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Improvement of C5.0 algorithm using internet of things with Bayesian principles for food traceability systems

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Abstract

Purpose – The purpose of the food traceability is used to retain the good quality of raw material supply, diminish the loss and reduced system complexity.

Design/methodology/approach – The proposed hybrid algorithm is for food traceability to make accurate predictions and enhanced period data. The operation of the internet of things is addressed to track and trace the food quality to check the data acquired from manufacturers and consumers.

Findings – In order to survive with the existing financial circumstances and the development of global food supply chain, the authors propose efficient food traceability techniques using the internet of things and obtain a solution for data prediction.

Originality/value – The operation of the internet of things is addressed to track and trace the food quality to check the data acquired from manufacturers and consumers. The experimental analysis depicts that proposed algorithm has high accuracy rate, less execution time and error rate.

Keywords Food supply chain, Traceability, Food safety, Internet of things, C5.0, Bayesian posterior theory, Bayes theorem, Verification strategies

Paper type Research paper

1. Introduction

For the past decade, food is the primary energy resource of human civilization and its quality and safety has been a major issue throughout the world especially in China for several causes (Liu *et al.*, 2016). For example, the event of 2008, the embarrassment of Sanlu melamine milk powder, has staggered humanity because of its effects on thousands of babies, resulting in the deaths of many of them (Wen *et al.*, 2018). Another event that shocked Chinese society and humanity occurred in 2011, when the Shuanghui assembly's animal protein which is the China's largest meat supplier was exposed to carrying a drug named Clenbuterol hydrochloride that is forbidden from injecting into food substances in China (Lin *et al.*, 2019a) (Abad *et al.*, 2009). Therefore, it is very important to expand technologies to ensure food safety for entire food supply chain (FSC) includes manufacture, processing, warehouse, shipping, storage and distribution.

To deal these issues from a technical perspective, people need a system of food traceability, which is capable of monitoring the complete life of food cycle including the

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production, processing, transport, storage and sales of foodstuffs (Lin *et al.*, 2019b), which involve numerous untrustworthy issues. More studies around the globe have been carried out with the introduction of several technologies such as the internet of things (IoT) to help the food user recognise food quality and safety concerns (Li *et al.*, 2019). IoT is an idea to tie the whole thing around the time to time, and it's expected to change the importance of our human life dramatically in the future (Liang *et al.*, 2019). IoT technologies should be capable of providing possible solutions for identifying traceability, tracking and manageability concerns for FSC. IoT will take part in the task of deciding the problems of food quality and safety in terms of monitoring the nutrient value of each product, throughout its lifetime and also providing functional information to make it easier and more secure (Tolba and Altameem, 1331).

Sensors are capable of boosting an IoT's anxiety and other parameters (Tsang *et al.*, 2019). The environmental conditions of the food traceability system are evaluated using sensors with cost-reduced techniques based on an economical background and quick communication with the system. Connectivity has been made within Transport Systems, Agriculture, Energy Use, Security and Privacy, Building Management, Embedded Systems, Industry Systems (Etim and Lota, 2016), Pervasive Computing, Smart Home (Feng *et al.*, 2017) and Applications for Health Care (Riazul Islam *et al.*, 2015). When the volume of knowledge obtained from a number of IoT device increases, big data processing and monitoring remain a significant problem for IoT applications. While big data will usually be assisted by data compression methodologies, the likelihood is that compression would minimize an unnecessary volume of data (Xiao *et al.*, 2018).

Big data is data collected from mobile Internet communication devices, social networking, video sharing, IoT sensors and smart devices, and so on. Big data consists of a wide-ranging collection of datasets, primarily in the definition of information for research, manipulation and effective storage, which are the scalable specifications of the architecture (Chen *et al.*, 2015). The sensors scattered across the globe and the precise tools that operate on the system. Once these machines are exposed, a large volume of data is transferred to a centralized storage place for end. The right decision to interpret such data in real-time requirements was taken on the basis of an objective obsession (Wang *et al.*, 2020). To make the best choices about individuals and issues using data mining methodologies and machine learning techniques, it allows making the best decisions. The IoT that infuse large quantities of knowledge needed to be explored with application parameters will be processed and disseminated in order to provide access to reliable, usable and bug-free details for the purposes of data analysis of the right decision and avoiding problems (Tran *et al.*, 2012).

Traceability is part of public security and sustainable development (Chen *et al.*, 2019). The main measure of food-related management is the operation of the entire supply chain. If any problems arise in the production of food safety, they can be easily identified by effective management (Liu *et al.*, 2019).

The prime contribution of the paper is

(1) Construction of cost-effective methodologies for the management of the FSC from manufacturer to customer, facilitating and updating any abnormal food condition.

(2) The manufacturing cycle is sustained by supplying sufficient data and confirmation to all customers.

(3) Guaranteed information retrieval device the data inside communications and applications to prevent unnecessary details that would impact the comfort of the consumer and even economic development.

The rest of the paper is organized as Section 2 demonstrates the Related Works, Section 3 presents the proposed work, Section 4 presents the performance evaluation, and finally the conclusion of the paper.

2. Background and related work

Every state of the food supply chain management system has been conceded and demonstrated meticulously to improve the safety of the food. HACCP is an anticipatory methodology to remove the chemical contents in the production system (Food Safety Management Sy, 2014). The Internet of Vehicle is introduced to communicate the vehicles in real-time using the sensor network with a wide communication range. The related software is used to implement connectivity (Ryan, 2014). A methodology (Borthakur *et al.*, 2017) is implemented to represent the relationship between big data and business analytic. The smart environment evolved which consist of transmitting the data onto the smart network of IoT. For getting the right decision, decision-making model used on the data gathered from (IoT) devices by the business analytic. Conclude that the data analytic in a business field gives the right decision at the right time. Moreover, it is a successful key in business.

The innovative method (Alam *et al.*, 2016) is used to demonstrate a complete review of the use of the C5.0 algorithm for clinical speech data. Analysing the data obtained by smart devices, the C5.0 quantitative algorithm used is focused on the foggy design of smart devices. This showed the potential of massive data to carry out work in the field of smart media apps. Effects and skill of algorithms focused on data mining techniques. The ID3 and C4.5 archive enhanced performance, mostly through increased memory capacity and high operation. At the end of the process, ANN and DLANN show the highest accuracy by modelling high-level data abstraction but are computationally expensive (Meidan *et al.*, 2017). In order to identify approved machines, IoT system data has been used as a differential effect on machine learning algorithms. Random prediction refers to the analysis of network traffic data collection functions. The inventory is defined in order to specifically monitor IoT products and multi-class classifiers tested for each category of class. The optimal description of the particulars is recorded as the most reliable result (Singh and Gupta, 2014).

Discussions were held on the problems and methods of the comparative study of three classification algorithms. In comparison, various data sets are included in this analysis from UCL data set repositories. Experiment tests database, C5.0 algorithm has increased performance in all cases (HSSINA *et al.*, 2014). A new significant attribute introduced by a filter that characterizes the decision defined for each instance by a quantified classification algorithm (Patil *et al.*, 2012). Whether the classification algorithm is built from an initial batch of results or the comparison is a sequentially categorized model file to be used instead. Mathematically, the filter is a special subset of a partially well-arranged set. Filter is invoked for converging while its lower limit is low and its upper limit is high (Kaur *et al.*, 2015). C5.0 is a decision type used for exploratory data processing of the gathered knowledge. C5.0 is a probabilistic modelling technique and a fairly significant volume of knowledge is used in data mining (Krishnan *et al.*, 2020). The purpose of this algorithm is to detect the amount of collections given by the parameter itself, the data set.

FSC has been used to minimize the wastage of foods in developed countries. The impact of utilizing the environmental aspects provides the resource utilization in effective manner. The life cycle management has been utilized to assess the environmental and customer satisfaction in real-time scenario (Carino *et al.*, 2020). The economic aspects of food service has been improved using the FSC, it will also help the patients for utilizing the enhanced food safety. The appraisal tool has been used to identify the quality of appraisal from Environmental Science and Evaluation Databases (Kay and Janssen, 2019). Traceability in FSC has been used to deliver the high quality of food globally in complex situations.

Blockchain concept has been implemented to provide the traceability in FSC with trust. The boundaries are identified to categorize the quality of traceability to effective independent governance (Xu *et al.*, 2020). Security in the Eco system has been maintained by utilizing the natural resources and food management. The food supply networks may cover the food components and to maintain the eco system with safety. The optimized mathematical modelling has been generated to utilize the IoT (Abid HaleemKhan and Khan, 2019). The FSC with the traceability functionality has been developed to maintain the confidence to the customer. The grey related methodology is utilized to identify the relationship with the customers and supply chain management (Gu *et al.*, 2017).

The rest of this section will review the related work on different methods, technologies and applications for smart FSC and IoT.

The new method was developed using Material Conscious and Information Network (MCIN)-based smart agriculture architecture, which is different from the current vertical architecture and includes development, management and commerce (Kaur, 2016). This architecture was used for enhances current agriculture and stimulates a lot in the electronic commerce combined with production-marketing. The realization of IoT in the field of agriculture and food, including a comprehensive review of its implementation structure, considerations and implications is arrived. The result shows that using IoT in fields and orchards can help farmers reap the benefits of their multiplicity of technology (). Many researchers surveyed several traditional Agriculture IoT Sensor Monitoring Network innovations using the backbone of cloud computing. This shows precision farming sensor monitoring network is widely used to measure agro-related information such as temperature, humidity, soil pH, soil nutrition, water level, etc. so IoT farmers can monitor their crop and equipment remotely by phones and computers (Cambra *et al.*, 2017).

The design of a smart IoT communication system that would be used as a low cost controller and novel fuzzy computational algorithm for smart IoT irrigation systems. All data collected from the microcontroller for statistical information and processing are sent to a cloud database (Kokkonis *et al.*, 2017; Kinjal *et al.*, 2018). The new application was developed in the field of IoT, called “Smart Irrigation Analysis,” which provides the end-user with remote field irrigation analysis that is better than traditional field crop irrigation. Cloud data is analysed, and irrigation-related graph report is made for future use by farmers to determine which crop to sown (Hsu *et al.*, 2008).

Traceability is very important for ensuring food safety for consumers within the FSC. In recent years many solutions have been proposed with different emerging ICT technology to improve the traceability of animals, plants, and food products. A traceability system enabled by RFID for the supply chain of live fish is managed and system has been implemented and deployed for trial in the Live Fish logistics centre, and the results are valuable for practical reference (Tian, 2016). It also proposed a traceability system for the agro-food, using RFID (Radio-Frequency IDentification) and Blockchain technology. He analysed the advantages and disadvantages of using RFID and Blockchain technology in the construction of the traceability system for the agro-food, and demonstrated this system’s construction process (Zinas *et al.*, 2017).

In new innovation and implementation to open source IoT for the monitoring of cows using LoRaWAN architecture for long-range communication and studied that system architecture of high-level cattle tracking systems (Carbone *et al.*, 2018). It also proposed a new approach that would lead to trusted cooperative applications and services within the agro-food chains. They used Blockchain to enhance transparency, information flow and management capacity, allowing farmers to better interact with other parts of the supply chain, particularly the consumer. Through proposing new food-on-demand model, they think the research will provide better performance value chains (https://catalog.data.gov/dataset/nyserda-new-york-offshore-wind-supply-chain-dataset-9b665).

3. Proposed work

3.1 System model

Figure 1 demonstrates the Food traceability from the manufacturer to the features of the customer and the mutual methodology for the food traceability method. The track is mentioned that the farmers connected with the manufacturers and transport regulation play an important role to establish food traceability. The distribution endeavours are used to transform the things to the retail endeavours and finally the customer, this process is called as Backtracking. Tracking and backtracking procedures have been travelled in a simultaneous way to form food traceability. For people's wellbeing and social security and growth, food traceability plays an extremely rare role. It is an essential indicator of risk management for food safety and an efficient technology to monitor the whole supply chain. If there is a food safety processing concern that can be traced back to the source, the issue and successful governance can be established. The food safety traceability scheme not only involves the recording and tracking of agriculture from birth to the slaughterhouse feeding process (feeding and control, disease prevention, treatment), but also includes food items on the customer market (supermarket), customers can question food products breeding, slaughtering, harvesting , processing via any food specific identification code.

Sensors have the capability to improve the apprehension of an IoT and several associated parameters. Food traceability system the environmental conditions are evaluated using the sensors with cost reduced techniques based on economical computer board and fast communication with the system. The connectivity has been done within the Transport systems, agriculture sector, Energy utilization, Security and Privacy, Management of Building, Embedded systems, Wireless systems, Pervasive computing, Wireless Sensor network, Smart cities and healthcare applications.

Traceability and environment detection are the two vital parameters for food-related supply chain management. The traceability of FSC system is to maintain the confidence for the customer regarding the quality. The production unit is produced the product based on the customer needs.

To achieve the goal, several standards are developed. They are

(1) Sensors with tiny, minimized cost, and easy to handle.

(2) Bleakness and easily movable.

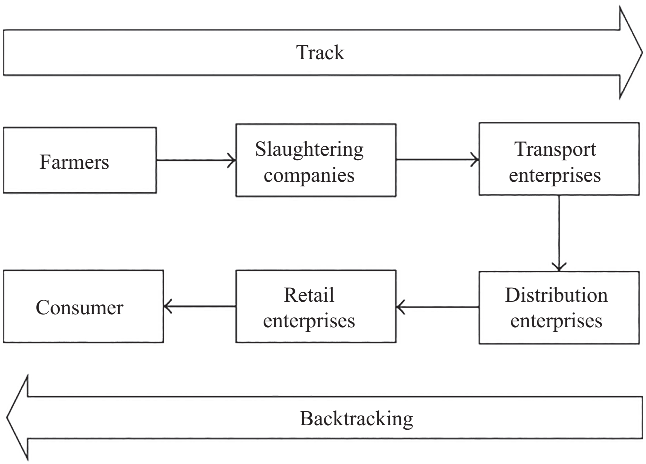

Figure 1.
Procedure for food traceability

(3) A minimum amount of persistence.

(4) Comfort and Consistent data.

(5) Consists of the data about the product set and available resources.

(6) Permanent monitoring system for food traceability.

(7) Ensure the decision indication.

(8) Storing the data about the procedure of the production system and the communication way to other systems.

(9) Transmit the output to the communication system they only the data are viewed in the presented format.

(10) Enhanced system to eliminate the vulnerability in this food traceability system.

The Enterprise Resource Planning system is combined with IoT to share the data related to the FSC. The IoT framework is responsible for connecting within the users and the supply chain devices. The entire process is demonstrated in Figure 2.

3.2 Enhanced C5.0 Bayesian network
Initially, we require keeping the study for traceability of the entire simulation of the FSC and scheming the entire improvement. If the C5.0 classifier and Bayesian theory are joint, it can outcome in an efficient tree generation, pruning and optimization algorithm, which can be accepted to produce very close-optimal decision trees. This paper proposes an algorithm that adopts the C5.0 as the classifier and uses the post-pruning step of Bayesian posterior theory as a precision enhancer. Figure 3 demonstrates the cycle which will be followed by the proposed algorithm to generate, prune and optimize the decision tree.

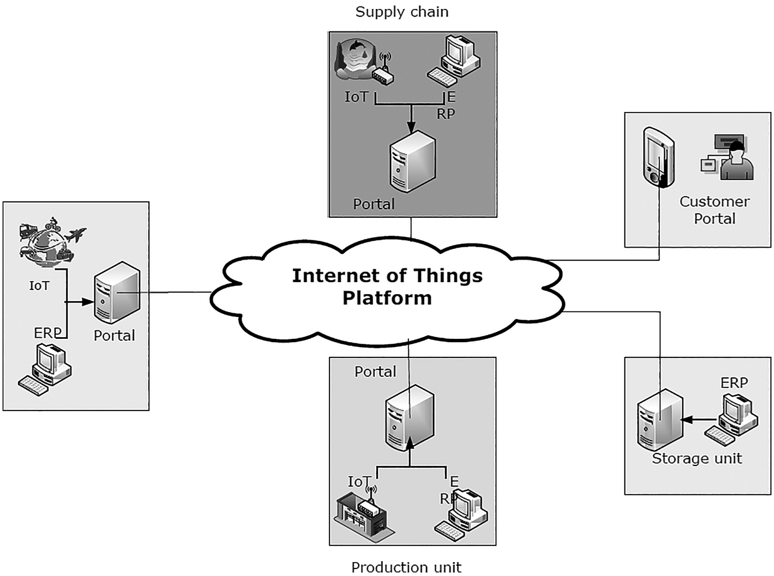

Figure 2.
Architecture for food based internet of things

There is some information gain associated with the attributes associated with every record in the training data collection. The C5.0 classifier operates by extracting the attribute with the highest gain of knowledge and is using this area of attributes as the dividing factor. To generate multiple subsets, this function is done recursively. Ultimately, a tree-like structure is created which follows structural hierarchy to enforce the training set classification. Fundamentally, splitting requirements are required for proposed algorithms to break a node into a tree structure.

Entropy analysis is used to determine a food node's degradation. It is specified as: (for values of a class)

$$\text{Entropy}(t) = -\sum p(i/t)\log 2\, p(i/t) \tag{1}$$

Gini Index is the calculation of the difference between the probability distributions of the FSC, the values of the food attribute is different from that of impurity and is defined as:

$$\text{Gini Index} = 1 - \sum [p(i/t)]2 \tag{2}$$

Classification Error: is computed as:

$$\text{Classification error}(t) = 1 - \max[p\ \ (i/t)] \tag{3}$$

where, p (I / t) at a specified node t denotes the fraction of records belonging to class i.

Information gain is a variable based on impurity that utilizes entropy calculations as the impurity quantifies. It's the differentiation between manufacturer entropy and consumer entropy.

$$\text{Info Gain} = \text{Entropy}(\text{manufacturer}) - \text{entropy}(\text{consumer}) \tag{4}$$

The benefit ratio "normalizes" the advantage of information as follows

$$\text{Advantage Ratio} = \text{Information Gain for food system}/\text{Entropy} \tag{5}$$

Impurity metrics such as entropy and Gini Index are likely to support various food attributes of dissimilar values. Then Gain Ratio is determined which is used to evaluate the food quality of a break. According to their function and type properties, each splitting criterion has its keep analysis and rule.

The Gini Index will face problems with food safety when the target food attribute domain is relatively broad. In this scenario, differential requirement named towing criteria may be employed. We describe this requirement as:

$$\text{Towing Criteria}(t) = \text{PLPR}\left(\sum (|p(i/tL) - p(i/tR)|)\right) \tag{6}$$

At the present, it is an opportunity to put a reference to the principle of the Bayes, which is, among the features, self-determination. So now, we are splitting proof into the new parts. Now

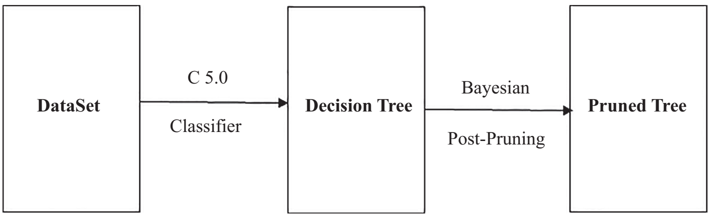

Figure 3.
Operational view of algorithm

if these two X and Y incidents are separate

$$P(X, Y) = P(X)P(Y) \tag{7}$$

Consequently, we enter the result:

$$P(y|(x1, x2\ldots, xn)) = P(x1|y)P(x2|y)\ldots P(xn|y)P(y)/P(x1)P(x2)\ldots P(xn) \tag{8}$$

this can be translated as

$$P(y|(x1, x2\ldots, xn)) = P(y)\prod_{i=1}^{n} P(xi|y) \Big/ P(x1)P(x2)\ldots P(xn) \tag{9}$$

Now, as the denominator for a given effort leaves constant, we can remove that term:

$$P(y|(x1, x2\ldots, xn)) \propto P(y)\prod_{i=1}^{n} P(xi|y) \tag{10}$$

Now, for all potential ideals of the class variable y, we need to build a food model to discover the probability of recognized place of inputs and desire the yield with the highest probability. That can be scientifically articulated as:

$$y = \mathrm{argmax}y\, P(y)\prod_{i=1}^{n} P(xi|y) \tag{11}$$

Finally, the assignment of manipulative $P(y)$ and $P(xi)$ where $P(y)$ is also called probability of class and $P(xi)$ is called probability of condition. The dissimilar Bayesian networks diverge largely from the recommendation they make regarding the $P(xi)$ distribution.

A Bayesian network is two-way methods of thinking that inputs (manufacturer) will compute output (consumers) and vice versa. The understood values of food nodes, the organization analyses the potential distribution of objective nodes to predict what is needed for food or to determine the likely reasons of big generated products. The investigation of observation is the significant source of decision making. It can set the unreliable that has the most consumer preference control. It implies that if distribution from the changeable is large, consumers are additionally likely to obtain. Shared data is a dependency function between 2 random variables and is ideal for forecasting the food data for the Bayesian network. It is the decrease in uncertainty attributed to meaningfulness, and vice versa. The shared data is between 2 variables and is given by:

$$D(A, B) = \sum_{a,b} p(A, B)\log\frac{P(A, B)}{P(A)P(B)} \tag{12}$$

where $P(A, B)$ is the object of the joint probability distribution, $P(A)$ and $P(B)$ are the boundaries of the A and B probability distribution functions respectively. $D(A,B)$ implements abuse of A on B. The well-constructed the significance of the is $D(A,B)$, the stronger the influence of A on B. Then the volatile result would be rank wise based on the value of $D(A,B)$. And the element that has the upper priority role should be given extra focus and order of the produce process in real time. Create a food prediction model to determine the likelihood of reported input location for all possible class vector y values, and wish the yield with maximum probability. This can be objectively described as:

$$B = \mathrm{argmax}y\, P(B)\prod_{i=1}^{n} P(Ai|B) \tag{13}$$

To establish that the attribute tuple X from the classification regulation matches one of the class mark attributes $(R1, R2\ldots Rn)$, we need to prove that A belongs to Rx. It is possible if and only if

$$P(Ra|X) > P(Ri|X) 1 \leq i \leq n,\ i \neq a$$

Calculating all class mark attributes probabilities $P(Rk)$ and probability of $P(X|Rk)$:

$$P(Rk) = |Rk,\ D|/|D|,\ \text{where}\ k = 1,\ 2,\ \ldots i \tag{14}$$

where's ($k = 1,\ldots,n$) is the class mark attribute having n kinds of different classes that define n kind of different classes, Rk, D is a set of tuples that belongs to class Rk in training set D, $|D|$ is the number of training set D, $|Rk, D|$ is the number of Rk,D. The value of $P(X|Ra)$ can be calculated with the help of data set D.

Using Bayes theory,

$$P(Ra/X) = P(X/Ra)^{*}P(Rx)/P(A) \tag{15}$$

Attribute tuple A can be classified into class Sx only if the value of $P(X|Ra)$ is maximum. This means that this branch should not be pruned. If this condition is not true, then the branch should be pruned.

The Bayesian network can entirely illustrate the replacement of conditional probability to logic gate. The application of conditional probability method can make full use of the historical data and the prior probability of food traceability to improve the accuracy of data. Using Bayesian network quantitative methods to analyse the performance of C5.0 is more helpful to analyse the food contamination in the actual operation while conducting in-depth research on the influencing factors and risk transmission links of its operation mechanism and traceability. Some reasonable suggestions are put forward to solve the problems such as unbalanced supply and demand of fresh agricultural products, and difficulties in continuous supply under seasonal consumption peaks or emergency management conditions caused by information asymmetry, natural disasters, food safety, etc.

This paper suggests a hierarchical technique called the C5.0 Bayesian Network which enables determined sets of their entity to be combined with other distinct ones. Although this attributes has not been accepted in the IoT data logic region, we have developed it and make it possible to improve the quality of the product in Figure 4. Enhanced C5.0 Bayesian model for the phase of the food supply chain management is typical of the analytical approach for incremental production.

C5.0 BN is a high-accuracy classification method by combining decision tree and Bayes theorem together. It uses averaged global accuracy as the measurement of goodness in the induction process of the tree structure, and chooses the local classifier that is most specific for the target instance to make the decision. It mainly introduces a pruning strategy based on local accuracy estimation. Instead of directly using the most specific local classifier (mostly the classifier in a leaf node) to making classification in C5.0 BN, our pruning strategy uses the measurement of local accuracy to guide the selection of local classifier for decision.

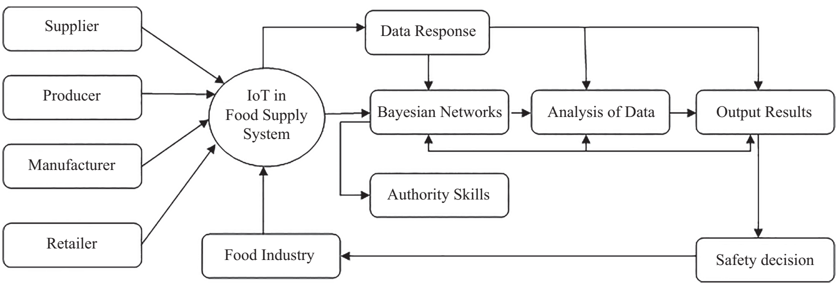

Figure 4.
Analytical approach based on Bayesian in FSC

3.2.1 Enhanced C5.0 Bayesian modelling algorithm. The C5.0 BN is a novel development of Bayesian Network Algorithms focused on decision trees and constructed from a directory of conditional possible attributes and testing case location, and then the decision trees may be used to identify subsequent test case sets. C5.0 BN has been extended as an improved version of a respected and commonly used C4.5 classifier, and has many important factors over its predecessor. C5.0 BN is the categorization algorithm that is suitable for very large data set. On time of execution, contrast of performance, and precision-recall, it is higher than C4.5. The C5.0BN model works by dividing data on food quality training and gives full impact. C5.0 BN actually includes further attributes and omits attributes from the set of data on food quality preparation.

The training quality data is used in this paper to construct C5.0 decision tree when forecasting the research food results. It causes the resulting trees for judgment to be minimized and also the acceptance of numeric attributes, omitted values and noisy data. This produces a threshold in order to hold continuous attributes, and then splits the array into those attribute worth which is more than the threshold which is less than or equivalent to it. C5.0 Bayesian network has formerly formed through the decision tree and attempts to eradicate branches that do not help by replacing them with leaf nodes. This paper enlarges C5.0 classifier accuracy by applying Bayesian post-pruning technique. Using Bayesian posterior theory, the decision tree created by C5.0 is checked and all branches that do not meet the necessary requirements are removed. The following steps describe the proposed algorithm to:

Input: Target Attribute, Example, Attribute

Begin Procedure c5.0BN ()

a. divide $\rightarrow$ tag;

b. divide $:=$ 0;

c. For every $a \in S$

i. $\bar{a} = \text{pre\_regions}(a);$

d. If closure $(\bar{a}) \neq 0$ then

i. divide (a);

ii. divide $:=$ 1;

e. End if

f. connect.process $\rightarrow$ connect.controller;

g. process.start $\rightarrow$ complete;

h. If connect.controller $\neq$ complete then

i. shift.process;

i. End if

j. connect.process $\rightarrow$ unification;

k. Evaluate(result);

l. End for

m. End Procedure

Output: A tree of post-pruned decisions.

3.3 Splitting formation

C5.0 uses the splitting variable for maximizes the gain ratio. When tracing the path from the root node (manufacturer) to a particular leaf node (consumer), a set of rules can be established which condition path is used. In this way, traversing all the leaf nodes produces a rule collection, which is a textual description of the decision tree was created. The C5.0 algorithm is as follows;

Input: Target Attribute, Example, Attribute

Step 1: Analyse the reference cases.

Step 2: Use the training data to create a decision tree.

Step 3: Choose the highest information gain value.

Step 4: Using the decision tree to decide its class for each element in the dataset, since the application of a given tuple to a decision tree is relatively straightforward.

Output: A decision tree.

3.4 Calculating the probabilities for food traceability management

Traceability is a key pillar in providing a perception of safety. Further, in terms of firm behaviour, the cost of penalties (e.g. infringement notices, prohibition, seizure, and plant closure), loss of reputation or prestige, and the probability of detecting unsafe food (e.g. food-borne illness surveillance) improves the cost-benefit equation for traceability systems.

At the moment, it's time to set a food data assumption to the Bayes' theorem, which is, independence among the food attributes. So now, we divide evidence into the independent parts.

Now, if any two events X and Y are independent, then

$$P(X,\ Y) = P(X)P(Y) \tag{16}$$

Hence, we reach to the result:

$$P(y|(x1,\ x2\ldots, xn)) = \frac{P(x1|y)P(x2|y)\ldots P(xn|y)P(y)}{P(x1)P(x2)\ldots P(xn)} \tag{17}$$

this can be expressed as:

$$P(y|(x1,\ x2\ldots,\ xn)) = \frac{P(y)\prod_{i=1}^{n} P(xi|y)}{P(x1)P(x2)\ldots\ P(xn)} \tag{18}$$

Now, as the denominator remains constant for a given input, we can remove that term:

$$P(y|(x1,\ x2\ldots,\ xn)) \propto P(y)\prod_{i=1}^{n} P(xi|y) \tag{19}$$

Now, we require building a decision classifier to find the probability of known set of inputs for all possible values of the class variable y and choose up the output with maximum probability. This can be expressed mathematically as:

$$y = \text{argmax}y\, P(y)\prod_{i=1}^{n} P(xi|y) \tag{20}$$

So, finally, the mission of calculating $P(y)$ and $P(xi \mid y)$ where $P(y)$ is also called class probability and $P(xi \mid y)$ is called conditional probability. The different naive Bayes classifiers differ mainly by the hypothesis they make concerning the distribution of $P(xi \mid y)$.

3.5 Bayesian classifier influences food traceability management

Food monitoring issues at manufacturing is focussed to defect tracking process, a form based on Bayesian Network investigation is a useful implement to examine this dilemma. The BN associations are created by the device which is collected data from the sensor. In the verification that there is no contamination found in transportation makes the Chemical Contamination2 independent of the Biological Contamination1. This confirmation made from the concept of Markov chain of the Biological Contamination1 affect the producer, dealer and shopkeeper nodes. Using Bayesian rule, capable of not only to examine and approximation the probable origin of food defect, also to recognize opportunity of contamination extend such as Biological Contamination2 and Biological Contamination3 are shown in Figure 5.

3.6 Food quality monitoring procedure

Irrespective of the development of an automated approach for the FSC information system, the container is linked to the CPU and the temperature and humidity of the sensors are regarded. The most significant use of the proposed research is to develop the auxiliary sensors with the constriction of the related instruments. The complete system is user friendly with the barcode reader apps, and the Bluetooth is attached to RFID. Web-related services are provided with the Web and GSM. The sensor is responsible for identifying the variation of contact between RFIDs. Each time the car rotates, the sensor inspects the RFID data. After inspecting the obtainable data, the Monitoring system may review the information.

The safety system locates the connectivity to the database by classifying the essential constraints for the sensor dimension. To observe the system, the IoT data is used for monitoring the food products. The image for the management of food traceability in real time is updated to ensure that the commodity is defect or not. Using the self-governing power system, the entire system is motorised. The suggested research is used with the corresponding freight framework, using the sensor networks.

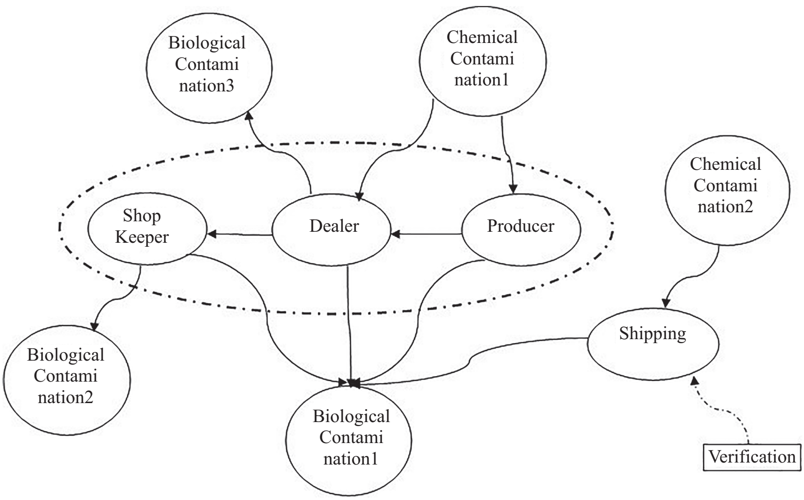

Figure 5. Traceability with Bayesian network

4. Performance evaluation

In this section, we discuss the steps of the study and the experimental to get the result. The data was collected by applying industrial Dem and J Response (DR) by the IoT. Data is for facility energy management systems. This can be used for academic purpose. NYSERDA supply chain Dataset [44] is used for the performance evaluation. The proposed model is trained using the classifier and the training dataset has the parameters of variable selection and validation process. It is used to produce the efficient result. It contains 16,382 instances which split into two parts train 11,467 and test 4,914 and includes 7 attributes itemized below:

Demand_Response {Numeric} , area {Numeric}, season {Numeric}, energy {Numeric}, cost {Numeric}, pair_no {Numeric} and distance {Numeric} (Figure 8).

The dataset is divided into training and testing sets. The proposed C5.0 BN is used to implement the training of the dataset and produced the output. The Bayes theorem is used to construct the decision. The simulation parameters are demonstrated in Table 1.

Through the use of RStudio IDE using java programming language, the experimental data is filtered in order to remove the missing or erroneous values generated during the collection of data. The original data was divided by the ratio of 7:3 after the characteristic variables through correlation analysis. The 70% group (Training set) is used to training the decision tree. The remaining 30% group (Test set) is used to verify the tree's classification accuracy. A flow chart for the steps in generating the decision tree is shown in Figure 6.

4.1 Analysis of quality parameters

4.1.1 Accuracy. According to the findings obtained, the quality of the decision tree is significantly improved after execution of the Bayesian Network Classifier with the C5.0

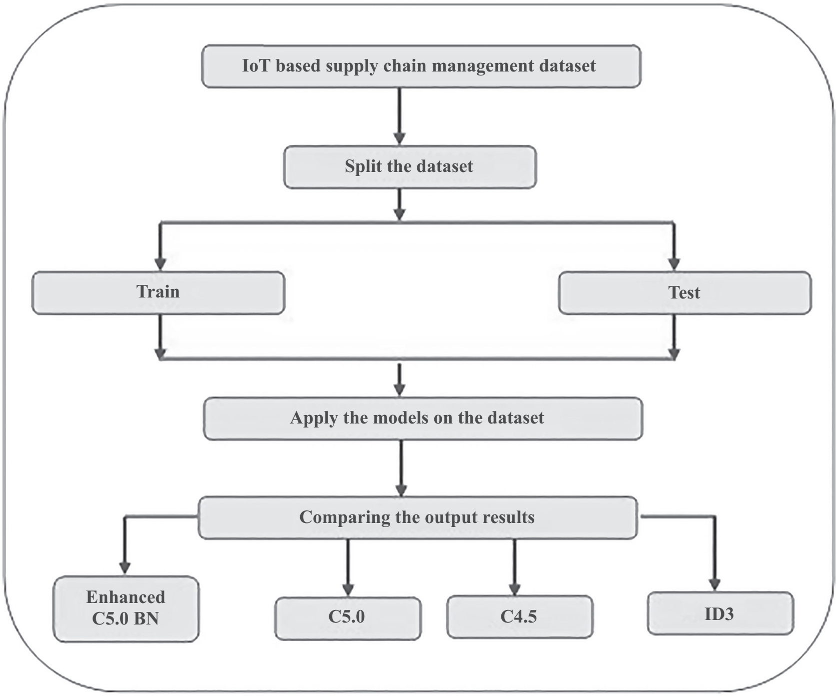

Figure 6.
Steps of work

algorithm. Table 1 and Figure 2 note the accuracy analysis of ID3, C4.5 and C5.0 results and of the proposed C5.0BN algorithm. The accuracy rate of proposed C5.0 BNA algorithm has obviously been improved.

It is conditional from Table 2, that the C5.0 Bayesian Network Algorithm (C5.0 BNA) has highly developed classification accuracy compared to the previous classification algorithms such as the ID3, C4.5 andC5.0 algorithms. The relation of the decision tree classifiers consistency tests is shown in Figure 7.

4.1.2 Memory utilization. Table 3 shows the complete memory representation used by ID3, C4.5 andC5.0 and the suggested C5.0 BNA algorithm, and their comparison. And the relative memory consumption of the proposed C5.0BN and algorithms ID3, C4.5 and C5.0 is provided using Figure 3. According to the findings achieved; the volume of memory usage of the ID3, C4.5 and C5.0 algorithms is larger than the suggested C5.0BN algorithm.

It is tentative from Table 3 that the C5.0 Bayesian Network (C5.0BN) algorithm has limited memory consumption as compared to previous classification algorithms such as the ID3, C4.5 and C5.0 algorithms. The power usage relation for the decision tree classifiers can be seen in Figure 8.

4.1.3 Training time. Based on the results collected, the training time required to approximate the data is greater than the algorithms ID3, C4.5 and C5.0. Thus output of the algorithms ID3, C4.5 and C5.0 is expected in training time stipulations. Using Figure 9, the sum of training time is given. The implemented algorithms were proposed for ID3, C4.5 and C5.0 and for C5.0BN.

It is impermanent from Table 4 that the C5.0 Bayesian Network (C5.0BN) algorithm has better training period than the previous classification algorithms such as the ID3, C4.5 and C5.0 algorithms.

4.1.4 Search time. The relative training period of the proposed algorithm, as well as ID3, C4.5 and C5.0 is shown in Table 5. The suggested C5.0BN takes less time to train the model when tested on the ID3, C4.5 and C5.0 algorithms as it is in performance. The efficiency of the proposed classification algorithm is highly proficient relative to the ID3, C4.5 and C5.0 algorithms, according to the predicted production figures. The comparative search time for algorithms from the decision tree is also given using Figure 10.

It is indicative from Table 5 that the C5.0 Bayesian Network has less search time than previous classification algorithms such as ID3, C4.5 and C5.0. The quest period relation for the decision tree classification is shown in Figure 13.

4.1.5 Error rate. Table 6 shows a comparison of traditional C5.0 algorithm performance and an improved CBN algorithm in error rate. Improved CBN algorithm has been seen to give fewer errors. The proposed percentage error rate and the traditional decision tree algorithm for the C5.0 are given using Figure 11.

It is conditional from Table 6 that the C5.0 Bayesian Network algorithm has a low error rate as compared to previous classification algorithms such as ID3, C4.5 and C5.0 algorithms. The comparison of the measurements of accuracy for the decision tree classifiers is shown in Figure 11.

Research estimates the quality of the FSC that the proposed procedure will have the increased sensitivity according to the original value. Figure 12 illustrates a quality management of the FSC. It mainly uses past data to predict the stipulation of the market, but market demand depends on a range of compound factors, quality of facilities counting, customer groups and government plan.

Figure 13 demonstrates the efficiency of the FSC, it also shows that 4 algorithms are evaluated and the output is determined that the proposed C5.0BN is well evaluated according to the algorithms ID3, CART and C4.5. It is concluded that the C5.0BN performs 1.6 percent better than the C4.5 algorithm, 2.8 percent better than the CART and 5.5 percent better than the ID3 algorithm for correctly classified instances.

The proposed C5.0BN finds the optimum as opposed to all other algorithms in the decision tree during the results analysis. Finally, the C5.0BN is the most accurate classifier compared to any other classification algorithm based on measurements of efficiency, accuracy and error rate and Table 7 shows the overall performance among the four algorithms.

4.2 Implications of the work

The experiments show that C5.0BN performs better in terms of memory consumption, training time, search time, error rate and performance measures than the other algorithms on

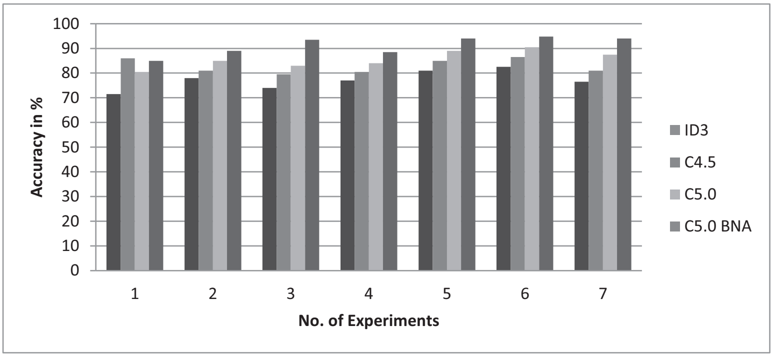

Figure 7.
Comparison of accuracy measure for decision tree algorithms

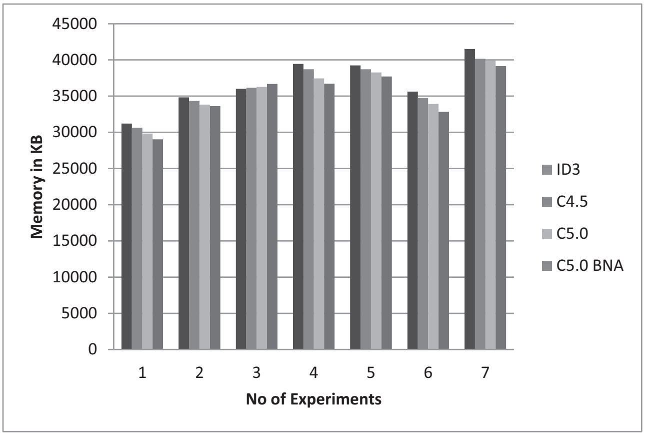

Figure 8.
Comparison of memory consumption for decision tree algorithms

Table 1.
Simulation parameters

Simulation parameter	Meaning
Software	ANYLOGISTIX
Output generator	J Response
Total instances	16,382
Training set	11,467
Testing set	4,915
FSC	1,000
Number of instances	10
Classifier functions	445

Number of experiment	Accuracy of ID3 algorithm (%)	Accuracy of C4.5 algorithm (%)	Accuracy of C5.0 algorithm (%)	Accuracy of C5.0 BNA algorithm (%)
1	71.5%	86%	80.5%	85%
2	78%	81%	85%	89%
3	74%	79.5%	83%	93.5%
4	77%	80.5%	84%	88.5%
5	81%	85%	89%	94%
6	82.5%	86.8%	90.5%	94.8%
7	76.5%	81.5%	87.5%	94%

Table 2. Comparison of accuracy measure for decision tree classifiers algorithms

Number of experiment	ID3 (KB)	C4.5 (KB)	C5.0 (KB)	C5.0 BNA (KB)
1	31,211	30,621	29,817	29,021
2	34,825	34,327	33,823	33,627
3	36,013	36,171	36,263	36,681
4	39,461	38,726	37,461	36,726
5	39,251	38,726	38,271	37,726
6	35,628	34,734	33,928	32,834
7	41,528	40,173	39,928	39,173

Table 3. Comparison of memory consumption for decision tree algorithms

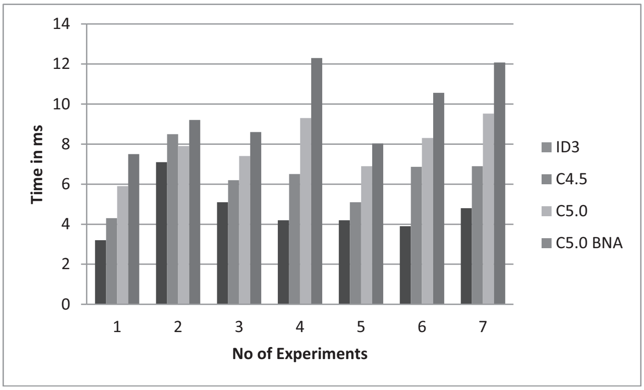

Figure 9. Comparison of training time for decision tree algorithms

Number of experiment	ID3 (ms)	C4.5 (ms)	C5.0 (ms)	C5.0 BNA (ms)
1	3.2	4.3	5.9	7.5
2	7.1	8.5	7.9	9.2
3	5.1	6.2	7.4	8.6
4	4.2	6.5	9.3	12.3
5	4.2	5.1	6.9	8.03
6	3.9	6.87	8.3	10.56
7	4.8	6.9	9.52	12.08

Table 4. Comparison of training time for decision tree algorithms

FSC problems, especially when the problem dimension becomes bigger. The main reason is that C5.0BN has some good features compared with other algorithms. Firstly, C5.0BN has a decision-providing algorithm is hybrid with C5.0 algorithm and Bayesian approach to the network. Therefore the well-organized decisions are made to examine the possibility of using IoT is to monitor and effectively track the quality and safety of the food. C5.0 is established to be supportive to afford an excellent balance of comprehensive and local search ability for the algorithm. In this regard, C5.0 BN is a novel development of Bayesian Network model focused on decision trees and constructed from a directory of conditional possible attributes and testing case location, and then the decision trees may be used to identify subsequent test case sets. Experiments in section 5 show that this mechanism can significantly improve the performance of the algorithm.

The classification performance of the Bayesian network classifier, compared to non-Bayesian classifiers using real-world problem data, outperformed the ID3 algorithm and the random forest, and demonstrated to be competitive to C5.0 and a neural network, obtaining near to 99 percent in correct classification. Also, it can be pointed out that for each one of the

Number of experiment	ID3 (ms)	C4.5 (ms)	C5.0 (ms)	C5.0 BNA (ms)
1	5.2	4.3	3.3	2.1
2	7.1	6.5	5.4	3.6
3	6.1	5.2	3.8	2.4
4	7.2	6.5	4.8	3.5
5	7.8	6.1	5.3	4.3
6	6.9	6.3	4.6	3.7
7	8.8	6.9	5.4	4.8

Table 5.
Comparison of Search Time for Decision Tree algorithms

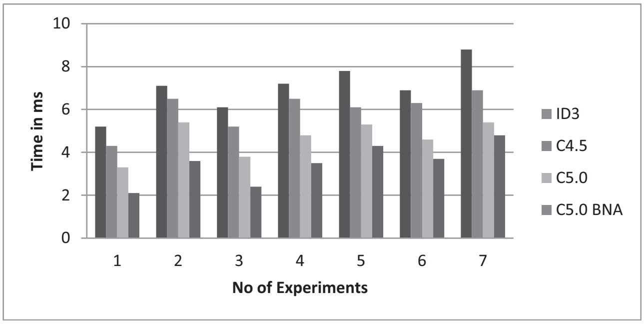

Figure 10.
Comparison of search time for decision tree algorithms

Number of experiment	ID3 (%)	C4.5 (%)	C5.0 (%)	C5.0 BNA (%)
1	29.5	23.5	19.14	16
2	20.87	17.89	14.9	11.45
3	19.21	18.12	17.83	17.1
4	22.14	19.45	15.98	11.51
5	21.54	17.45	11.01	5.78
6	16.25	13.56	9.56	5.45
7	23.47	18.56	12.23	6.02

Table 6.
Comparison of error rate for decision tree algorithms

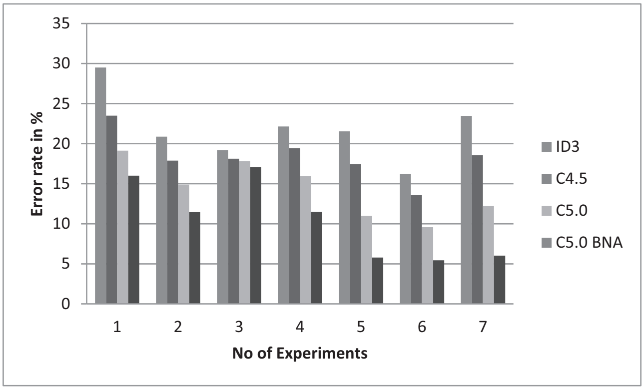

Figure 11.
Comparison of error rate for decision tree algorithms

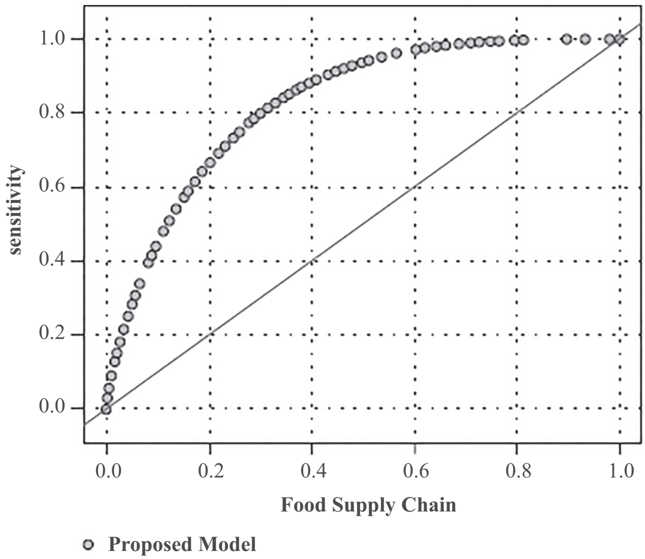

Figure 12.
Quality management of the FSC

folds in the five-fold cross validation experiment, the Bayesian network classifier presents less variability than the neural network due to the limited amount of edges in the network structure. Generally, the C5.0 BN classifier with its incremental learning method tries to overcome the bias/variance dilemma also known as overfitting, thereby improving the generalization power

5. Conclusion

With the fast development of processing services in FSC, it has become a significant concern to attain the optimal marketing service composition with a large number of manufacturer, distributer and retailer. We have proposed a hybrid algorithm to tackle the FSC problem. In FSC, this algorithm is implemented to address the limitations of the current FSC to prevent food defects from exceeding dangerous levels and to tell consumers when and where safety controls should be applied for the best results. Additionally, it is implemented to produce the

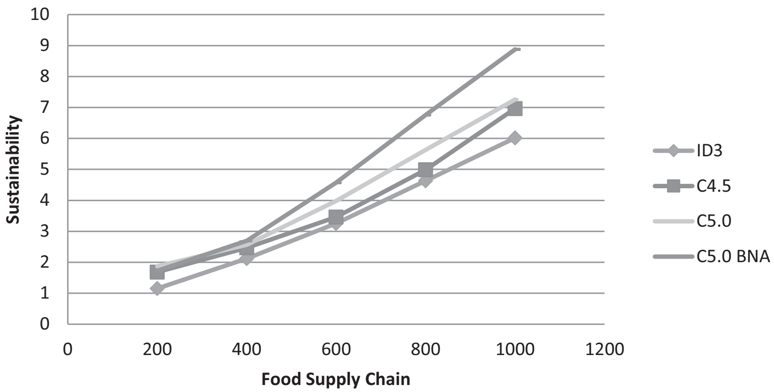

Figure 13. Sustainability of the FSC

Table 7. Overall comparison of performance of Decision Tree algorithms

Sl.no	Parameters	C5.0 BN	C5.0	C4.5	ID3
1	Accuracy (%)	92.21	86.78	81.67	76.58
2	Error rate (%)	11.01	15.81	19.17	27.09
3	Memory consumption (KB)	35,112	35,482	36,101	36,879
4	Training time (ms)	9.12	7.2	6.5	5.2
5	Search time (ms)	3.25	4.85	5.19	6.27

efficient food traceability management using IoT. The quality is maintained from the producer for the needs of the customer with effective transportation. The proposed methodology has been implemented in an abnormal food condition. The unwanted data has been removed to enhance the health of the customer with economic growth. The proposed work has achieved the reduced computational complexity and hardware utilization. The efficient food traceability methodology is used to discover the food products from the producer and it will use the traceability.

5.1 Future enhancement

The Decision Tree Classifier algorithm may be explored in future enhancement on other datasets to produce more booming accuracy. By reflection such as the training set, the Decision Tree Classifier algorithms can also be analysed; F-measure, TP rate, ROC curve, Precision and the Kappa value test set. In future, it will also be compared with ensemble algorithms like random forest and Chi-square automatic interaction detection algorithm (CHAID).

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Value chain, productivity and trade performance in the dairy industry

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Abstract

Purpose – The purpose of this paper was to establish the contribution of value chain and productivity to trade performance in the dairy industry using evidence from Uganda.

Design/methodology/approach – This study research design is cross-sectional and correlational. Data were collected through a questionnaire survey of 108 dairy farmers, processors and exporters. Data were analysed through correlation coefficients and linear regression using Statistical Package for Social Sciences.

Findings – Hierarchical regression results indicate that value chain and productivity contribute significantly to variances in trade performance of dairy products. Therefore, appropriate value chain processes and high levels of productivity lead to increased trade performance in the dairy industry.

Research limitations/implications – This study focusses on trade performance of dairy products in Uganda. These research findings are useful for informing the deliberations of academicians, regulators and the business community. The results are applicable to all countries that carry out trade specifically in dairy products.

Practical implications – The results are important for trade policy development in the dairy industry. For example, this study informs farmers, processors and exporters of dairy products how value chain activities in dairy farming can be re-aligned to achieve better quality and productivity for exportation. Similarly, the current study provides policy guidance for the relevant ministries such as ministry of trade and other players to come up with holistic policy actions aimed at improving the trade performance of dairy products in the country.

Originality/value – To the researchers' knowledge, this is the first study that provides an initial empirical evidence on the contribution of value chain and productivity on trade performance of dairy products in Uganda.

Keywords Trade performance, Value chain, Productivity, Dairy products, Uganda

Paper type Research paper

1. Introduction

Trade performance is a major concern for both developed and developing countries since trade has been known as an engine for growth for quite a long time (Gnangnon, 2019; Omojimite and Akpokodje, 2010). According to Kabir *et al.* (2018) and Yan (2017), trade performance is a mechanism used to evaluate a trader's return and risk tolerance in the exchange of goods or services between people or countries, often with money as a medium of exchange. Indeed, the level of a country's trading performance is a target for its trade policy formulation and implementation (Kabir *et al.*, 2018; Daniels, 1993). However, developed countries are continuously dominating world trade as most developing countries are always

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importing goods and services from developed countries such as United Kingdom, USA, the European Union countries and other countries in the Far East (Gnangnon, 2019). It should be noted that trade statistics showing a rapid expansion of technology-intensive, high value-added exports from developing countries are misleading, because of double counting of trade among countries linked through International Production Networks (Dapiran and Kam, 2017; Akyüz, 2003). Surprisingly such products are taken as exports from developing countries when in reality, developing countries are only involved in the assembly stages of production using technology-intensive parts and components imported from more advanced countries such as United Kingdom, Germany, among others (Dapiran and Kam, 2017). As trade flows are measured in gross value rather than value-added, imported parts and components are counted among the exports of the countries assembling them (Mutebi *et al.*, 2018; Akyüz, 2003). Although developing countries are seen to be major players in world markets for supply-dynamic and high-tech products, they still account for only 10% of world exports of products which score high in research and development content, technological complexity and/or economies of scale (Akyüz, 2003). Therefore, developing countries such as those in Africa are faced with a weak export performance (Bıçakcıoğlu-Peynirci *et al.*, 2019; Freinkman *et al.*, 2004), and this has an impact on its balance of payments given that exports are always less than the imports.

According to Abdallah (2019), Uganda's annual export earnings from the dairy sector is approximately US$ 100m. However, the earning potential from Uganda's dairy products could increase to US$ 500m annually if the country successfully affords to control the high death rates in exotic livestock, attributable to tick-borne diseases, and resistance of the ticks to available acaricide. This clearly shows the need to re-align and improve the dairy products value chain processes and increase productivity to attain higher trade performance in the industry. Notwithstanding, the trading performance of other related exports is also being affected by value chain and productivity challenges in Uganda. Indeed, as a whole, Uganda currently has total exports of 3,087,363.58 in thousands of US$ and total imports of 6,729,436.50 in thousands of US$ leading to a negative trade balance of 3,642,072.92 in thousands of US$. But the trade growth is 16.83% compared to a world growth of 3.50% (World Integrated Trade Solution, 2020). Although Uganda's trade performance continues to improve over time, most commodities are exported in their raw form (Abdallah, 2019). The Uganda Export Promotion Board in 2013 opted to promote diversification of her exports by adding value to locally produced dairy products in order to enhance trade performance. But, Rauschendorfer and Spray (2018) note that, Uganda's export base has remained undiversified and dominated by a small number of raw commodities, and this is because the performance of the manufacturing sector has stagnated for most of the previous century. For example, in the recent past, Uganda has concentrated majorly on exporting non-processed agricultural products such as coffee and tea to the world market in addition to the unprocessed minerals. Nevertheless, by 2018, coffee earnings had already started falling, indeed in August 2018; coffee earnings fell by 24.2% following a drop in both its volume and the international coffee prices (Bıçakcıoğlu-Peynirci *et al.*, 2019). As such, Uganda's drive to diversify exports through dairy products is vital in improving its trade performance. Therefore, the unanswered question of how to improve Uganda's trade performance is an issue this research intends to answer through examining the contribution of value chain re-alignment and increased productivity in the dairy industry.

Empirical studies suggest several explanations to trade performance and these include: comparative advantage (Mahajan *et al.*, 2015; Abbas and Waheed, 2017), standards (Swam *et al.*, 1996), innovation (Greenhalgh, 1990) and exchange rate reforms (Omojimite and Akpokodje, 2010). While carrying out their study in the Indian pharmaceutical industry, Mahajan *et al.* (2015) concluded that comparative advantage has a positive effect on trade performance, and this implies that if Uganda has milk products it can process and export, then it is likely to improve its trade performance. Further, Abbas and Waheed (2017) note that comparative advantage is a determinant for trade performance of Pakistan. As there exists minimal studies on trade performance, the existing few empirical studies call for further research on the topic (see Abbas and Waheed, 2017; Daniels, 1992). To the researchers' knowledge, available studies on trade performance have even used evidence obtained from other countries other than African countries such as Uganda. Also, no study has attempted to employ value chain and productivity as possible explanations of trade performance using evidence from a developing agrarian economy such as Uganda. Yet, according to Kataike *et al.* (2019), value chain systems are critical in ensuring increased value addition to the final products in order to achieve international acceptance. Similarly, productivity which is the ratio of output to inputs is paramount in ensuring that the level of a country's production meets the available demand of its products (Bakhtiar *et al.*, 2018). Moreover, Sharma (2015) states that productivity is used to compare performance between firms over time. Indeed, productivity growth without an increase in inputs is the best kind of growth aimed for rather than attaining a certain level of output by increasing inputs, since these inputs are subject to diminishing marginal returns which expressed efficiency in production (Koebel *et al.*, 2016). By enlisting responses from 138 farmers, processors and exporters, we find that value chain and productivity are significant predictors of trade performance of dairy products in Uganda.

The present study results are important in a number of ways. The study adds on the already scant existing literature on trade performance by providing initial empirical evidence on the contribution of value chain and productivity to trade performance using evidence from an African developing country (Uganda). In terms of policy formulation on trade, this study is critical for government to come up with holistic policy actions aimed at improving the trade performance of the country through the promotion of increased production and processing of quality dairy products.

The rest of this paper is organized as follows. The next section is study setting, and this is followed by literature review and hypotheses development. Next is the methodology section which is then followed by results. The discussion section then follows and finally, summary and conclusion are provided.

2. Literature review and hypothesis development

2.1 Theoretical foundation

According to the new trade theory by Krugrnan (1989), in order to maximize the benefits from international trade and increase trade performance, return to scale in production should be increased. This will increase competitive equilibrium and productivity since the resulting economies of scale are internal to the firm and these internal economies of scale will position the firm to influence the market by controlling price and market share which spreads to the economy as a whole. Since the Second World War, economists took a deep study to ascertain whether a country should build its export and import base or whether it should focus on one in order to increase trade performance and economic growth. In many developing countries after 1988 through adoption of value chain and introduction of innovative ways to create quality, these countries began to show favourable trade performances informed of trade surpluses where exports exceed imports. (Semancikova, 2016). According to WTO (2013), free trade improves trade performance since more resources are utilized to produce more commodities for export, investment increases leading to growth in technology and incomes. Kabir *et al.* (2018) and International Trade Centre (2007) show that trade performance is characterized by rough indicators, such as the level of openness (total trade in goods and services divided by GDP) or growth of exports over a given period. As such the increment of exports and imports of a country over time on the world market with exports exceeding imports in terms of volume and quality is paramount. Studies show that globalization has become an important topic to many state leaders because with globalization comes increase in trade and trade performance as well as a reduction in tariffs. This leads to increase in growth, reduction in poverty and inequality.

2.2 Value chain and trade performance

According to Dapiran and Kam (2017), value chain refers to the process or activities by which an entity adds value to a product or service, including production, marketing and the provision of after-sales service. Also, value chain entails a set of activities that a firm operating in a specific industry performs in order to deliver a valuable product for the market (João and Sónia 2014; Swinnen and Maertens, 2007). Balikowa (2011) indicates that the dairy value chain involves activities such as milk production, collection, bulking and transportation, processing, distribution and marketing which jointly transform raw milk into valuable products such as ice cream, butter, cheese, among others. In light of the aforementioned, international trade is increasingly appreciating value chains. Indeed, the emphasis is currently on the value of the services, raw materials, parts, components and final products exchange across countries. To that end, participation in value chain has also been increasing, thus presenting new prospects for growth. According to Dapiran and Kam (2017) and OECD (2013), economies are presently participating in value chain by using imported inputs in their exports (the so-called backward linkages in value chain) or by supplying intermediates to third-country exports (forward linkages). This shows that the overall participation in value chain (measured as the sum of backward and forward linkages) differs substantially across countries, with larger economies relying less on international trade and small open economies more integrated into value chains (Nickerson *et al.*, 2007). The overall participation in value chain (measured as the sum of backward and forward linkages) has increased for every OECD member country since 1995, despite the recent slowdown that followed the economic crisis (OECD and WTO, 2015). Value chains also act as the paradigm for the international organization of production since nowadays, most processes of production of goods and services are produced in separate stages located in different countries and assembled either sequentially along the supply chain or in a final location. As a matter of fact, the rise of these value chains, interlinked with the strong expansion of international trade, especially of parts, components and foreign direct investment flows, mostly by multinational corporations are the key players in the operation of world networks and have produced a deep and lasting impact on the world economy. This has affected competitiveness, macroeconomic developments and strongly increased the economic interdependence between countries (João and Sónia, 2014).

There are minimal studies that link value chain to trade performance. However, few studies attempt to argue that value chain is linked to trade performance, for example, Dapiran and Kam (2017); Kaplinsky and Morris (2000) put it that the value chain describes the full range of activities which are required to bring a product or service from conception, through different stages of production, delivery to enterprises' export performance final consumers and final disposal after use. Different stages along the value chain are associated with value-added components, measured as total industrial output minus materials used and labour costs in the production process and regarded as an indicator of the level of profitability and/or efficiency (Yi *et al.*, 2012). It is important that an analysis of the stages of a product is done as this has an effect on the quality of the product. For example, the stages through which milk is processed up to the final stage need to be analysed frequently in order to have quality milk from Uganda on the world market. Value chain analysis according to Porter (1985) has been mostly used for manufacturing industries to maximize value through an evaluation of production and distribution chains, with particular emphasis on delivery time and quality commensurate with price (Maaja and Kulno, 2009). Value chain of any given product should be given attention in order to have better products at the world market. Recent evidence from sub-Saharan African countries suggests that while hospitality industries are experiencing significant growth, value (such as return on investment) is not being created efficiently due to firm-specific or external influences (Kataike *et al.*, 2019; Sharma and Christie, 2010). Whereas the aforementioned study was conducted in hospitality industries, it is likely that the results can be generalized to the dairy industry as well. Given that value chain is important for improving quality of the product as well as the delivery time and price, it is likely that in an organization or country where value chain is emphasized, there will be improved trade performance. Similarly, if the dairy industry in Uganda emphasizes value chain in the processing of milk, then the world market is likely to be attracted to such milk and this will automatically lead to better trade performance. Therefore, we hypothesize that:

H1. There is a significant positive relationship between value chain and trade performance in Uganda.

2.3 Productivity and trade performance

According to Sharma (2015), productivity has been used to compare performance between firms over time. For example, productivity growth without an increase in inputs is the best kind of growth aimed for rather than attaining a certain level of output by increasing inputs, since these inputs are subject to diminishing marginal returns which expressed efficiency in production (Topalova and Khandelwal, 2011; Winkler, 2010). Administrative procedures and public policy play a crucial part in influencing productivity and the considerable variance in productivity growth across states is attributed to regional differences in infrastructural facilities which showed that infrastructure is a key factor to productivity (Kumar, 2006; Babu and Natarajan, 2013). Even with the increased global integration in developing countries, productivity levels between different sectors as well as between firms within a sector are seen to have large gaps which indicated inefficiencies in resource allocation and wastage (Schwörer, 2013). So, in order to improve the overall productivity in the economy, the resources and workforce from activities are moved from low productivity to activities with higher productivity (Bakhtiar *et al.*, 2018). In addition, enterprises that operated at the optimum scale and generated maximum value achieved the best productivity from costly and scarce resources by designing policies that promoted the most productive scale of operations for growth in the manufacturing sector and other sectors in the economy (Dhwani and Seema, 2015). Also, government policies that promote productivity gains are directed on sources of productivity that perform poorly and needed policy support (Sharma, 2015).

Studies that link productivity to trade performance are rare. Studies such as Koebela *et al* (2016); Melitz and Ottaviano (2008) have treated productivity as a dependent variable. The authors found trade increases aggregate productivity by forcing the least productive firms to exit. In another study conducted by Bakhtiar *et al.* (2018), productivity was treated as a dependent variable while the independent variables were research and development investments and export. However, there are studies where productivity has been used as an independent variable (see Cui *et al.*, 2015). Cui *et al.* (2015) suggest that facility productivity is negatively associated with air emission intensity. Further, Cui *et al.* (2015) found that exporting facilities have significantly lower emissions per value of sales than non-exporting facilities in the same industry. Hence, according to Koebel *et al.*, 2016, productivity is correlated with the level of exports. As a result, it can be argued that productivity is likely to lead to improved trade performance. Therefore, we hypothesize that:

H2. Productivity is positively and significantly related to trade performance.

3. Methodology

3.1 Study setting

This study gathered data from dairy farmers, processors and exporters in Uganda. Uganda is a land-locked country with a population of 41.49m according to World Bank (2016). It is also is predominantly an agrarian economy where 72% of Uganda's population is employed in agriculture (UBOS 2016). Uganda's agricultural sector is majorly comprised of crop husbandry and livestock farming. According to Kataike *et al.* (2018) and Uganda Export Promotion Board (2013), the government of Uganda, in an attempt to promote diversification in its trade pattern, emphasized value addition to dairy products in order to enhance trade performance of the country. Uganda's dairy industry has bucked a trend in the agricultural sector in which production grew very slowly since the late 1990s and was less than 1% in 2010/2011. However, milk production grew quite rapidly at about 7% annually since then, and the number of livestock also increased. Whereas in the early 1990s, Uganda was dependent upon imported milk powder, it is now largely self-sufficient in fresh milk. Livestock and dairy products were some of the new products that the government of Uganda promoted for export as a way to diversify and increase trade performance which increased productivity throughout the value chain. In Uganda, dairy farming is regulated by the Dairy Development Authority (DDA) formed under the Dairy Industry Act of 1998. DDA started its operations in 2000 (FBAM, 2014). Regardless, the dairy industry in Uganda faces a number of constraints. First, the dairy keepers are not keepers of animals for business but are part of their culture and lifestyles. The second relates to high milk spoilage and poor-quality milk because of lack of cooling facilities and high electricity costs to keep the milk in cold conditions. Kataike *et al.* (2018) and Uganda Export Promotion Board (2014) make conservative estimates of about 80% of the milk produced to be sold through informal market channels mainly by small-scale farmers owning over 90% of the cattle population of country. According Kataike *et al.* (2018) and DDA (2010), the milk industry in Uganda is highly skewed comprising 1m smallholders, 10,000 of middlemen with least agents in the milk supply chain being processors and exporters. It is thus a worthwhile endeavour to undertake a study of this nature in an emerging economy where agriculture is the backbone.

3.2 Design, population and sample

Cross-sectional and correlational research designs were used. Cross-sectional research design is a type of observational study that analyses data collected from a population, or a representative subset, at a specific point in time (Saunders, 2009; Sekaran, 2003). This research design is now gaining considerable attention for similar studies (see Yan, 2017; Gnangnon, 2019). In this study, we intended to collect data within a short period of time and thus the appropriate design was a cross section. We also employed a correlational study because we wanted to establish relationships among study variables. The study population constituted of various individuals in the dairy sector in Western Uganda including farmers, processors and exporters. According to Mbarara Dairy Farmers Association (2017), there are 213 farmers, 3 exporters and 3 processors. Following the Krejcie and Morgan table of 1970 of sample size determination, we selected a sample of 136 farmers (simple random sampling) and also included all exporters and processors. We received 108 useable questionnaires. Of the 108 useable questionnaires, 81 (or about 75%) were from male respondents while 27 (or about 25%) were female respondents. Majority of the respondents were aged between 36 and 45 years whereby 51% were aged between 36 and 45 years, those aged 47.2 years and above were 22.2%, 26.9% were aged between 26 and 35 years and the remaining were aged 18–25 years. In terms of education background, majority of the respondents had only secondary education – ordinary level (42.6%), and these are followed by those who completed primary education (29.6%). Those who went to school but never completed primary seven were only

2 respondents (about 1.9%) while those who completed tertiary education were 3.7%. The aforementioned information is summarized in Table 1.

3.3 The questionnaire and variables measurement

This study's data collection instrument involved the researcher preparing a set of questions pertaining to the field of enquiry. The choice of a questionnaire was justified by the fact that it was the single best tool in collecting quantitative data from a big number of respondents (Amin, 2005). We designed our questionnaire on a five-point Likert scale ranging from strongly disagree (1) to neutral (3) to strongly agree (5). We used perceptions of farmers, processors and exporters given that the culture of information availability in Uganda is far from the desirable. Our questionnaire had only closed ended questions. We operationalized our variables as follows:

Trade performance which is our dependent variable was operationalized using the trade volumes which entailed comparing the amount of exports (dairy products) to imports (raw materials used in production), profitability by comparing revenue from the sale of dairy products and the cost of production. We also used the product varieties to measure trade performance by comparing how many products dealers in the diary sector export and import (Kabir *et al.*, 2018; Cattaneo *et al.*, 2013).

Value chain which is one of our independent variables was operationalized by looking at the value created at each stage of production, the intermediate commodities at these stages of production and how the stages were well coordinated (Dapiran, and Kam, 2017; Cattaneo *et al.*, 2013; João and Sónia, 2014).

Productivity was our other independent variable which was operationalized by analysing the quality of the output used in production, the cost incurred while producing the dairy products, the innovation in this production and the income received from the sale of the dairy products (Bakhtiar *et al.*, 2018; Kumar, 2006; Babu and Natarajan, 2013).

3.4 Validity, reliability and parametric tests

We assessed validity of the instrument using a content validity index. The instrument was given to three academicians and three practitioners. The overall content validity index was 0.78 which is acceptable (Field, 2009). Field (2009) explains validity as evidence that a study allows correct inferences about the question it was aimed to answer or that a test measures

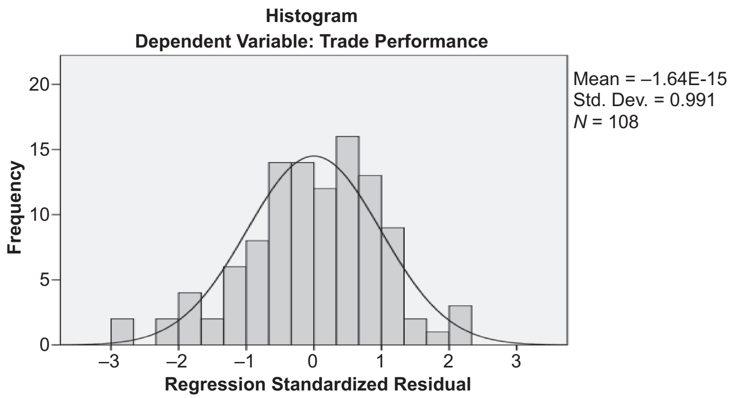
Item	Frequency	Percent
Male	81	75.0
Female	27	25.0
Total	108	100.0
18–25 years	4	3.7
26–35 years	29	26.9
36–45 years	51	47.2
46 years and above	24	22.2
Total	108	100.0
None	2	1.9
Primary	32	29.6
Secondary (S.1–S.4)	46	42.6
Secondary (S.5–S.6)	24	22.2
Tertiary/institution	4	3.7
Total	108	100.0

Source(s): Primary data

Table 1.
Respondents' profile

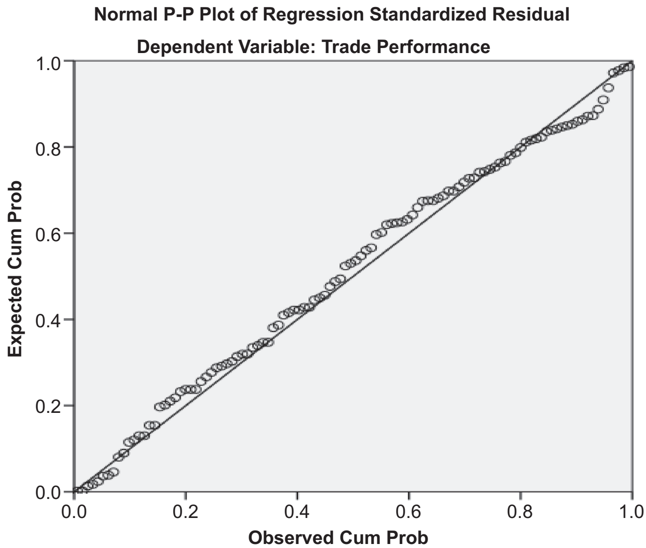
what it is set out to measure and further explains content validity index as evidence that the content of a test corresponds to the content of the construct it was designed to cover. We further tested for reliability of the questionnaire using Cronbach α coefficient, and the Cronbach α values for value chain, productivity and trade performance are 0.759, 0.816 and 0.898 respectively. Cronbach (1951) requires a Cronbach α coefficient of at least 0.7 and above, and for this study, the instrument was reliable. Reliability is the ability of a measure to produce consistent results when the same entities are measured under different conditions (Field, 2009).

For parametric tests, we tested for normality, linearity and homogeneity. We carried out parametric tests because this study was correlational and thus intended to use Pearson correlation coefficient which requires data that is normally distributed. Normality can be assessed to some extent by obtaining skewness (symmetrical) and kurtosis (peakedness) values of each measured variable. According to Field (2009), skewness and kurtosis indicate the deviation from normality, whereas Tabachnick and Fidell (2001) suggest using a histogram to evaluate the shape of data distribution. Therefore, the bell-shaped histogram (Figure 1) confirms that data are normally distributed in the current study. Linearity refers to the presence of a straight-line relationship between two variables. As the regression analysis is only suitable for testing linear relationship between the independent variables and dependent variables, this assumption must be met before performing this analysis. Linear data is obtained when the scores are seen to be in the form of fairly straight line, not a curve. A normal probability plot (normal Q-Q plot) was used in this study to plot the residual against the predicted scores. Field (2000) noted that if the assumption of linearity between the independent variable and dependent variable is met, the plot of the residual against predicted scores will also be linear (Figure 2). Therefore, the normal plot results revealed a fairly straight line showing that the data was linear. Homogeneity test was conducted to assess the suitability of data for parametric tests. This assumption means that the variance of one variable should be stable at all levels of the other variable (Field, 2009). Graphically, a scatter plot was drawn plotting the residual against the dependent variable. The results of the scatter plot (Figure 3) showed that the points are dispersed around zero and there was no other clear trend in the distribution. This is an indication that homogeneity and linearity assumption were met. If the graph funnels out or if there is a curve in the graph, it indicates the probability of heteroscedasticity in the data which can violate the condition of multivariate analysis (Field, 2009), hence it is not the case for this study. Given the fact that the tests for parametric assumption were met, parametric tests were found suitable for the study.



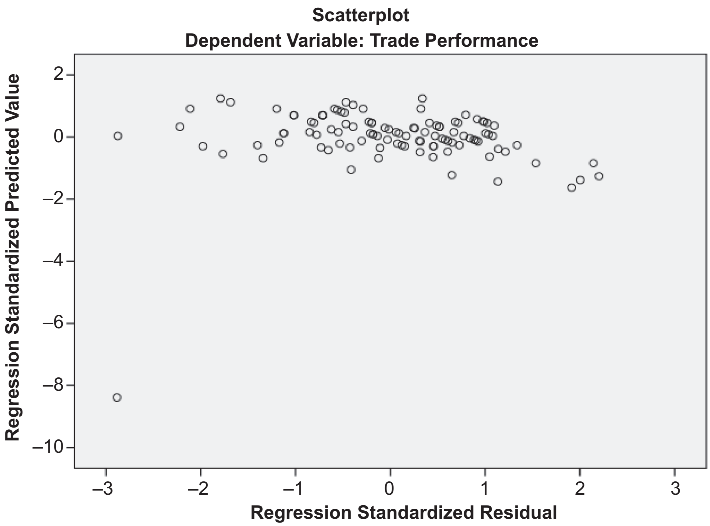
Source(s): Primary data

Figure 1. Graphical presentation of normality test – Histogram



Source(s): Primary data

Figure 2.
Graphical presentation of linearity test – normal P-P plot



Source(s): Primary data

Figure 3.
Graphical presentation of homogeneity test

4. Results

4.1 Descriptive statistics

We present summary descriptive statistics in Table 2 for value chain, productivity and trade performance. We report the means and standard deviations since the calculated means represent the data while standard deviations show how well the means represent the data (Field, 2009). For this study, the means and standard deviations for productivity, value chain and trade performance are 4.50 and 0.37, 4.52 and 0.38 and 4.52 and 0.36 respectively. Given that the standard deviations as compared to the mean values of the study variables are small, it implies that the means highly represent the data.

4.2 Correlation analysis

We used Pearson correlation coefficient to establish whether or not there are relationships between the study variables as hypothesized in literature review. From Table 3 results, value chain is positively and significantly related to trade performance ($r = 0.491^{**}$, $p < 0.01$), this implies that a positive change in value chain brings about a positive change in trade performance. Results further indicate a positive significant relationship between productivity and trade performance ($r = 0.631^{**}$, $p < 0.01$), and this means that a positive change in productivity leads to a positive change in trade performance. Therefore, preliminarily, H1 (*there is a significant positive relationship between value chain and trade performance*) and H2 (*productivity is positively and significantly related to the trade performance*) are supported. In terms of control variables (number of years spent in dairy farming and type of dairy products), none of them is positively and significantly associated with trade performance, and thus our model is not affected by the confounding variables. We also examined correlations among our independent variables to determine whether multicollinearity problems exist. As Table 3 shows, none of the correlations between independent variables is close to these threshold values of 0.80 or 0.90 as suggested by Field (2009). Therefore, our study did not suffer from multicollinearity problems.

4.3 Hierarchical regression analysis

A hierarchical regression analysis was conducted to establish the contribution of each independent variable in explaining factors influencing value chain on the trade performance of dairy products in Uganda for the case of western Uganda. Hierarchical regression analysis was used to determine the predictive power of the separate variables on the dependent variable as shown in Table 4. The model specification was as:

Variable	*n*	Min	Max	Mean	Std. Deviation
Trade performance	108	1.75	4.92	4.5293	0.36034
Value chain	108	1.86	5.00	4.5225	0.38529
Productivity	108	1.60	5.00	4.5033	0.37367
Duration in dairy processing	108	1.00	5.00	1.2991	0.68975
Product processing stages	108	1.00	3.00	2.1574	0.82215

Source(s): Primary data

Table 2. Descriptive statistics of the study variables

Variable	1	2	3	4	5
Trade performance (1)	1				
Value chain (2)	0.491^{**}	1			
Productivity (3)	0.631^{**}	0.529^{**}	1		
Duration in dairy processing (4)	−0.128	0.054	−0.176	1	
Product processing stages (5)	0.168	−0.043	0.131	-0.257^{**}	1

Note(s): **Correlation is significant at the 0.01 level (two-tailed)
Source(s): Primary data

Table 3. Correlation analysis results

Table 4.
Hierarchical regression analysis

Item	Model 1			Model 2			Model 3		
	B	SE	*β*	*B*	SE	*β*	*B*	SE	*β*
Constant	4.624	0.117		2.504	0.359		1.359	0.373	
Duration in dairy processing	−0.067	0.051	−0.129	−0.086	0.044	−0.164	−0.028	0.040	−0.053
Product processing stages	−0.003	0.055	−0.004	−0.027	0.047	−0.049	−0.004	0.042	−0.007
Value chain				0.482	0.078	*0.516***	0.224	0.082	*0.239***
Productivity							0.490	0.086	*0.508***
R^2		0.016			0.280			0.455	
Adjusted R^2		−0.002			0.259			*0.434*	
R^2 change		0.016			0.264			0.175	
F change		0.871			37.750**			32.704**	

Source(s): Primary data

Model 1: $TP = b_0 + b_1N + \ b_2S + \varepsilon$

Model 2: $TP = b_0 + b_1N + b_2T + b_3VC + \varepsilon$

Model 3: $TP = b_0 + b_1N + b_2T + b_3VC + b_4P + \varepsilon$

Where:

TP = trade performance

$b0$ = constant

b_1N = standardized beta coefficient (β) of the number of years spent in dairy farming

b_2T = standardized beta coefficient (β) of product processing stages

b_3VC = standardized beta coefficient (β) of value chain

b_4P = standardized beta coefficient (β) of productivity

ε = error term

Results of Model 1 in Table 4 indicate that the control variables (number of years spent in dairy farming and type of dairy products) explain 1.6% variance in trade performance. Model 1 is the baseline model where only control variables were entered. The results indicate that control variables do not individually explain any significant variance in trade performance. That is, duration in dairy processing (standardized $\beta = -0.129$, $p > 0.05$) and product processing stages (standardized $\beta = -0.004, p > 0.05$). This reveals that the models in this study are not sensitive to confounding factors and the models are highly acceptable (Field, 2009). Model 2 shows that the addition of value chain to the equation accounts for an extra 26.4% of the variance explained by the model ($R^2 = 0.280$; fΔ; = 37.750; $p < 0.05$), and value chain is a significant predictor of trade performance, thus providing support for H1. The addition of productivity in Model 3 indicates an extra 17.5% of variability in trade performance ($R^2 = 0.455; f\Delta = 32.704, p < 0.05$). The model results also show that there is a significant relationship between productivity and trade performance ($\beta = 0.508$; $p < 05$), thus providing support for H2. Lastly, the variables entered in the regression model explained an overall of 43.4% (Adjusted $R^2 = 0.434$) of the variance in trade performance implying that the remaining 56.6% is explained by factors not considered in this study. Nonetheless, considering the two main predictors (value chain and productivity) in this study, the results show that productivity has a better contribution effect on trade performance of dairy products than value chain. Therefore, the study results support both H1 and H2. Generally, the results suggest that Model 3 in Table 4 is the most plausible model. The incremental validity in adjusted *R2* in Models 1–3 suggests a better fitting model which develops as value chain and productivity are successively introduced (Field, 2009) because in all the cases but Model 1, the *F* change is significant.

5. Discussion

According to the present study results, the contribution of value chain and productivity to trade performance is such that both value chain and productivity are significant predictors of trade performance. It can further be noted that the wholesaler in the major two channels acts as a middle man since he can buy dairy products from the farmer or from milk retailer which he or she may choose to send to the processor or take to urban retailers and finally to the consumer. The findings obtained imply that any business person/government should be able to understand the quickest way to have these products reach the final consumer. It should further be noted that this chain can be improved and value of milk can be added at farm level most especially in deep villages if government sets up rural industrial centres since this will improve on trade performance. According to the findings of this study, value chain is a significant predictor of trade performance. This therefore signifies that, when there is connected value chain, better intermediated products and good coordination of dairy products, trade performance will be improved. Economies can participate in value chain according to OECD (2013) by using imported inputs in their exports (the so-called backward linkages in value chain) or by supplying intermediates to third-country exports (forward linkages) showing that the overall participation in value chain (measured as the sum of backward and forward linkages) differs substantially across countries, with larger economies relying less on international trade and small open economies being more integrated into GVCs. The overall participation in value chain (measured as the sum of backward and forward linkages) has increased for every OECD member country since 1995, despite the recent slowdown following the economic crisis. This study's findings are in line with those of Tinta (2017) and Kaplinsky and Morris (2000), who put it that the value chain describes the full range of activities which are required to bring a product or service from conception, through different stages of production, delivery to enterprises' export performance final consumers and final disposal after use.

The results further revealed a significant positive relationship between productivity and trade performance. This implies that once quality inputs are used during processing and handling of dairy products and continued innovations are emphasized in processing and handling dairy products, it will lead to improved trade performance. These findings are in line with Sharma (2015) and Crespi *et al.* (2015), who argue that productivity is used to compare performance between firms over time, for example, productivity growth without an increase in inputs is the best kind of growth to aim for rather than attaining a certain level of output by increasing inputs, since these inputs are subject to diminishing marginal returns which will not be an expression efficiency in production. Administrative procedures and public policy play a crucial part in influencing productivity, and the considerable variance in productivity growth across states which can be attributed to regional differences in infrastructural facilities shows that infrastructure is a key factor to productivity (Kumar, 2006; Babu and Natarajan, 2013).

6. Summary and conclusion

The purpose of this study was to establish the contribution of value chain and productivity to trade performance. This aim was achieved through a questionnaire survey of 108 respondents. Results suggest that both value chain and productivity are significant predictors of trade performance. The present study results are important to both academicians and practitioners. Whereas there had not been any empirical evidence on the contribution of value chain and productivity to trade performance, this study provides additional literature on the determinants of trade performance in an emerging economy such as Uganda. This study is also critical for government to come up with holistic policy actions aimed at improving the trade performance of the country through the promotion of production of dairy products. The dairy products traders/dealers may also improve their productivity and ensure that they increase productivity. Therefore, it is clear that for dairy industry managers to realize increased trade performance, they must re-align the dairy products supply chain. They should rear the right breeds of livestock and ensure proper management of the farms and livestock. Similarly, at the time of harvesting the milk, it should be properly collected, processed and the outputs (dairy products) should be well packaged and preserved in line with the international standards. Marketing and sales in oversea bigger markets should also be emphasized. At the same time, it is imperative to gather customer feedback to keep improving the quality of dairy products. To facilitate these core dairy industry value chain primary activities are the facilitating factors such as proper procurement, transportation, accounting, finance and competent human resources in the dairy products business. Productivity in terms of increasing the quality of the output used in production of dairy products, minimizing the cost incurred while producing the dairy products, the innovation in this production and the income received from the sale of the dairy products should also be emphasized for increased dairy products trade performance in Uganda.

Like any other study, this study has a number of limitations which we discuss along with areas for future research. The study employs only value chain and productivity as major determinants of trade performance, but there could be other determinants of trade performance. Future studies may explore other determinants of trade performance in Uganda and in other national settings. The study only explores the agricultural sectors and ignores the other sectors. Future studies could consider other sectors as their sample. Trade performance is an area that up to date has been understudied especially in the developing nations, and for this case, future study may be undertaken to further add on the existing scant literature. Nonetheless, the study results are useful in informing policy and adding on the already existing scant literature.

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The potential of bio certification to strengthen the market position of food producers

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Abstract

Purpose – The purpose of the paper is to critically evaluate the applicability of bio certification in farmers' activity to reduce unfair trading practices in the food supply chain. The secondary purposes are describing the economic reasons of using bio certification and perspectives of using web trading platforms among food producers.

Design/methodology/approach – Data collection included face-to-face interviews with 15 Austrian and German farmers who operate on bio food markets as well as a quantitative survey regarding their assessment of unfair trading practices. This study presents both quantitative and qualitative analyses.

Findings – Bio certification is more likely unable to eliminate or mitigate unfair trading practices in the food supply chain, however bio certification is able to increase efficiency of farmers together with other web tools.

Originality/value – The study is the first to empirically investigate the applicability of bio certifications, its advantages and impact on unfair trading practices in the food supply chain. It focuses on small and medium-sized food producers and farmers. The research also reveals the perspectives of using web trading platforms in farming activity.

Keywords Unfair trading practices, Food supply chain, Bio certification, Fairtrade, Fair trade, Trading platforms, Food producers, Survey

Paper type Research paper

1. Introduction

A food supply chain comprises all activities which move food items from a primary producer to consumers. Usually, food supply chains are a combination of sequential activities which connect all production and distribution activities ranging from the planning of food production by farmers to the final consumption. Within modern food supply chains, food producers tend to be most vulnerable to the impact of unfair trading practices (UTPs), which have a severe negative impact on business-to-business relationships (Abdollah Dehdashti, 2018; Schebesta *et al.*, 2018). Among food product manufacturers, small and medium-sized enterprises (SMEs) account for 43% of the traded value. In terms of trade export value, SMEs' accounted for 81% in agriculture, forestry and fishing in 2016 (Eurostat, 2020). These enterprises lose on average 2.27% of their annual turnover due to various kinds of UTPs (Kononets and Qineti, 2020).

According to the European Commission (2014), UTPs are business-to-business practices that deviate from good commercial conduct, are contrary to good faith and fair dealing and

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are unilaterally imposed by one trading partner on another. Many such practices occur in the food supply chain, whose functioning is essential for human well-being. Improper handling of food stuffs can cause severe health issues (Hafliðason *et al.*, 2012; Ringsberg, 2014) or economic losses (Fernando *et al.*, 2019). Frequently, UTPs are caused by unequal bargaining power leading to commercial practices that are unjust, unfair or undesirable from an economic, social or political point of view (Falkowski *et al.*, 2017; European Commission, 2009). Such practices may occur at each step of the food chain and include, for example, late or upfront payments, order cancellations or unilateral changes in contracts. A major problem for small food producers is that they usually contract with large retailer groups who have better access to consumers, indicating severe power asymmetries in the food supply chain (Madichie and Yamoah, 2017).

In 2017, an open public consultation (OPC) took place regarding the issue of unfair trade among various stakeholders, including farmers and farming organizations, member state authorities, nongovernmental organizations, food processors and retailers. In total, 91% of participants agreed that UTPs exist in the food supply chain and 76% stated that UTPs have a negative impact on the industry (Valletti, 2018). SMEs acknowledge a strong pressure from the side of large companies due to unevenly distributed bargaining power and information asymmetry along the entire food supply chain (Sun and Wang, 2019). This asymmetry causes UTPs that lead to contractual imbalances which benefit the more powerful partner through better contractual conditions (European Commission, 2009).

The huge losses caused by UTPs through complex interrelated economic activities can take the form of lost profits, unnecessary expenses, spoiled or unsold goods and waste of time. Practical solutions are therefore needed to remedy this pain point of the food industry. To date, the negative impact of UTPs is rarely discussed in the academic literature. Therefore, in our research, we investigate whether certifications or direct sales can eliminate or at least mitigate the problem of UTPs for SMEs and help to increase the efficiency of small producers in the food supply chain. More specifically, we pose the following research questions:

(1) To what extent can bio certification and web-based trading platforms help producers in the food supply chain to mitigate the effect of UTPs and strengthen their market position?

(2) What are the reasons hindering the widespread use of bio certification programs and web platforms among farmers?

This paper is organized as follows: First, we present two different types of certifications and various UTPs. Next, we briefly discuss our methodological approach, followed by the core of this paper in which we discuss the quantitative and qualitative findings from our study. Summarizing the findings from our qualitative study, we suggest some research questions for further investigation. We end our article with several conclusions and some limitations.

2. Certifications and unfair trading practices

In recent years, there are increasing efforts to improve supply chains by implementing green supply management practices in order to improve companies' environmental performance (Zhu *et al.*, 2019) or to ensure markets that provide fair conditions for all participants (Qian *et al.*, 2020). In this respect, organic products were shown to have a huge market potential (Bazaluk *et al.*, 2020), and certification was introduced as a tool that can improve sustainability (Whelan, 2015), which in turn positively impacts a company's competitive advantage (Rajesh, 2020). In the following sections, we briefly present two different kind of certifications, namely Fairtrade and bio certifications, elaborate on their respective goals and introduce several UTPs that are relevant for food supply chains.

2.1 Fairtrade certifications

As of 2016, 1,411 producer organizations in 73 developing countries were certified by Fairtrade, representing over 1.66m farmers and workers. Fairtrade International started with coffee and, over time, has extended the range of certifications to different kinds of fruits, vegetables, berries and meat. The basic benefits of a Fairtrade certification for an SME food producer include a guaranteed minimum price, an additional premium on top of the market price for their investment in social and environmental projects, an advance to reduce the stress of selling their product under pressure and a commitment to minimize intermediaries in the supply chain (Fairtrade International, 2019).

The main organization behind the certification is the World Fair Trade Organization. Private seals for promoting fair trade are also issued by Fairtrade International, GEPA, UTZ and the Rainforest Alliance. Fairtrade standards contain minimum requirements that all producer organizations must meet to become certified as well as progress requirements that oblige producers to demonstrate improvements over time. To become certified Fairtrade producers, cooperatives and their member farmers must operate according to standards laid down by Fairtrade International.

Fairtrade certification especially focusses on the sustainable development of territories, protects the labor force from unjust exploitation, which includes gender equity and the restriction of child labor, ensures that farmers get a fair remuneration for their work, promotes direct trading, helps to eliminate unnecessary intermediaries and regulates the use of chemical pesticides in the cultivation of crops. Several types of Fairtrade standards exist, including standards for contractual situations specifically for importers, which cover a wide range of different products (Fairtrade International, 2011). Fairtrade standards for small farmers' organizations also include requirements for democratic decision-making, so that farmers have a say in how Fairtrade premiums are invested. This also includes requirements for capacity building and the economic strengthening of the Fairtrade organization. FLOCERT is the audit and certification body ensuring that both producers and traders meet Fairtrade standards and its inspections and certifications follow the international ISO standards for product certification entities (FLOCERT, 2020).

2.2 Bio certifications

In the perception of many consumers, organic and fair trade certifications are more or less identical (Bulut, 2010). While both certifications aim at ethical goals, "organic" sets standards for agricultural methods and the use of natural resources whereas fair trade pertains to trade and working conditions. Organic production and fair trade have separate certification processes, although the underlying principles are similar and strive to achieve an ethically responsible food production. Some organic certifiers include rules about social sustainability in their certification, such as the Swedish organization KRAV. Bio certification deals with healthy food growing, organic methods of crop cultivation, reasonable water and energy use and controls farmers' seeds.

The European Union regulates organic certification with norms EC 834/2007 and EC 889/2008 for operators (i.e. farmers, processors, traders, importers) willing to obtain an EU organic certification seal for their products and production facilities. The acquisition of all general EU certifications is shown through the EU logo, which is widely known as the Euro-leaf. The head certification body that deals with EU certification through certification agents within Europe is the European Organic Certifier Council (EOCC).

In addition to EU organic certification, other national and local bio certification seals are owned by government or private certification bodies. Austria has, amongst others, AMA, Bio Austria, Demeter International, Austria Bio Garantie, Erde and Saat and the Lacon Institut seal. The biggest market of bio certifications is in Germany. To this day, Germany remains one of Europe's leading countries in terms of both acreage and total number of farms devoted to organic farming practices. As of 2018, 31,713, organic farms ("Biohöfe"), 12% of all farms in Germany managed over 3.75m acres (1.52m ha), or 9.1% of farmland in adhering to organic standards (Federal Ministry of Food and Agriculture in Germany, 2020). Germany has also played a pioneering role in the history of organic farming. In fact, the organic food movement was started in Germany in the early 1920s, when Rudolf Steiner created a form of organic farming known as bio-dynamic agriculture (Von Friedeburg, 2018) but in the meantime has gained worldwide attraction (Niederle *et al.*, 2020). In Austria about 26% of the total agricultural area and 22% of all farms used organic management in 2019 (Federal Ministry of Agriculture, Regions and Tourism in Austria, 2020), which is among the highest rates in the EU.

2.3 Certification goals

Both Fairtrade and bio certifications motivate SME food producers to pursue a fair and sustainable production with the goals of generating higher incomes for farmers, a better production efficiency and more sustainable production processes (Furumo *et al.*, 2020). For example, the German private certification seal "Kreis" has two commercial labels that target the respective goals separately, namely the bio seal "Bio Kreis" and the Fairtrade seal "regional and fair". According to Biokreis.de, "regional and fair" is the organic seal for processing and trading companies, beekeepers and the gastronomy. This certification ensures high-quality raw materials and fair purchase agreements that contain binding prices and quality guarantees. In agriculture and handicraft processing it ensures fair prices that lead to a sufficient profit margin and provide capital for investments, short transportation distances, market partnerships based on trust instead of anonymous market mechanisms, high quality raw materials and the promotion of regional cultural landscapes. Both Fairtrade and organic certifications affect the market position of food producers and strive to eliminate or mitigate the occurrence of UTPs among their holders (Biokreis.de, 2020).

2.4 Unfair trading practices

An EU open public consultation that included several European countries during August 2017 and December 2017 identified the most important UTPs, as shown in Table 1. The frequency indicates how often a specific UTP was mentioned by the 1,432 respondents, each of whom named the three most important practices (European Commission, 2017).

Kononets *et al.* (forthcoming) summarized these practices into the 12 most impactful types of practices that potentially affect SMEs:

(1) *UTP type 1 (U1)*: Unilateral and retroactive changes to contracts (concerning volumes, standards, prices).

Stronger parties use their bargaining power to force the weaker party into signing a contract that contains conditions under which unilateral and retroactive changes to the contract can take place by the stronger party without permission by the weaker party.

(2) *UTP type 2 (U2)*: Last-minute order cancellations.

The producer carries the risk of order cancellation when it is too late to redistribute the order to other customers. This is especially important for perishable products.

No	Practice	Frequency
1	Unilateral and retroactive changes to contracts (concerning volumes, standards, prices)	771
2	Last-minute order cancellations concerning perishable products	316
3	Payment periods longer than 30 days for perishable products	275
4	Payment periods longer than 30 days for agro-food products in general	273
5	Imposing contributions to promotional or marketing costs	248
6	Unilateral termination of a commercial relationship without objectively justified reasons	227
7	Requests for upfront payments to secure or retain contracts ("hello money")	185
8	Imposing claims for wasted or unsold products	182
9	Imposing private standards relating to food safety, hygiene, food labeling and/or marketing standards, including strict verification procedures	179
10	Imposing an upfront access fee for selling a product ("listing fees")	152
11	Programmed overproduction leading to food waste	146
12	Withholding by one party of essential information to both parties	114
13	Passing onto other parties of confidential information received from partner	98
14	Additional payment to have products displayed favorably on shelves ("shelf-space pricing")	90
15	Imposing on a contract party the purchase of an unrelated product ("tying")	78
16	Inconsistent application of marketing standards leading to food waste	60
17	Imposing to suppliers costs related to product shrinkage or theft	40
18	Imposing a minimum remaining shelf life of goods at the time of purchase	11

Source(s): DG AGRI, EC 2018

Table 1. The most common UTPs

(3) *UTP type 3 (U3)*: Payment periods longer than 30 days for perishable products.

Delayed payments to producers can have a negative impact on investments as well as the farm output. This is an issue especially for producers of perishable products.

(4) *UTP type 4 (U4)*: Requiring contributions to promotional or marketing costs from the producer by the stronger parties.

This practice forces the weaker part of the contract to fund the cost of a promotion.

(5) *UTP type 5 (U5)*: Unilateral termination of a commercial relationship without objectively justified reasons.

Contractual sanctions are applied in a nontransparent manner and are disproportionate to the damages suffered. In other words, if a supplier does not satisfy the buyer's informal requirements, the contract can be terminated without any formal reason.

(6) *UTP type 6 (U6)*: Requests for upfront payments to secure or retain contracts ("hello money") and/or an access fee for selling a product ("listing fees").

A charge made by a retailer to a supplier for introducing the supplier's goods to its stores and/or imposing listing fees that are disproportionate to the risk incurred in stocking a new product.

(7) *UTP type 7 (U7)*: Requiring the weaker party to pay claims for wasted or unsold products. Programmed overproduction leading to food waste.

Once purchased, the risk of not selling a product or an impairment that renders it unsellable (and wasted) lies with buyers, maintaining their incentive to efficiently plan and manage their business. Some of the main drivers for food loss at retail stores include: overstocked product displays, expectation of cosmetic perfection of fruits, vegetables and other foods, oversized packages, the availability of prepared food until closing, expired "sell by" dates, damaged goods, outdated seasonal items as well as overpurchasing of unpopular foods. Claims to cover such losses addressed to the producer should be considered as an unfair practice.

(8) *UTP type 8 (U8)*: The stronger party imposing private standards relating to food safety, hygiene, food labeling and a minimum remaining shelf life of goods.

Private standards are usually referred to as "technical regulations". Usually they are voluntary, although they may in practice become a de facto mandatory standard where compliance is required for entry into certain markets or store shelves.

(9) *UTP type 9 (U9)*: Passing of confidential information to other parties or withholding of essential information.

A contracting party uses or shares sensitive information with a third party that was provided confidentially by the other contracting party, without the latter's authorization, in a way that enables it to obtain a competitive advantage. Also, there is the withholding of essential information relevant to the other party in contractual negotiations, which the other party should have received.

(10) *UTP type 10 (U10)*: Additional payment to have products displayed favorably on shelves.

Retailers sometimes earn more profit from agreeing to carry a manufacturer's product than they do from actually selling the product to retail consumers. According to retailers, fees serve to efficiently allocate scarce retail shelf space, to help balance the risk of a new product failure between manufacturers and retailers, to induce manufacturers to signal private information about the potential success of new products and to widen retail distribution for manufacturers by mitigating retail competition.

(11) *UTP type 11 (U11)*: Imposing on a contract party the purchase of an unrelated product ("tying").

Tying (also named "product tying") is the practice of selling one product or service as a mandatory addition to the purchase of a different product or service.

(12) *UTP type 12 (U12)*: Requiring the weaker party to contribute to the retailer costs related to product shrinkage or theft.

Imposing a requirement to fund a contracting party's proprietary business activities or the transfer of unjustified or disproportionate business risk to a weaker partner.

3. Methodology

3.1 Data collection

15 respondents were selected for personal interviews using a semi-structured interview guideline. The survey instrument included items for quantitative assessment as well as open questions that were analyzed in a qualitative manner. The interviews were structured such that first the respondents assessed the relative importance of various UTPs, and then we explored several issues in more detail using open-ended questions. We chose Austria and Germany as our main target regions, since bio certification is already fairly developed in these countries. There are 17 private bio certification bodies operating in Germany alone in 2018, which is more than in most European countries (Federal Ministry of Food and Agriculture in Germany, 2020). The second reason for our geographic choice was the public availability of information regarding farmers who own a bio certificate. It was therefore possible to easily

identify certified food producers for our study. The market situation in Austria, albeit with less certification institutions, is similar to Germany, with numerous certification agencies in existence and sufficient public information being available. We combined several means of data collection, including a mail survey, phone calls and field trips to several farms. The mail survey was mainly used to address target groups in Germany. A combined approach of phone calls and field trips was used for Austrian farmers. The data were collected between February and March of 2020.

3.2 Respondents

Basic information about the farmers are shown in Table 2. In order to ensure the confidentiality of the respondents, no personally identifying information is disclosed. Two of them are from Germany, and 13 come from Austria. All respondents were identified over the internet and are currently actively engaged in farming. Five farmers produce cereal, four corn and fruit, three soybeans and vegetables, two honey, wine and meat, and one produces milk and hay. When it comes to the size of their land, two own more than 60 ha, five have 11–60 ha, five have up to 10 ha and three farmers preferred not to disclose their land size. When it comes to the duration of the bio certificate ownership, five farmers have had it for 20 years or longer, four respondents from six to 19 years and six respondents have had it for up to five years.

Respondent	Interview	Main product	Size (ha)	Bio certificate	Bio certificate ownership (years)
A	Google form	Honey	–	Biokreis	3
B	Email	Honey	–	Biokreis	20
C	Questionnaire	Wine, cereals, soybeans, corn	56	Austria Bio Garantie / Erde and Saat	27
D	Questionnaire	Meat, vegetables, fruit	1,5	Austria Bio Garantie	2
E	Questionnaire	Goat milk products	10	Austria Bio Garantie / Bio Austria	11
F	Questionnaire	Grain production	130	Lacon Institut / Erde and Saat	4
G	Questionnaire	Cereal corn	–	Lacon Institut / Erde and Saat	4
H	Questionnaire	Wheat, corn, soybean	180	Austria Bio Garantie / Bio Austria	14
I	Questionnaire	Soybean	2	Lacon Institut	1
J	Email + personal interview	Organic asparagus and strawberries	700	Lacon Institut	20
K	Questionnaire	Cereal, corn, wine	60	Austria Bio Garantie / Bio Austria	20
L	Questionnaire	Apricots	20	Bio Austria	23
M	Questionnaire	Stock breeding (lamb production)	60	Bio Austria	11
N	Questionnaire	Cereals, vegetables, spices	22	Bio Austria / SGS AMA GA.P.	11
O	Questionnaire	Hay	3	Bio Austria	1

Table 2. Farmers' basic information

4. Results

4.1 Quantitative results

4.1.1 The impact of bio certifications on UTPs. The respondents were asked whether bio certification can potentially eliminate or mitigate the respective UTPs using Likert-type items ranging from 0 (strongly disagree) to 10 (strongly agree). The respective values can be found in Table 3. The total average across all UTPs was 2.8, indicating that the farmers, on average, are quite skeptical regarding the potential of certifications to reduce UTPs. However, it can also be seen that the respective assessments for basically all categories have a wide range, implying that bio certifications might be more beneficial for some farmers than for others, depending on the region, the produce and the current market situation.

4.1.2 Change in product profitability through bio certification programs. One further goal of this research project was the overall assessment of the economic benefits that bio certifications can provide to farmers. Only five respondents were able or willing to assess the economic benefits. Notably, all of them saw a positive effect which, on average, leads to an increase in product profitability by 21%, with answers ranging from 10 to 30%. The products in question included vegetables, fruits, meat, cereals, spices and hay (see Table 4).

4.1.3 Fees for organic seals. The costs of bio certification in EUR/year are shown in Table 5. In order to better understand whether organic certification can yield economic benefits, it is necessary to compare the additional income resulting from organic products with conventional products. The added benefit differs from product to product, but, on average, the farmers report a higher margin from organic products and a moderate return of investment from the bio certification, albeit the exact benefit turned out to be hard to quantify.

4.1.4 Perspectives of trading web platforms. Additionally, we asked the farmers whether they believe that web-based trading platforms will play a bigger role in the future to facilitate trading between small and medium-sized food manufacturers. These platforms enable direct communication between trading partners and help small farmers to save costs by cutting out intermediaries. On average, the respondents believe that this will be the case, with a mean value of 6.4 out of 10.

4.2 Qualitative results

4.2.1 Positive aspects about bio certification. Table 6 lists several benefits as perceived by the farmers resulting from bio certification. Our findings confirm that bio certifications are

#	Respondent	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12
1	A	0	0	0	0	0	0	0	0	0	0	0	0
2	B	10	0	0	0	0	0	0	0	0	5	5	0
3	C	0	4	7	8	0	3	4	0	0	8	2	2
4	D	4	5	5	5	5	6	5	8	8	5	4	5
5	E	1	0	0	5	0	0	0	5	0	0	0	0
6	F	0	0	0	3	0	1	0	0	6	0	9	8
7	G	7	4	7	3	6	8	7	8	6	3	7	8
8	H	5	4	0	7	7	6	7	5	0	6	3	3
9	I	6	7	8	4	7	7	6	7	3	8	5	5
10	J	8	8	0	0	0	0	0	0	0	0	0	0
11	K	0	0	0	8	8	2	8	6	6	7	6	6
12	L	0	0	0	0	0	0	0	0	0	0	0	0
13	M	3	0	0	2	2	3	2	4	4	3	2	3
14	N	2	2	2	4	2	4	3	3	3	4	3	4
15	O	0	5	0	0	0	0	0	0	0	0	0	0
Average		*3.1*	*2.6*	*1.9*	*3.3*	*2.5*	*2.7*	*2.8*	*3.1*	*2.4*	*3.3*	*3.1*	*2.9*

Table 3.
Impact of bio certification on UTPs

frequently used as a marketing tool with the main goal to increase sales. Furthermore, they help to signal superior quality to the consumers or simply reflect farmer's inner conviction.

4.2.2 Disadvantages of bio certification. 14 out of 15 respondents indicated that there were no disadvantages arising from bio certification. Only one farmer complained about requirements that were "too strict" and led to additional responsibilities.

#	Respondent	How much does the profitability of certified organic products change (in percent) as compared to noncertified products?
1	J	+15%
2	L	+20%
3	M	+10%
4	N	+30%
5	O	+30%
Average		*+21%*

Table 4. Change in profitability after bio certification

Respondent	Land size, (ha)	Cost of bio certification (year), EUR	Main product
A	–	n/a	Honey
B	–	250	Honey
C	56	280	Wine, cereals, soybeans, corn
D	1.5	80	Meat, vegetables, fruit
E	10	100	Milk goat products
F	130	1000	Grain production
G	–	900	Cereal corn
H	180	700	Wheat, corn, soybean
I	2	290	Soybean
J	700	3200	Organic asparagus and strawberries
K	60	700	Cereals, corn, wine
L	20	n/a	Apricots
M	60	1000	Stock breeding (lamb production)
N	22	350	Cereals, vegetables, spices
O	3	117	Hay

Table 5. Responses on the question by respondents

Respondent	English version
A	Quality becomes visible to consumers
B	Marketing, self-image
C	Quality standards, marketing
D	A small step back to nature
E	By conviction
F	Marketing
G	Marketing
H	Control over production
I	Better sales opportunity
J	Recognition of organic cultivation safety for customers and consumers
K	n/a
L	n/a
M	Increased sales
N	Documentation, traceability
O	Control

Table 6. Benefits of bio certification

4.2.3 Web trading platforms for farmers. Web trading platforms were not used by the farmers in our sample, and it was our goal to better understand the underlying rationale for this situation (Table 7). Analyzing the qualitative answers, we identified two main reasons. First, agricultural markets mostly work following a strict preordering production plan, which means that food producers get preliminary market information that helps them to predict the future demand and price. Based on this information, the farmers create preplanned production volumes with the hope to sell the crop according to existing terms and conditions. Second, products that can be sold on commodity exchanges and be stored over a prolonged period of time strongly differ from fresh vegetables like strawberry or asparagus, and existing marketing platforms suffice for their exchange. Additionally, the farmers pointed out that they have strong personal relationships with their main customers or that they are too small to benefit from trading platforms.

4.2.4 In-depth interview analysis. In the final section of our survey, we asked the farmers to briefly comment on important future developments and to give us a more detailed explanation of what they expect from certifications and the application of web-based platforms. We clustered our findings into five research areas which we believe deserve further attention. We will briefly discuss them in the following sections and also include several seminal statements of the farmers.

Research area 1: the impact of certification on sales and consumers' perceptions The certification of food products has gained importance over the past couple of years. This can be attributed to numerous food scandals as well as to consumers' growing interest in the origin and quality of their products. As one farmer pointed out: "*What I can observe is that the origin of a food product now is more important for a consumer, especially if they are from Austria, Germany or Switzerland.*" Additionally, certifications might also be a suitable means to shape consumers' perception regarding the quality of a specific product: "*Consumers who buy organic products pay more attention to the origin of the product. They think that regional or local productions of foods are fresher and healthier [. . .] even if it is not so.*" We thus propose the following research questions:

RQ1a. How does the certification of food products impact consumers' perception regarding their quality?

Table 7.
Reasons for not using a web trading platform

Respondent	English version
A	n/a
B	Direct marketing is preferred. Strong relations with major customers
C	Direct marketing is preferred. Farmer delivers directly to end customers
D	n/a
E	Unnecessary
F	n/a
G	Contract production only
H	Marketing through local product trade
I	Farm too small. We market processed products directly to the organic trader
J	Existing relationships with long-term partners on the basis of trust Asparagus and strawberries are sold before they are harvested There are no contracts and no penalties if the harvest does not match the planned amount. Sales are based on personal relationships
K	Delivers directly to dealers
L	n/a
M	Everything from the farm is delivered to private customers
N	Needs to collect more information first
O	No need for such a platform

RQ1b. What is the impact of certification on the sales of food products?

Research area 2: the impact of certification on profitability As we have outlined above, certifications cost money, but they can also positively contribute to a company's image and therefore help to increase the profit margin. The market price for organic and bioproduction can help to increase profitability along the supply chain. However, during the interviews, it turned out that there might be other factors that affect the price more than the bio certification itself. Additionally, it was revealed that substantial price differences for final consumers mainly result from added value in the supply chain rather than being a result of increased production costs: *When you look at the price in the retail store you can see a difference of around 40% for organic and conventional products, but this is a difference for consumers. In fact, the difference in price upon Incoterms "EXW" (from the farm) is not so big and only about 15%.* As one farmer pointed out, having a price premium is not always an option: "*It depends on many circumstances and terms of trading. [...] when we have a surplus of production and the bio certification itself does not affect that situation, we sell organic foods for the same price as the conventional product, sometimes even cheaper.*" Furthermore, it was pointed out that certification is only one determinant of pricing and that other factors might be at least as important for the final consumers' willingness to pay: "*Profitability it is more about quality, logistics and terms of sales and much less about a bio certification for production.*" It is therefore crucial to quantify the exact contribution of a certification:

RQ2. How does a certification contribute to value creation along the supply chain and which market participants benefit the most?

Research area 3: the potential of certifications to reduce the level of retroactive changes in contracts and last-minute order cancellations As is shown in Table 3, during the interviews several farmers pointed out that certifications only mildly mitigate the problems arising from the first two UTPs, namely unilateral and retroactive contractual changes and last-minute order cancellations. We used the qualitative interviews to gain further insights on why this might be the case. A striking feature of most producers of organic products is their small size, which fosters interpersonal communication: "*Personal relationships in our businesses is a key feature and we work on trust. Violations of contracts occur quite rarely.*" These personal relations can even substitute written contracts: "*I did not and do not have any paper contracts with clients, and my clients are several wholesaling companies. When you talk about changes in contracts, for me this means a breach of contract which was agreed upon with a handshake.*" Summarizing, we found that the impact of certifications was fairly limited due to existing market structures that foster personal relations and simple communication channels: *All in all, bio certification by itself does not improve anything because of the small market share of the bio producers.* Hence, we suggest to further investigate the important role of personal relations in supply chains for organic products:

RQ3. To what extent do personal relationships substitute contractual relations for SMEs producing organic products?

Research area 4: the influence of bio certification on the remaining ten UTPs One striking result regarding farmers' assessments of the potential for certifications to positively impact various UTPs was the great range of answers as shown in Table 3. In every category, there was at least one farmer answering with "0", indicating that no positive effect whatsoever exists, while the maximum value that was achieved in all of the categories was an "8". This illustrates huge differences of opinions on this matter and somehow reduces the explanatory power of the mean value. In previous sections, we have already highlighted some of the potentials of certification, but it is also crucial to understand why some farmers do not see much potential. It turned out that at times a certification can even be a disadvantage and leads to additional scrutiny from buyers: "*Sometimes we have to sell our production as conventional products in order to avoid additional laboratory and test controls from powerful buyers. This creates additional obstacles for retail store access rather than simplifies it.* Again, trust and personal relations turned out to be major constituents of market relationships. In spite of clear-cut standards that are frequently publicized and go along with certification, there might still be some distrust on the side of the retailer. As one farmer points out, this can even have a detrimental effect in case the certification procedures are not well-known: "*I would say that there is an impact with an opposite effect. For example, if your products have a bio certification label it does not guarantee easy access to a retail store. On the contrary, many retailers do not believe that you follow all organic certification requirements"*. Finally, one farmer points out that retailers, as the stronger partners in the business relationship, might prefer to impose their own standards on the farmers: "*Bio certification allows the stronger party to impose private standards relating to food safety, hygiene, food labeling, and a minimum remaining shelf life of goods."* Given the big differences in the quantitative assessments, in combination with the qualitative reasoning on why certification might not work out for certain farmers under specific market conditions, we suggest further research into those factors that determine whether or not a certification yields positive results regarding UTPs:

RQ4. What are the contingency factors that determine whether or not certifications contribute to the elimination or mitigation of UTPs?

Research area 5: usage of web-based trading platforms Finally, we asked farmers about their lack of usage of web-based trading platforms. One important insight that we gained was that a fairly large share of the production was sold based on pre-orders, eliminating the need for platforms on the open market: "*Fresh vegetable suppliers like us are working on a production plan that is based on pre-orders. We know with a high probability how much we will have to produce and which price we will finally get [. . .] we just do not need such web trading platforms to sell our products."* Additionally, the farmers pointed out that the usefulness of web platforms also depends on the types of products and their durability: "*These types of platforms are suitable for storable foods such as potatoes, carrots, or cabbage or for farmers who prefer to make direct sales."* Given the wide-ranging needs of farmers depending on the products or market situations, we suggest that further research closely investigates those conditions that might favor the use of web-based platforms:

RQ5. What are the contingency factors that induce farmers of organic food products to use web-based platforms?

5. Managerial implications

Summarizing, the most important findings for managers are as follows:

(1) Bio certification is not the only selling point for farmers but a powerful marketing tool to address end consumers.

(2) The market price for bio production exceeds that of regular production, which increases the level of profitability in raw commodity procurements by +15% and in retail by +40%.

(3) Bio certification reduces the likelihood of several unfair trading practices.

(4) Web platforms do not work equally well for all food producers and make more sense for storable products.

6. Conclusions and further research

Based on the findings from 15 in-depth interviews with certified farmers, we conclude that bio certifications can have several positive effects that can help to partially mitigate several UTPs. First, bio certification can reduce the level of unilateral and retroactive changes to contracts concerning volumes, standards and prices. The main reason for this is that organic producers experience limited competition, which strengthens their position on the market. Second, bio certification can reduce the level of last minute order cancellations. This is possible since certifications restrict the entry of new players in the market, which reduces competition and strengthens the negotiation power of existing market participants. However, in both cases it turned out that these positive effects only hold for some farmers, contingent on their products and existing market relationships.

As far as the remaining UTPs are concerned, the farmers also see minor benefits from bio certification. One benefit is that bio certification improves a product's image among final consumers and increases retail sales. This, in turn, leads to a higher profitability. Organic trade exchanges, such as o-tx.com, rawex.info or biowarenboerse.de can serve as tools to further increase sales or to trigger direct sales. Although not commonly used today, two-thirds of the respondents believe that such platforms will play a larger role in selling food productions in the future. Taken together, the answers from the farmers signaled a substantial potential of certifications and trading platforms that is not yet fully exploited. Further research therefore needs to investigate consumers' perceptions regarding certifications, the impact of certification on profitability, the mechanisms through which certifications can help to reduce UTPs, the role of personal relationships in food supply chains and the acceptance of web-based trading platforms.

This study also points attention to the increasing digitalization of markets in the food industry. The use of technology has the potential to greatly improve market transparency and significantly reduce the incidence of UTPs. One example of how this can be achieved is blockchain which enables increased transparency in value networks (Treiblmaier, 2018) and, in combination with the Internet of Things, opens up new possibilities for modern supply chains (Rejeb *et al.*, 2019). In this regard, the wide availability of information on the activities of manufacturers will drive the spread of bio certification which will provide equal opportunities for all manufacturers.

This study has several limitations. First, the sample size was relatively small, which allowed us to conduct in-depth interviews and to analyze our raw data in much detail. However, this also limits the generalizability of the findings. Organic products and bio certifications are used for a wide variety of agricultural products, and further empirical studies are needed to assess farmers' general sentiment as well as different strategies to respond to increasing competition across agricultural products. Second, this research was geographically limited to Austria and Germany, a region in which bio certificates already play an important role. Further research is needed to explore its importance in different geographical regions in which certifications are less common.

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Reverse logistics uncertainty in a courier industry: a triadic model

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Abstract

Purpose – Due to increasing supply chain complexity, the supply chain uncertainty has become an imperative issue, which hinders the development of modern logistics and supply chain management. The paper attempts to conceptualize reverse logistics uncertainty from supply chain uncertainty literature and present the types of reverse logistics uncertainty in a triadic model.

Design/methodology/approach – The concept of reverse logistics uncertainty is developed based on a triadic model of logistics uncertainty and supply chain uncertainty literature. A desk research is conducted to develop a taxonomy of reverse logistics uncertainty. To better depict the reverse logistics uncertainty, we use case studies to discuss the types of reverse logistics uncertainty in the triadic model.

Findings – The study reveals four types of supply chain uncertainties in the reverse logistics. We call them reverse logistics uncertainty. Type-A and Type-B uncertainty are new types of supply chain uncertainty in the reverse logistics.

Research limitations/implications – The types of reverse logistics uncertainty have not been empirically validated in industries. Especially, the two new types including Type-A and Type-B reverse uncertainty need further exploration.

Originality/value – Although reverse logistics has been discussed in the past decades, very few studies have been conducted on the supply chain uncertainty in returns management arena. The paper offers valuable insights to better understand the supply chain uncertainty in the reverse logistics. This also provides suggestions for both managers and researchers to reflect on the reverse logistics uncertainty management and business sustainability.

Keywords Reverse logistics uncertainty, Supply chain uncertainty, Uncertainty management, Logistics management, Courier

Paper type Conceptual paper

1. Introduction

Both forward and reverse logistics (RL) link the different suppliers, manufacturers, wholesalers and retail stores in supply chains (Govindan *et al.*, 2015). According to the American Reverse Logistics Executive Council, RL is defined as "The process of planning, implementing, and

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controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Govindan *et al.*, 2015).

An effective and efficient supply chain system needs a well-designed distribution channel and logistics network to perform its supply chain activities. The traditional logistics management often focuses on the forward logistics, which is used to control the forward movement of physical good from point of origin to the point of consumption. An RL manages the reverse flow of physical goods from the final consumers to the retailer, manufacturer or recycling (Govindan *et al.*, 2012). Due to the increasing environmental pressure, such as climate changes, population, energy, regulations, pollution, waste reduction etc., firms require the RL to collect, reuse, recondition, remanufacture, recycle, dispose their items to reduce the waste and mitigate the negative impacts and resource shortages caused by economic activities to achieve sustainable development in a long run. RL is a primary component of green supply chain management initiative (Eltayeb *et al.*, 2011; Govindan *et al.*, 2015; Khor *et al.*, 2016).

Strategic outsourcing the transportation and logistics is considered as a strategic solution to reduce the costs (Beier, 1989), especially during the global pandemic crisis, many firms attempted to minimize their costs in every possible way. Using third party logistics providers such as courier delivery is viewed as an effective way to reduce the logistics cost. Today, courier service has been widely used for RL.

Modern RL has been given new meaning in the Industry 4.0 era. Industry 4.0 was described as technologies whose main characteristics involve the integration of physical machinery and devices with network sensors and software, used to predict, control and plan for a new level of value chain organization and management across the life cycle of products (Kagermann *et al.*, 2013). RL enables a circular supply chain and closed-loop life cycle management of products, it is now closely associated with the "sustainability", "waste reduction", "green" and "recycling" (Geissdoerfer *et al.*, 2018; Hervani *et al.*, 2005). This also has positive effects on environment and society (Govindan and Bouzon, 2018). As firms often use a courier service provider (CSP) to perform their returns, for example, to use courier service to collect the return products from customers. In the study, we focus on the RL in the CSP, the definition of the CSP is a logistics firm that provides a courier service to its customers of outsourced (or "third party") logistics and delivery service for part or all of their supply chain management functions.

Supply chain uncertainty is an issue in the CSPs (Wang, 2018). Although studies have discussed the supply chain uncertainty in the logistics and supply chain (Flynn *et al.*, 2016; Simangunsong *et al.*, 2012; Sreedevi and Saranga, 2017), very few studies have been conducted on the supply chain uncertainty in the RL. Moreover, reverses logistics is often viewed as a supportive role in green supply chain management studies (Eltayeb *et al.*, 2011; Govindan *et al.*, 2015). In fact, RL have much more uncertainties than the forward logistics, due to the complexity of the return procedures (Davis, 1993). There is a crucial need to improve the RL performance to support green supply chain initiatives (Eltayeb *et al.*, 2011). In this paper, we proposed the concept of RL uncertainty based on a triadic model of logistics uncertainty. The contingency theory is adopted to further support the study. The triadic model reveals five types of the RL uncertainty in the RL operations. This would provide insights into uncertainty management in RL and sustainability.

The remainder of this paper is structured as follows. First, we introduce the courier delivery. Then, we look at RL and supply chain uncertainty from the existing literature. In the following sections, we offer a triadic model and taxonomy of RL uncertainty that allows us to classify the types of uncertainty in the RL operations. Case studies are presented based on the triadic model to help readers to better understand the types of RL uncertainties. The subsequent sections provide the conclusion and recommendation.

2. Courier delivery

Typically, a courier service is started from a pickup; once a courier company received a request from a customer, the origin courier depot arranges for a courier pickup. The pickup courier usually uses a relatively small vehicle/van to collect the parcels from the shipper to the local depot. In the origin depot, the parcels are consolidated, then a larger vehicle is used to deliver the freight to the central hub. In the case that a client has a special requirement, such as a large volume of parcels movement, a trailer can often be arranged for the customer. In such situations, it is likely that the lorry / truck will take the parcels direct from the customers' site to the central hub.

Before leaving the hub, parcels are sorted into delivery regions and consolidated with other parcels destined for the same area. They are then transported from the hub to the destination courier depot. Once the parcels reach the destination depot, they are sorted ready for local distribution to their final destination. Following delivery of the parcel, a number of additional value-added services may be offered, such as obtaining a proof of delivery signature, collection of a payment.

If a parcel that has been successfully delivered requires returning to its shipper, the reverse process occurs. It is picked up by the local depot driver, labelled with a return identification number / paperwork, and then transported back to the shipper via the central hub and then the shipper's local depot. Returns are often the results of forward logistics and may be redirected into forward logistics systems after proper processing (Wang *et al.*, 2017). There are two common types of courier delivery service including domestic and international. The following subsections depict the domestic and international courier delivery.

2.1 Domestic courier delivery

Please note that the activities may vary in different CSPs, the typical domestic courier delivery provides a snapshot in the New Zealand (NZ) courier industry. Generally speaking, the domestic courier service is comprised of six separate activities The set of transactions in the transportation chain are (1) a domestic pickup courier collects a parcel from a shipper (the sender of a parcel); (2) and transports the parcel to an origin depot; (3) an origin depot consolidates it for air or road transit; (4) an subcontract air or road carrier transports the parcel to a destination depot; (5) the destination depot separates or deconsolidates the parcels under different delivery addresses and (6) delivery couriers delivers the parcel to its final destination (Figure 1) (Wang, 2016).

2.2 International courier delivery

The international courier service has similar transportation chains. However, more activities and regulated processes may be involved (i.e. customs clearance, security screening) in an

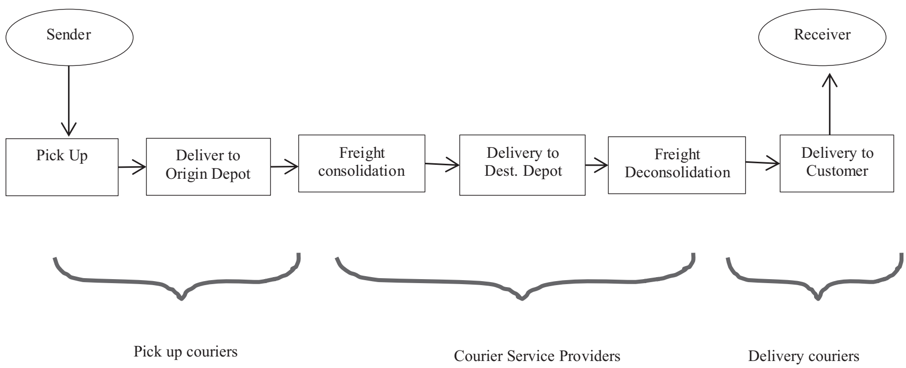

Figure 1.
The typical domestic courier delivery
Wang (2016)

international courier delivery. Each courier company may have different international courier partners in different countries or use own company's overseas network. Courier companies may use in-house customs brokers or freight forwarders to process customs clearance and then book the cargo with international airlines to do international air transport in most flight routes.

The international courier service is comprised of nine separate activities. The set of transactions in the transportation chain including (1) an international pickup courier collects a parcel and customs paperwork from a shipper (the sender of a parcel); (2) and transports the parcel to an origin depot; (3) an origin depot forward all the international items and paperwork to an international freight agent; (4) the international freight agent processes all the items and paperwork and consolidate the international items depend on the different destination countries; (5) an subcontract air or road carrier transports the parcel to a destination country; (6) an foreign freight forwarder organizes customs clearance and trucking service from destination airport to an foreign courier company's depot, (7) the foreign courier company's depot performs similar processes (i.e. consolidation or deconsolidation); (8) the final destination depot separates or deconsolidates the parcels under different delivery addresses and (9) a foreign delivery courier delivers the parcel to its receiver (Figure 2) (Wang, 2016).

Obviously, an international courier delivery is much more complex than a domestic delivery. There are more parties and regulated processes involved in the international transaction. And each company may have different policies and processes for international freight. Courier delivery has become a popular and effective way to move small items in

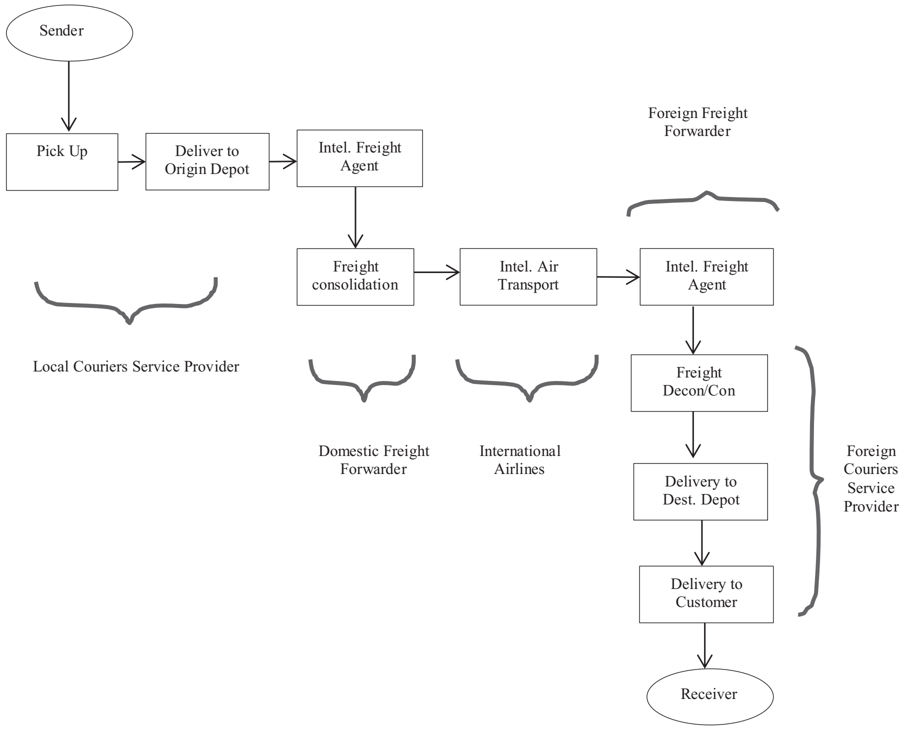

Figure 2.
The typical international courier Wang (2016)

today's businesses. Therefore, it is significant to know both domestic and international courier services.

3. Theoretical background

3.1 Modern reverse logistics

Modern RL is viewed as an important part of green supply chain management (GSCM) (Eltayeb *et al.*, 2011). Although the green supply chain was later used by many scholars with various names, such as reverse supply chain, sustainable supply chains, closed-loop supply chain, circular economy (Franco, 2017), circular supply chain, the meaning of itself has not changed much. In literature, GSCM is defined as GSCM = Green Purchasing + Green Manufacturing / Materials Management + Green Distribution / Marketing + RL (Hervani *et al.*, 2005). Green supply chain management may reduce waste, minimize pollution, save energy, conserve natural resources and reduce carbon emissions (Sundarakani *et al.*, 2010). In this study, we study its most basic meaning RL and its uncertainty in a courier and logistics operations.

RL is a process to return the products and materials from the point of consumption to the forward supply chain (Amin and Zhang, 2012). The three main drivers that motivate companies to adopt RL are identified as economic, corporate citizenship and legislation (Breen and Xie, 2015) and main purposes of RL including reuse, remanufacturing and recycling (Eltayeb *et al.*, 2011). RevLog (the European working group on RL) described the RL as "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal". More precisely, RL is the process of moving goods from their typical final destination for the purpose of capturing value or proper disposal (Khor *et al.*, 2016). Today, remanufacturing and refurbishing activities are included in the RL (Govindan *et al.*, 2015). Besides, RL includes processing returned merchandise due to damage, seasonal inventory, restock, salvage, recalls and excess inventory. The return process also includes different programs, such as recycling programs, hazardous material programs, obsolete equipment disposition and asset recovery. Moreover, RL is one of the five basic categories of green supply chain initiatives (Eltayeb *et al.*, 2011).

Rubio *et al.* (2008) analyse the main characteristics of articles on RL published in the production and operations management field from 1995–2005, three fundamental areas of research on RL including (1) management of the recovery and distribution of end-of-life products; (2) production planning and inventory management and (3) supply chain management issues in RL. Wang *et al.* (2017) provides a bibliometric analysis of RL research from 1992 to 2015, this study found that RL research started with a focus on costs and specific solutions to operational problems and has increasingly emphasized strategic issues. On the operational side, research has already demonstrated that operational RL includes multiple processes, including source reduction, product returns, reuse, recycle, disposal, repair, remanufacturing and resale. On the strategic side, researchers have moved beyond minimizing cost and improving efficiency as the sole objective of RL to study RL value, network design and RL's interfaces with other management areas.

Although many RL studies have been published in literature, very few RL researchers addressed the RL uncertainty issues. For example, Turrisi *et al.* (2013) studied the impact of RL on supply chain management. Hazen *et al.* (2014) suggest information systems play a substantial role in managing RL (RL) processes. Guo *et al.* (2017) studied supply chain contracts in RL. Morgan Tyler *et al.* (2016) found the positive moderating influence of an IT competency on the relationship between collaboration and an RL competency. Dev *et al.* (2020) attempts to model the RL in Industrial 4.0 technological real-time information scenarios.

RL is now closely related to the "sustainability", "waste reduction", "green" and "Recycling" (Wang *et al.*, 2017). RL is viewed as a part of logistics and supply chains. It is essential to understand that the operational process of RL is different from the forward logistics and involves the implementation of material disposition management rules (Govindan *et al.*, 2012). In addition, the prime objective of RL is to enable the product to get its maximum value even at the end of its market life. There are various types of activities involved during the process of RL for the purpose of achieving its objective, such as packaging, repair, refurbishment, restoring, recycling, transportation and disposal. In this study, we focus on transportation in the courier industry.

3.2 Supply chain uncertainty

Uncertainty is complex, there are many ways to understand the uncertainty from various perspectives. First, we seek the general definition of uncertainty from Oxford English Dictionary; it is the quality of being uncertain in respect of duration, continuance, occurrence, etc.; liability to chance or accident. Also, the quality of being indeterminate as to magnitude or value; the amount of variation in a numerical result that is consistent with observation. The other definition of uncertainty under economics is a business risk which cannot be measured and whose outcome cannot be predicted or insured against. This study focuses on the RL uncertainty, which is a type of supply chain uncertainty.

Knight (1921) illustrated that the uncertainty is immeasurable. Miller (1992) argue about the uncertainty refer to the unpredictability of environmental or organizational variables that impact business performance or the insufficient information about these variables. Logistics uncertainty may occur when decision makers cannot estimate the outcome of an event or the probability of its occurrence (Sanchez-Rodrigues *et al.*, 2008). People can use the best forecasts and do every possible analysis, but there is always uncertainty about future events. It is this uncertainty that brings risks (Waters, 2011). There is a very close relationship between risk and uncertainty, because uncertainty increase the possibility of risk occurrence, and risk is a consequence of uncertainty. In other words, risk occurs because of uncertainty about the future, this uncertainty means that unexpected events may occur, and when these unexpected events occur, they cause some kind of damage. Although uncertainty and risk often are interchangeable (Wang *et al.*, 2015), in this study, we deliberately focus on the uncertainty in logistics and supply chain. One of the main reasons is that the triadic model is designed for RL uncertainty.

Davis (1993) establishes an uncertainty cycle and states that the supply chain uncertainty is caused by the supply chain complexity and uncertainty propagates through a manufacturing network. Three distinct sources of uncertainty including suppliers, manufacturing and customers have been revealed in this study. Mason-Jones and Towill (1998) presents a simple generic supply chain uncertainty model, including types of uncertainty from demand side, supply side, manufacturing process and control systems. Wilding (1998) develops a supply chain complexity triangle, which adds a new type of uncertainty-parallel interaction which is the situation where there is interaction between different channels of the supply chain in the same tier. This may demonstrate that interactions between parties in supply chain is a type of uncertainty. Later, researchers look at the supply chain uncertainty from the macro and micro levels and causes of the uncertainty. Such as Prater (2005) suggests that supply chain uncertainty can be divided into two levels; macro level uncertainty refer to risks due to disruptions and macro level uncertainty is a higher level category of uncertainty, whereas micro level uncertainty relates to a more specific source of uncertainty, studies the main causes of contingent uncertainty in transport operations, identifies the three types of supply chain uncertainty including customer side, company side and environment in the Australian courier industry.

Supply chain uncertainty has both positive and negative impacts on the forward logistics performance (Wang, 2018). In this paper, we predominantly focus on these negative impacts because these uncertainties could cause problems and inefficiency in supply chains (Davis, 1993). We live in an uncertain world, it is difficult to eliminate all uncertainties. Coronavirus disease 2019 (COVID-19) demonstrates a perfect example of supply chain environmental uncertainty. Having said that, it is important to mitigate the negative impacts of supply chain uncertainty in RL. To manage these supply chain uncertainties, the first predominant task is to identify and understand the types of supply chain uncertainty in the RL. Therefore, we proposed a triadic model of RL uncertainty based on the logistics triad (Beier, 1989) and a simple courier RL process consisting of three parties. The following section will introduce the new triadic model.

4. A triadic model of RL uncertainty

The first logistics triad consisting of shipper (consignor), carrier and receiver (consignee) was established by Beier (1989). Later, Larson and Gammelgaard (2001) defined a logistics triad as a cooperative, three-way relationship among a buyer of goods, the supplier of those goods and an CSP moving and/or shoring the goods between buyer and supplier used the logistics triad to develop five uncertainty sources that can have negative impacts on transport operations. In this study, a triadic model of RL uncertainty is drawn based on an extensive literature review and practical RL operations in a courier industry.

This study provides a different view on the RL uncertainty. Modern supply chain is better equipped, most sources of uncertainty can be managed by various new technologies. This study attempts to identify the types of RL uncertainty based on the interactions among three major parties including courier services provider, consignor/ return customer and consignee / return receiver. The four types of uncertainties in the triadic model are depicted in a RL transaction.

In the triadic model, the CSPs' focus is to deliver products or materials back from customers to a forward supply chain. In a forward logistics, firms focus on the cycle time, delivery time and lead time. However, form the RL operation's perspective, the customers play a vital role in the RL delivery, as a parcel return processing starts from a pickup, the customer need to collaborate and work with CSP to complete the return pickup, but the individual customers are often unable to control the pickup time. Previous study indicates that high percentage failure rate was caused by incorrect pickup (Wang *et al.*, 2015). Another example, if people missed the rubbish collection time, the rubbish would not be collected until next time. Customer is one of the important sources of uncertainty, which could directly lead to the service failure in a RL operation. In addition, both consignor and consignee are important in the RL. Thus, we keep the consignor and consignee in the triadic model. Figure 3 shows a triadic model of RL uncertainty in this study.

The supply chain uncertainties in the RL are various due to the complexity of RL in real-world operations and many unknown factors or risks. It is impossible to capture every single uncertainty in the RL, as each return may have different elements and requirements, which may occur more uncertainties. However, serial interactions in RL occur between each party in the supply chain, i.e. a return customer and a CSP. We focus on the interactions among the firms and customers in the RL, the supply chain uncertainties are categorized as four types. Two brand new types of supply chain uncertainties have been established based on a well-known study Wilding (1998). Both Type-A and Type-B uncertainties are derived from the interactions between different parties; more specifically, Type-A uncertainty is derived from the interactions between CSP and its customers including both consigner and consignee in this study because both parties involve in a delivery and return. Therefore, the Type-A uncertainty is applied for both parties; Type-B uncertainty is derived from the interactions only between consigner and consignee.

The triadic model maps a simple and basic RL process and offers directions to identify the different types of uncertainty in the RL. We indicate three types of flows including psychical goods flow, information flow and financial flow in the model. In this paper, we did not

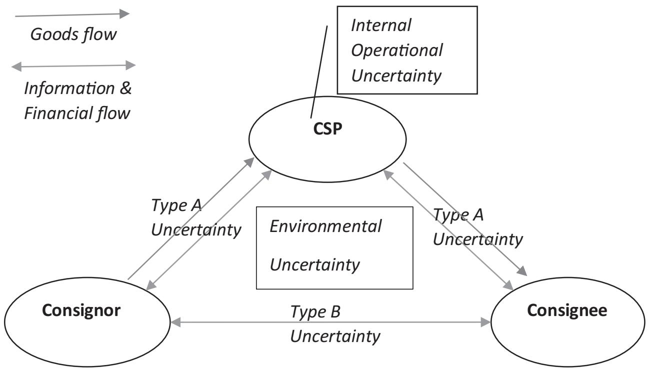

Figure 3.
A triadic model of RL uncertainty

differentiate information and financial flow, the psychical goods flow is only considered between CSP and consignor or consignee in this basic model. This helps both researchers and practitioners to better understand the supply chain uncertainties in the RL.

(1) *Internal operational uncertainty* refers to the RL uncertainty predominantly occurs within logistics firms during the reveres logistics delivery. For example, health and safety at work, the failure in daily operations, missing freight, damages, transport delay, etc. (Davis, 1993; Simangunsong *et al.*, 2012; Wang *et al.*, 2014)

(2) *Type-A uncertainty* refers to the RL uncertainty predominantly occurs between CSP and customers including consigner or consignee, the interactions consisting of physical goods, information and financial flows. This type A uncertainty may directly influence customer satisfaction.

(3) *Type-B uncertainty* refers to the RL uncertainty predominantly occurs between the consigner and consignee; the interactions mainly consisting of information and financial flows. CSP is not directly involved in this Type-B uncertainty. For example, communications, payment and goods refund between consigner and consignee.

(4) *Environmental uncertainty* refers to the RL uncertainty predominantly occurs in the external environment. For example, COVID-19 pandemic, China–US trade war, natural disasters, policy, fuel price, etc. (Sanchez-Rodrigues *et al.*, 2009; Wang, 2018).

These four types of uncertainties may cover all major uncertainties in the RL services. The internal operational uncertainty typically originates from the CSPs. This type of uncertainty is considered as a control uncertainty (Davis, 1993). Type-A and Type-B are two new types of uncertainty are developed based on the study Wilding (1998), both types of uncertainties predominantly occur during the situation where there are interactions between different stakeholders in the triadic model. This study describes interactions that occur between different stakeholders including CSP and customers in the same RL channel. More specifically, Type-A uncertainty describes the relevant supply chain uncertainties between the CSP and its customers, this may include the situation where there are multiple CSPs in the same RL transaction. Type-B uncertainty describes the relevant uncertainties between the consigner and consignee, this may include the situation where there are multiple customers (>2) in the same RL transaction. Sometimes, if multiple customers and CSPs have been involved in the same RL process, Type-A and B uncertainty can still be applied into the cases. The environmental uncertainty has been often mentioned in previous studies (Wang, 2016; Wang and Jie, 2019). It is from external uncertain environment. A taxonomy for supply chain uncertainties in a RL service is presented as follows.

5. Taxonomy of RL uncertainty

Up to now, according to the published papers from Scopus database, which providing the most comprehensive coverage (Rovira *et al.*, 2019), there are very few studies conducted on RL uncertainty, which are crucial to the success of the green supply chain initiatives, as RL is one of the five basic categories, they are eco-design, green purchasing, supplier environmental collaboration, customer environmental collaboration and RL (Eltayeb *et al.*, 2011). This section presents a taxonomy for supply chain uncertainty in a RL (see Figure 4). There are four types of RL uncertainty including internal operational uncertainty, Type-A uncertainty, Type-B uncertainty and environment uncertainty in the triadic model. The impacts of RL uncertainty are briefly discussed at end of this section.

5.1 Internal operational uncertainty

The internal operational uncertainty has been widely discussed in the previous studies (Davis, 1993; Sanchez-Rodrigues *et al.*, 2010). This type of RL uncertainty occurs in the internal operations within CSPs. For example, the advanced equipment and new technologies have been widely used in the logistics and the transport industry during the Industry 4.0 era, this may directly improve the logistics performance. However, the equipment failure and incorrect using could lead to uncertainties, which may cause potential issues. Many internal uncertainties cannot be eliminated, but the negative effects of these internal uncertainties may be reduced and minimized (Davis, 1993). This type of uncertainty inherent in the company operations, and each logistics company may have its own internal uncertainties, as each one has different logistics capability, return procedures, equipment, delivery network, personnel and company's structure and policy (Wang, 2016).

5.2 Type-A uncertainty

Type-A uncertainty is a new type of supply chain uncertainty. This type of uncertainty may include all the uncertainties between CSP and customers who are either business customers or individual customers. Individual customers may have a higher level of Type-A uncertainty than business customers from a CSP's point of view, due to the customers' characteristics, and often there is a long-term business relationship between CSP and business customers rather than the personal customer. We consider that Type-A is the most important type of uncertainty in the RL. Some examples of the Type-A uncertainty are delays due to customers' mistake, lack of communication between CSP and customers, insufficient capability to meet customers' requirements, etc. Many customer-related factors may easily turn into a Type-A uncertainty. There are several important factors in the Type-A uncertainty being listed as below.

5.2.1 Volume of return. The volume of return could directly influence the performance of the return processing and the charging for the different volume of return is different, as many CSPs have separated freight processing for the bulk delivery and small parcels delivery.

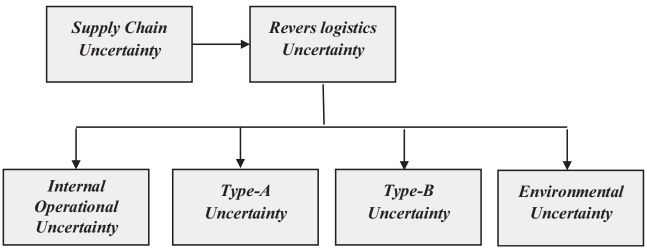

Figure 4.
Taxonomy of RL uncertainty in this study

The returns need to be processed by correct return procedures to avoid any unnecessary delay and failure. Service providers may pay more attention to the individual customers.

5.2.2 Error and mistake from customer. Error and mistake from customers may directly lead to the failure, for instance, the delivery or pickup address is not clear or incorrect, the return item has not been packed correctly and the relevant return paperwork has not been completed such as custom declaration form, dangerous good declaration form, return form, etc.

5.2.3 Return frequency. Return frequency means how often a customer returns the items. Return frequency is one of the crucial dimensions in RL. The CSPs need appropriate strategies for different customers to minimize the costs and improve the performance of services. This uncertainty could be reduced and eliminated depending on the situations, for instance, a business customer such as a retailer has higher return frequency than an individual customer, and the CSP may offer regular pickup service and dedicated return services for the business customer to reduce the uncertainty.

5.3 Type-B uncertainty

Type-B uncertainty refers to the supply chain uncertainties between consigner and consignee. As discussed before, Type-B uncertainty is considered as a type of uncertainty, which is derived from the interactions between consigner and consignee, they may directly influence the performance of returns. RL is much more complex than a forward logistics, in the RL, often all parties including consigner, consignee and CSP are involved prior to a RL start. Although this Type-B uncertainty often does not directly involve the physical goods movement, it can influence internal operational uncertainty and Type-A uncertainty. For example, poor communication between consigner and consignee, insufficient pickup address, and unpaid delivery cost, etc. And most Type-B uncertainties are related to the information and financial flows.

5.4 Environmental uncertainty

Environmental uncertainty is one of the most common types of supply chain uncertainty in the forward logistics studies (Mason-Jones and Towill, 1998; Sanchez-Rodrigues *et al.*, 2009; Wang, 2018). This type of uncertainty often occurs in the external environment and indirectly influences the internal logistics operations. In addition, environmental uncertainty can influence other types of supply chain uncertainties including Type-A and Type-B uncertainties. COVID-19 pandemic is an example of environment uncertainty, it can cause various supply chain uncertainties and has direct or indirect impacts across the supply chains including RL. Other important environmental uncertainty may include technologies, market competition, economic environment, consumer behaviour, government and regulations, etc. (Wang, 2011; Wang and Jie, 2019). Some significant trends may become the external uncertainties of return, which influence the RL activities. The trends include globalization, offshoring, customization and Industry 4.0. Figure 2 illustrates the taxonomy of RL uncertainty. The following subsection discusses the impacts of supply chain uncertainties and provides some resolutions and suggestions for managing the supply chain uncertainties in the Industry 4.0 era.

5.5 Impacts of RL uncertainty

The impacts of RL uncertainties are significant. Typically, the impacts of logistics uncertainty on sustainable transport operations are negative (Sanchez-Rodrigues *et al.*, 2009). The uncertainties may directly influence many aspects in firms and supply chains. For example, increasing the lead time–lead time is always predominant in logistics and supply chain activities, and many RL uncertainties are directly related to the lead time, such as unexpected delays, customer complaints, extra storage costs, etc. Therefore, it is significant to minimize and even eliminate the uncertainties in an RL system.

Cost is an essential key performance indicator (KPI) in firms. RL uncertainties may increase the cost significantly, for instance in a courier delivery, a negative pickup job, which means an incorrect pickup job, is normally caused by the Type-A uncertainty between CSP and consignor such as wrong item, insufficient pickup address and poor communication. The negative pickup job increases both the delivery time and the cost, as couriers have to re-pickup it. Besides, various extra costs could be further caused by various uncertainties such as overtime costs, extra operation cost, etc.

Uncertainty may break the supply chain relationships among the parties in a RL, and this phenomenon normally is resulted from the Type-A and Type-B uncertainties such as vague requirements of return, payments, insufficient information sharing, etc. Besides, the internal operational uncertainty may influence the inter-organizational relationships.

6. Case study

We have described a triadic model for identifying and assessing supply chain uncertainty and its impacts from a RL operation perspective in the preceding pages. Some practitioners may question so what? Next, we will describe a few cases of the successful example of adopting different ways to reduce the types of RL uncertainty based on the model. This may shed light on RL uncertainty management. The first is about the parcel tracking system in NZ Couriers. The case shows that the technologies may be used to help reduce the types of RL uncertainty in our triadic model. The second case descries the situation how Apple manages its returns in NZ. This demonstrates that a good return process design can also help reduce the supply chain uncertainties in the model. In the final case, we will present some results that clearly indicate the types RL uncertainty in the triadic model.

6.1 New Zealand couriers

Information sharing is predominant in logistics and supply chain. As discussed previously, green supply chain, circular supply chain or closed-loop supply chain encompasses both forward logistics and RL. The RL information sharing ensure complete supply chain information sharing (Hayrutdinov *et al.*, 2020; Lee *et al.*, 2018). New Zealand Couriers (NZC) is a leading provider of network courier services to NZ businesses. NZC has successfully implemented the technologies into their delivery service to track and trace the parcels. There are emerging technologies in Industry 4.0, such as big data, artificial intelligence (AI), Internet of things (IoT), and they can help courier firms to further improve the RL system design (Dev *et al.*, 2020). The barcode technology is used as a successful example of RL information sharing, as it often can be found in an integrated courier tracking system. The barcode technology has been well-used to record delivery information and status in NZC. The barcode's information is difficult to be modified or changed during a courier delivery process and this would result in fewer mistakes or errors and in turn lead to lower uncertainty of a return logistics process. This would help reduce the internal operational uncertainty and Type-A uncertainty. In addition, each consignment ticket barcode is a unique identification of the parcel during the courier delivery process. This allows different parties to share the parcel delivery information that has been digitalized in a real-time system. As the RL information sharing is an important part of the product life cycle information sharing, which increases the profit of the whole chain and decreases with the increase of customer's price sensitivity coefficient (Hayrutdinov *et al.*, 2020). Every time the barcode is scanned by different parties such as pickup couriers, depot staff, truck drivers, delivery couriers during the delivery process, the RL information is recorded and uploaded to online database. Different stakeholders also can use the information for different purposes, such as the delivery verification, financial report, returns management etc. Thus, a wealth of information generated by the tracking system would help reduce the Type-A uncertainty and Type-B uncertainty in the model. The firm may use big data analytics to create value for customers and support decision-making (Govindan and Bouzon, 2018). Moreover, the RL information sharing maximizes the value of information across the supply chains, it improves predictability and allows different stakeholders to collaborate and share the delivery information during a return delivery. This also helps the stakeholders to against the environmental uncertainty.

6.2 Apple return process

Apple Inc. is an American multinational corporation that designs and markets electronics such as computer software, mobile phone, personal computers, etc. The company's best-known hardware products include the Macintosh line of computers, the iPod, the iPhone and the iPad. Apple establishes a well-rounded reverse supply chain to develop a sustainability strategy. Apple's reverse supply chain strategy focuses on collaborating closely with third party logistics (3PL) companies (Kumar *et al.*, 2012). There are no official Apple Stores in NZ. Apple uses third party courier companies to distribute its products from its warehouse directly to the NZ customers and so is the RL. In this Apple return case, a customer contacts Apple online store customer services team to request a product return such as exchange, refund, damaged and wrong order in NZ. Once Apple Store receives the return enquiry, it will be processed case by case. Apple may refuse or accept the return request. The rejected return enquiry will be ended without further logistics process. If the return has been authorized, the customer will be informed and receive a pre-printed delivery consignment note with the detail information including return address, pick up address and contact person. The customer follows the instructions to print and attach the label on the return items. The courier dispatch team then arranges a courier pick up for the return. After return items reach the TNT depot, the forward logistics process will be performed for the return delivery. If some issues occur, for example incorrect pickup address, the courier customer service team will contact Apple to get an updated information. Then a new courier job will be generated to pick up the item. The Apple return process simplifies the information flow and operations among the parties during the return processing. Childerhouse and Towill (2003) emphasized that the simplified supply chain flow facilitated supply chain integrations, reduced the supply chain uncertainty and suggested that firms can improve their ability to handle returns through supply chain collaboration. Overall, the well-deigned, standardized and simplified return process with supply chain integration and collaboration can help reduce all types of the RL uncertainty in the Apple case.

6.3 Interpreting findings

We develop RL in the triadic model including CSP, consignee and consignor to demonstrate an underlying mechanism for RL uncertainty from RL perspective. The supply chain uncertainty predominantly occurs during the interactions (Wilding, 1998). Consequently, four types of RL uncertainty including internal operational, Type-A, Type-B, environmental are emerged. RL uncertainty is derived from supply chain uncertainty. Although supply chain uncertainty is unpredictable and immeasurable (Wang, 2018), some RL uncertainties can be managed or reduced through several ways in this model, we used the first case to show that the technology may be an effective way to reduce the uncertainty in a courier delivery, which is a popular delivery method for goods return. The second case is Apple return process in NZ, which may demonstrate that a good business process design help reduce the supply chain uncertainties in the model, such as simplification, standardization, gate keeping.

Many firms' return process is similar to the Apple returns in NZ. Another example, OfficeMax *officemax.co.nz*, which is a large American office supplies retailer for office supplies, solutions and services as well as workplace products and furniture. Its supply chain focuses on cross-functional alignment and supply chain efficiencies (Slone *et al.*, 2007). OfficeMax recently closed its 14 shops across NZ and shift operations online. It uses a centralised RL system to handle all its returns from both individual and business customers in NZ. Based on the triadic model, one of the significant facets could be found from these return cases is that the consignor no longer requires to arrange a return delivery with CSP, consignor only needs to contact the consignee to book the delivery instead of CSP. The consignee works with the CSP to arrange the returns. This has significant impacts on Type-A and Type-B uncertainties, as the CSPs only have to deal with one party which is consignee, instead of dealing with both parties–consignee and consigner simultaneously. However, this requires consignee to pay more attention on the Type-B uncertainty in the RL.

Another significant facet is that the CSP plays a central role to manage the entire return process in the modern RL. Such as Apple and OfficeMax use CSPs to perform RL operations in NZ, and both has a centralised RL system, which enable consignee to maintain a good gatekeeping. This is used to filter the defective and unauthored return items and products at the entry point into the return/RL channel (Govindan *et al.*, 2015; Guo *et al.*, 2017). This also promotes both internal and external supply chain integrations and collaboration between firms and CSP to achieve a green/circular supply chain (Kumar *et al.*, 2012; Slone *et al.*, 2007). The Type-A uncertainty between CSPs and consignor may be minimized and transferred to Type-A uncertainty between CSPs and consignee and Type-B uncertainty between consignor and consignee.

Further, the triangle relationship of RL may reveal that the customer service plays a vital role to help reduce RL uncertainty, the results are in line with previous supply chain uncertainty studies in forward logistics (Amin and Zhang, 2012; Hayrutdinov *et al.*, 2020; Sanchez-Rodrigues *et al.*, 2008). As Type-A uncertainty between CSPs and consignor can be managed by consignee in a centralized logistics system by adopting a well-designed return system, i.e. Apple (Kumar *et al.*, 2012), supply chain contract and a long-term supplier-buyer relationship between CSPs and consignee (Guo *et al.*, 2017) also can overcome the Type-A uncertainty. The Type-B uncertainty trends to predominate the RL uncertainty in the model, customer is a major source of uncertainty (Wilding, 1998). The customer demand in almost every industrial sector seems to be more volatile than was the case in the past, and the supply chain uncertainty has many significant impacts on the customers (Christopher and Lee, 2004). The customer-side uncertainty is a major part of supply chain uncertainty and risk in a forward logistics (Wang, 2018). In the case study, OfficeMax offers dedicated account managers to serve its customers and solve problems, and its cross-functional alignment can better support customer in RL. Therefore, we suggest that superior customer service is key to manage the Type-B uncertainty.

7. Conclusion and recommendation

In this conceptual paper, according to the contingency theory, we investigate the supply chain uncertainty in a RL, which is different from a traditional logistics (Richey *et al.*, 2005). RL is not a new industrial practice. However, it has received increased attention and been given new meaning including the “green”, “circular”, “waste reduction”, “sustainability” in the modern supply chains (Franco, 2017; Khor *et al.*, 2016). As more firms emphasized the environmental aspects in their supply chain management, environmental consideration has become one of the most important drivers in the development of RL (Eltayeb *et al.*, 2011; Kumar *et al.*, 2012).

This study identified four types of RL uncertainties in the triadic model, they are internal operational uncertainty, Type-A uncertainty, Type-B uncertainty and environmental uncertainty. Several case studies have been used to demonstrate the types of RL uncertainty in NZ context. In literature, RL comprise various activities (Govindan *et al.*, 2015). We focus on the RL transportation in a courier industry due to the essence of the study and popularity of courier service in the modern RL.

7.1 Research implications

This study provides both theoretical and managerial implications and significantly contributes to the research stream of RL uncertainty. RL includes a wide range of activities across supply chain, as there are no standardized return procedures in industries. In addition, the consignee and consignor are often from the different firms, thus this makes the return situations even more complex. Therefore, we focus on the courier transportation based on the model, Type-B uncertainty may influence the Type-A uncertainty. For example, the return volume among logistics company, consigner and consignee is a critical uncertainty, which is concerned by CSPs. The volume of return also influences the economies of scales, i.e. the costs of transportation of full container load (FCL) is much cheaper than that of less than container load (LCL). Thus, we suggest that CSP should understand the return procedures between the consignee and consigner and offer routine RL design / service to better help mitigate the Type-B uncertainty, as Type-B uncertainty is closely associated with other RL uncertainties in the model.

Due to the modern supply chain complexity, the RL requires an integrated information system to link the different parties in a return procedure (Hazen *et al.*, 2014). Information system is one of the important elements in logistics and supply chain (Hervani *et al.*, 2005; Wang *et al.*, 2021). It helps information sharing across entire supply chain. In our case study, NZC applied technologies to facilitate the delivery information for different parties in a RL delivery. Further, information system enables RL information sharing in supply chains, and many studies discussed the impacts of information sharing in the forward logistics management, one of famous simulations is the MIT Beer Game. The information sharing may reduce supply chain uncertainties (Wang *et al.*, 2015). Moreover, information sharing and transparency may improve the supply chain relationships between CSPs and customers, the benefits of which are beyond we can imagine. In the Industry 4.0 era, emerging technologies such as IoT, blockchain, AI, big data, etc. may offer many new opportunities and ideas to deal with these types of supply chain uncertainty in the RL. Future study may investigate the particular technology and its implications on RL uncertainty.

There are various return activities in the return procedures. Many firms do not only receive the return items, but also, they manage the returns (Govindan *et al.*, 2015; Kumar *et al.*, 2012). This require supply chain collaboration and integration in RL (Morgan Tyler *et al.*, 2016). In the case study, we reviewed the Apple return process, the return items may be remanufactured and refurbished in manufacturers, this may include recall products, outdated products, etc. while some return items have to be disposed such as un-reusable materials, battery, etc. (Kumar *et al.*, 2012). A centralized logistics system has been proved as an effective and efficient supply chain system in previous studies (Christopher, 2005; Slone *et al.*, 2007). The RL system could maximize the efficiency of entire system and reduce the various costs such as operations costs, inventory costs, etc. in order to improve the performance in a system wide (Dev *et al.*, 2020). The centralized RL system can be widely employed in the RL services. Therefore, this may offer resolutions for firms to achieve the economies of scale and reduce uncertainty in the RL.

Other types of RL uncertainty including internal operations uncertainty and environmental uncertainty are important facets in the RL triadic model (Sanchez-Rodrigues *et al.*, 2009). Although they have been well-discussed in forward logistics and supply chain studies, very few studies have been conducted to analyse these types of supply chain uncertainty in RL operation. The trends of environmental factors directly influence the RL. Such as landfill costs have increased steadily over recent years and are expected to continue to rise; products can no longer be land-filled because of environmental regulations; economic and environmental considerations are forcing firms to use more reusable packaging, totes and other materials; producers are required to be recycled at the end of their lifetime (Khor *et al.*, 2016).

As all parties are required to work together to perform a return from the point of consumption to the point of origin, the supply chain relationship management is important in RL management. There are many different types of relationships in supply chains, such as alliance, outsourcing, contract, casual, etc. (Guo *et al.*, 2017). However, stable and good supplier–buyer relationships and supply chain collaboration benefit all parties and may help to overcome some uncertain factors and optimize the return performance in the long run. To simplify the RL flow, the CSP is able to offer appropriate value-added services for customers. The characteristics of returns include a wide range of factors; some of which have been discussed in this study. Some solutions may be used to reduce this uncertainty, i.e. pre-arrange the delivery, routine services, centralized RL system and new Industry 4.0 technologies. These may shed light to manage the RL uncertainty in the modern supply chains.

7.2 Research limitations and future researches

This study includes several research limitations, the types of RL uncertainty are developed based on a logistics triad model and previous supply chain uncertainty studies. Because there is very limited number of published RL uncertainty studies. We used a desk research technique and descriptive analysis to understand the RL in the case study, this may limit the completeness of the results, we may not observe all the phenomena. As this is the first attempt to investigate the RL uncertainty, we only focus on a courier RL transportation in order to generalize more in-depth RL uncertainty results based on current available data and researches. The types of RL uncertainty have not been empirically validated in industries. Especially, the two new types including Type-A and Type-B uncertainties need further exploration, for example, more in-depth explanations on the hypothesized relationships among the uncertainties are required. But these research limitations offer plentiful future research directions to further examine the RL uncertainties from various angles, as there is a lack of relevant research in RL uncertainties.

Moreover, the logistics triadic model of RL uncertainty is first time published in the paper, we suggest that the triadic model needs further development from different perspectives to cope complex scenarios and represent complexity of modern logistics and supply chains. Researchers may merge the logistics triadic model with circular supply chain or intertwined supply chain to support the latest trends in logistics and supply chain management researches. More further researches may be conducted to understand the types of RL uncertainty and their interdependent relationships in a circular supply chain. Managers often have to consider the entire supply chain design and optimization. It is predominant to investigate factors which may hinder development of RL from different perspectives for different purposes across supply chains. This article contributes to the modern RL and supply chain management literature. Further researches may be conducted to distinguish the internal operational uncertainty and environmental uncertainty in forward and RL operations. This would provide further support to managers to continue improving the RL operations in a green or circular supply chain.

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