	65	52	65	55.9	59.8
11	50	50	50	47	47	47	48	50	50	55	49.4	50
12	60	60	59	55	59	57	59	58	61	60	58.8	59
13	65	65	65	57	55	58	59	58	59	59	60	58.6
14	56	56	56	51	51	51	51	51	51	51	52.5	51
15	46	60	60	60	61	62	60	60	60	60	58.9	60.4
SUM	789	829	830	809	814	829	825	847	840	868		
Scores	53.93333333	56.06666667	56.36666667	56	56.46666667	57.1	56.8	57.76666667	57.43333333	58.4		
Round						6	7	8	9	10		
Starting Price						46				46		

Appendix G

Post Experiment Survey

Question	Measurement	Level
Please write your group number	**Free-Text**	Nominal
Please write your participant number	**Free-Text**	Nominal
What is your gender?	**1-3:** Male, Female, Do not wish to disclose	Nominal
Please enter your age.	**Free-Text**	Ratio
What is the highest degree or level of education you have completed?	**1-5:** Less than high school, High school graduate, Undergraduate degree, Masters degree, Doctorate	Ordinal
What is your current annual income? (NOK)	**1-5:** <100,000, 100,000-300,000, 300,000-500,000, 500,000-700,000, >700,000	Ordinal
Have you or a close family member ever experienced food poisoning?	**Binominal:** Yes, No	Nominal
How severe was the experience with food poisoning?	**1-5:** Not severe, A little severe, Moderately severe, Severe, Very severe	Ordinal
In the last 6 months, how many news articles/reports have you read or heard regarding foodborne diseases?	**1-5:** <10, 11-20, 21-30, 31-40, >40	Ordinal

How much confidence do you have in the Norwegian food inspection and safety authorities?	**1-5:** No confidence, A little confidence, A moderate amount of confidence, a lot of confidence, a great deal of confidence	Ordinal
How much do you value additional assurances about food safety?	**1-5:** Do not value, Value a little, Value a moderate amount, Value a lot, Highly value	Ordinal
How much do you value knowing the exact farm that produced the animal?	**1-5:** Do not value, Value a little, Value a moderate amount, Value a lot, Highly value	Ordinal
How much do you value knowing the processes used by farmers to produce the animal?	**1-5:** Do not value, Value a little, Value a moderate amount, Value a lot, Highly value	Ordinal
Have you heard of blockchain technology?	**Binominal:** Yes, No	Nominal
In the last 6 months, how many news articles/reports have you read or heard regarding blockchain?	**1-5:** 0, 1-10, 11-20, 21-30, >30	Ordinal
Have you read or heard of the use of blockchain in the food industry, prior to the experiment?	**Binominal:** Yes, No	Nominal
How much confidence do you have in your knowledge of blockchain technology?	**1-5:** No confidence, A little confidence, A moderate amount of confidence, a lot of confidence, a great deal of confidence	Ordinal
How much confidence do you have in blockchain technology in the food industry?	**1-5:** No confidence, A little confidence, A moderate amount of confidence, a lot of confidence, a great deal of confidence	Ordinal