MODELLING AND INTEGRATED RISK MANAGEMENT IN TRANSPORT LOGISTIC NETWORK -A CASE STUDY OF AGRO FOOD PRODUCT

by

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ABBREVIATION

AFTL	Agro Food Transport Logistic
AHP	Analytic Hierarchy Process
ALARP	As Low as Reasonably Practicable
BN	Bayesian Network
BRB	Belief Rule Base
BR-BN	Belief Rule-Based Bayesian Network
CBA	Cost Benefit Analysis
C.I.	Consistency Index
CPT	Conditional Probability Table
C.R.	Consistency Ratio
CVI	Causal Variable Indicators
DEMATEL	Decision-Making Trial and Evaluation Laboratory
D-S	Dempster-Shafer
EDI	Electronic Data Interchange
EQA	European Quality Award
ER	Evidential Reasoning
ETA	Event Tree Analysis
FNIS	Fuzzy Negative Ideal Solution
FAHP	Fuzzy Analytical Hierarchy Process
FAO	Food And Agriculture Organization of The United Nations
FGA	Fuzzy genetic Algorithm
FMEA	Failure Mode and Effect Analysis
FPIS	Fuzzy Positive Ideal Solution
FRB	Fuzzy Rule Base
FST	Fuzzy Set Theory
FTA	Fault Tree Analysis
FTL	Food Transport Logistic
FTOPSIS	Fuzzy Technique for Order Preference by Similarity to Ideal Solutions
FZOT	Fuzzy Zone of Tolerance
GA	Genetic algorithm
HACCP	Hazard Analysis and Critical Control Point
HAZID	Hazard Identification
HAZOP	Hazard And Operability
IDS	Intelligence Decision System
IS	Information System
ISM	Interpretive Structural Modelling
ISO	The International Organization for Standardisation
IT	Information Technology
KPI	Key Performance Indicator
LSQ	logistics service quality
MADA	Multi-Attribute Decision-Analysis

MADM	Multi-Attribute Decision-Making
MBNQA	Malcolm Baldrige National Quality Award
NIS	Negative Ideal Solution
PZB	Parasuraman -Zeithami-Berry
PIS	Positive Ideal Solution
QA	Quality Assurance
QFD	Quality Function Deployment
QMRA	Quantitative Micro Biological
RCM	Risk Control Measures
R.I.	Random Index
RFID	Radio Frequency Identification
RM	Risk Management
RPN	Risk Priority Number
RQ	Research Question
SA	Simulated annealing
SCM	Supply Chain Management
SEM	Structural Equation Modelling
SERVQUAL	Service Quality
SERVPERF	Service Performance
SLR	Systematic Literature Review
S.D.	Standard Deviation
SCRM	Supply Chain Risk Management
STX	Shiga Toxin
SWOT Analysis	Strengths, Weakness, Opportunities and Threats Analysis
TFN	Triangular Fuzzy Numbers
TOPSIS	Technique For Order Preference by Similarity to Ideal Solutions
TQM	Total Quality Management
WHO	World Health Organization

ABSTRACT

Increased globalization and a growing world population have a significant impact on the sustainability of supply chains, especially within the food industry. In the food industry, transport logistic activities play an essential role in ensuring global food safety. Specifically, transport logistics is likely the most critical step throughout the food journey from farm to fork because of potential stress that affects the product, such as perishable nature and efficiency requirement, cost optimization, environmental impact, and sustainability. Hence, considering the volume of food transported and distributed globally and the range of participants involved in the process, there is a high complexity of risk factors that threaten the smooth flow and the food product's safety with severe consequences for global business. Although the assessment of the risk factors in an end-to-end food supply chain has emerged as a significant concern in research, Previous studies on the subject had only focused on the risk assessment of food supply chains from the production, post-harvest, and processing chain, there are very few studies on a whole food transport logistic (FTL) chain, particularly from quantitative assessment perspective due to imprecise and uncertainty of data information along with the networks, revealing a significant research gap to address. If the risk factors present in the FTL chain are left unaddressed, it will affect the whole supply chain link of the product and creates a considerable loss to the global economy. The study aims to bridge the knowledge gap by developing new uncertainty treatment models that facilitate the assessment and mitigation of risk associated with the safety of the agro-food product during the transportation and logistics network.

Methodology: To meet up the requirement of the research objectives, this research conducts empirical studies among the global Agro-food handling companies in Thailand, the Republic

of China, and the Republic of Vietnam and follow the four steps of an effective risk management process, namely risk identification and classification, risk assessment, risk cause and effect assessment and risk mitigation strategies. To ensure the analysis is systematic and inclusive, all the various risk factors associated with the agro-food transport and logistic (AFTL) chain were identified through a careful review of the literature following a Delphi technique with industry experts, to verify the reliability of the identified risk factors. The assessment of the risk was conducted with the data collected via a two-stages of questionnaire surveys and evaluated through the Analytic Hierarchy Process (AHP) and fuzzy rule-based (FRB), and Bayesian network (BN). Thereafter, the risk cause and effect and risk mitigation strategies identified via literature review were validated through a set of empirical studies and evaluated through DEMATEL, Evidential reasoning and Fuzzy Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) technique.

Findings: The verified forty-six risk factors are classified into two main categories: Internal risk derived from the internal activities of the AFTL firm (i.e Finance, physical, information, organisation, infrastructure /technology, and supply chain risk) and external risk derived from external events or situation that negatively impact AFTL firm that either occurs naturally or caused by human error (i.e Environmental and security risk). The risk and their sub-criteria were identified through empirical studies after the risk assessment with a fuzzy rule base and Bayesian network. The top priority risks are "deterioration in service quality" "leadership in food safety management" "food supplier transparency" and "adaptation to food standard regulation." Furthermore, thirty-five multi-criteria risk causal variables influencing the service quality were identified and classified into four main groups (i.e. Management, operation, resource and relational) such as "flexibility," "completeness of order," "the correctness of order," "the safety of service delivery," the "security of service delivery," "availability of order information," "a consistent procedure in the handling of orders" and "timeliness of shipment, pickup and delivery" among the indicators influencing the service quality of firm in the AFTL chain. The causal variable indicators (CVI's) such as "openness in information exchange" "company ethical image" "social responsiveness" "equipment efficiency" "correctness of order" "the application of IT and electronic data interface" are the net causal variables which would positively influence the other causal risk variables. To mitigate these causal risk variables, the strategies such as "transformation leadership and top management commitment strategy," "service culture, strategy," "information and analysis strategy" and the "continuous improvement and innovation strategy" are identified through empirical studies. After applying the fuzzyTOPSIS technique, assessment results indicate that "service culture strategy" and "information and analysis strategy" are the most important with strong relevance to the service quality performances of the firm in the AFTL chain.

Research implication: This study is one of the earliest to recognize the need for a comprehensive risk assessment in the AFTL chain. It contributes to the AFTL risk analysis from different networks of stakeholders and applies an advanced uncertainty modelling technique to evaluate such diversified AFTL risks with high uncertainty in data in the same framework and provide mitigation strategies to manage the AFTL service quality causal risk variable in an uncertain environment

Practical implications- The profile of the risk sources, the risk priority weighting, cause and effect interdependency relationship of the causal variables, quantitative assessment of the CVI's and the prioritization of the causal variables mitigation strategies can be beneficial to decision-makers in the food supply networks, transport logistic service provider, food risk assessor, the internal/external auditors in tackling uncertainty and vague information data to support safety-based decision making in the Agro-food transport logistic supply network in

Thailand, the Republic of China and the Republic of Vietnam. The research findings can also be applied in other countries

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DEDICATION

This thesis is dedicated

To the soul of my caring mother

To my beloved father

To my lovely and supporting wife Temitope Onakoya

To my lovely children Nasiha, Jawad and Nadia Onakoya

and

To my brothers and sisters

Thank you so much for your love and patience

CHAPTER ONE – INTRODUCTION

Summary

This chapter presents the basis and context of the Thesis. It begins with the research background, followed by the research problem and research question. This chapter also illustrates the research aims and objectives and presents an overview of the research methodology and the study scope followed by a brief explanation of the thesis structure.

1.1 Research Background

The food supply network involves a network of farmers, growers, ingredient suppliers, product processors, product distributors, product importers and product retailers in different regions of the world (Benson, 2011). Due to the global increase in the network of all the stakeholders involved in the process of food supply and their geographical location, food safety pose a serious global challenge (Van Boxstael et al., 2013). The safety of global food supplies is threatened by numerous risk hazards that persist in the environment and contaminate the entire food supply network. Such as Foodborne pathogens (Attenborough and Matthews, 2000; Valeeva et al., 2005) Parasites (Savov and Kouzmanov, 2009; Van Boxstael et al., 2013), Toxins (Ropkins and Beck, 2003), Organic pollutants (van Asselt et al., 2017), to name few. Virtually all these risk hazards have a consequence impact during the food transportation phase (Whiting et al., 2000). For instance, the dynamic of growth and inactivation of foodborne pathogens throughout the food chain and is potential risk alteration during handling and preparation might extend during transportation, causing excessive ripening, weight loss, softening colour and texture changes, physical degradation, bruising, and moulds attacks that affect the freshness, desirability and marketability of the food product (Jedermann et al., 2009). Similarly, the sheer disruption in the flow of food products, such as lack of adequate infrastructure and transport services, failure of critical infrastructure, adverse weather conditions, cumbersome customs processes, and cross-contamination have serious consequences on the safety of food products (Keener, 2003; Jetlund and Karimi, 2004; Sperber, 2005; Tamplin, 2007; Healy and Brent, 2007; Ackerley et al., 2010; Van Boxstael et al., 2013). Furthermore, in 1989, the multiple outbreaks of staphylococcal food poisoning caused by canned imported mushrooms were attributed to post-harvest and pre-processing collection and transportation practices used in the People's Republic of China. In 1994, the salmonellosis outbreak affecting 224,000 people was blamed on cross-contamination of pasteurized ice cream transported in tanker trailers that had previously hauled non-pasteurized liquid eggs. In 1995, shipments of vegetable oil from heated rail tankers were found contaminated with the heat transfer medium used for heating the railway tankers. In 1997, several bodies of deceased stowaways are found on three ships carrying cocoa beans and raw sugar. In 1999, a major illness outbreak among children and young adults in the European Economic Community was attributed to fungicide-contaminated pallets used for transportation and storage of product packaging materials, resulting in the recall of millions of cases of the implicated product (Keener, 2003). Between 1st August and 15th September 2003, there were 361 reported cases of Salmonella enterica Sarovar Typhimurium virus found in the salad vegetable product distributed in various food outlets in England and whales. In May 2005, there was a nationwide outbreak of multi-resistant Salmonella Typhimurium in Finland, due to contaminated lettuce transported from Spain (Takkinen et al., 2005). Early October 2007, Netherland patients were infected with Shiga Toxin (STX) producing Escherichia coli bacterial, after consuming pre-packed raw vegetables distributed in the supermarkets (Friesema et al., 2007). November 2008, Melamine contamination in milk products caused the death of six infants and sickness to 300,000 victims in china. The presence of any hazardous risk factors or undetected threats, at any point, will influence the overall safety of the food supply chain. Although the international food trade agreement had highlighted the importance of risk analysis for the international elaboration of food safety standards (FAO, 2017), a process that comprises risk assessment, risk management and risk communication, that aims to provide a framework for the evaluation of the hazardous factors in a substance, for a proper management decision making (Manning and Soon, 2013).

Over the last twenty-five years, various academics and researchers had carried out studies on how to effectively assess and manage the hazardous risk factors associated with the food supply network (Lammerding, 1997; Crerar, 2000; Varzakas et al., 2007; Van Boxstael et al., 2013; Chen et al., 2018). The Knowledge and understanding of the evolvement of previous research on food supply network studies can help future researchers to target the right direction and fill the gaps in the subject area.

In view, the study summarized the evolution of the different food supply network research studies based on the evolution of their publications concerning author field and geographical location, research area, the evolution of the significant hazardous risk factors in the food supply chain network, the trend in methodology and assessment models using 171 peers - reviewed papers from academic journals published in English from 1995 to 2019 (Q2). Based on the review. The knowledge gaps below were identified in the previous studies.

- There is a global awareness of the scope and magnitude of the various hazardous risk factors in the food supply networks affecting the safety, efficiency, and sustainability of food production. These hazardous risk factors were only considered as a random variable, with a limited focus on the assessment of their interdependency and inter-relationship in the food supply chain activities. Hence, it is crucial to analyse risk in a uniform format for proper mitigation and decision-making

- The risk control strategies found in the academic literature apply only to a few food products (Seafood, Diary, Fresh vegetables, and Wheat product) (Marvin et al., 2009; van der Fels-Klerx et al., 2010; Fegan and Desmarchelier, 2010; Fernandez-Piquer et al., 2013; Van der Spiegel et al., 2013; Chen et al., 2014). There is a need to develop a more flexible risk control mechanism for other varieties of food products
- It was essential to establish a common understanding of the assessment model techniques previously used in food supply network research. Review shows that most of the previously used models have shown some drawbacks and insufficiency in their practical application. Researchers over the years have adopted different methods to improve them. Knowledge on improving the risk assessment model to handle the uncertainty in the food supply chain is a new research direction that will fill the gap and enhance food supply chain safety research.
- The comprehensive assessment of the hazardous risk factors in an end-to-end food supply chain has emerged as a significant concern in research (Marvin et al., 2009, Van der Fels-Klerx et al., 2010). Previous studies mainly focused on the assessment of risk from the production (Chen et al., 2014), post-harvest (Van der Fels-Klerx et al., 2010, Faour-Klingbeil et al., 2016), and processing phases (Van der Spiegel et al., 2013). Few studies have quantitatively assessed the risk posed during the transport and logistics phase of food products (Ackerley et al., 2010) creating a research gap for studies.

1.2 Research Problem

A well-defined research problem is an integral part of the research study and a prerequisite to working out the study research design and all the consequential research processes (Kothari, 2004). The study research problem is to develop an integrated risk management model for agro-food production during the transportation and logistics phase under the challenge of data uncertainties. For further knowledge, the study research problem was carefully designed based on the uncertain risk factors present during the agro-food transport and logistics process reviewed from the academic literature.

Furthermore, the study research problem must translate into a research question to explain the nature, scope and method of the research(Creswell, 2018). For example, "What" research questions are *exploratory* to develop relevant hypotheses and propositions for further inquiry? "Who" and "Where" research questions are *descriptive* and mostly used when the research goal is to describe an incidence or when it is predictive about specific outcomes. Conversely "How" and "Why" research questions are *explanatory*, such questions deal with operational links that needed to be traced over time (Yin, 2009). However, this study adopts the "What and How" research questions which aim to provide a solution to the research problem and address the research objectives. The study research problem is construed into the following research question.

RQ1: What are the top priority risk factors affecting the safety of the agro-food product during the transport and logistics process, especially in a developing country and how can they be identified?

RQ2: How is an uncertainty treatment theory approach useful in evaluating and quantifying the risk factors affecting the safety and sustainability of agro-food products during the transportation and logistics phase?

RQ3: How are the core activities leading to the presence of the top risk factors in RQ2 identified?

RQ4: How to determine the best cost-effective and control measures of the activities in RQ3 in the context of a developing country?

1.3 Research aim and objective

This research aim is to develop an integrated risk management model to analyse the risks affecting the safety of the agro-food product during the transport and logistic process in an uncertain environment. The new framework will help to identify the various Agro-Food Transport and Logistic (AFTL) risk factors, enhance their resilience, and offer safety assessment tools to support management decision-making.

Objectives

O1. To identify the hazards affecting the safety of agro-food during the transport and logistic process with a focus on physical risks.

O2. To develop a new risk analysis model to analyze and prioritise the risk levels of the identified hazards (in O1) using a fuzzy rule-based and Bayesian Network (BN) technique.

O3. To evaluate the relevant root causes influencing the hazard(s) of the highest risk levels (from O2) and their interdependency relationships using DEMATEL techniques and the evidential reasoning (ER) approach

O4. To develop effective risk control measures (RCM) for the hazard(s) of the highest risk level(s) concerning the root causes (of the significant impact) from O3

1.4 Research Methodology

The research interest is primarily to develop an integrated risk management model that supports AFTL risk hazard identification and classification, risk cause and effect assessment and risk mitigation strategies under an uncertain environment. Typically, one research method was not sufficient to cover the entire risk process. The thesis adopts both qualitative and quantitative research methods to collect and analyze data in each phase of the research process in realizing the research objective as explained in chapter three. Empirical studies were conducted to understand the complex AFTL activities, using real-life raw data collected from AFTL companies in the Republic of China, Thailand, and the Republic of Vietnam.

1.5 Structure of the Thesis

Figure 1.1 illustrate the thesis structure. it consists of eight chapters as summarized as follow studies.

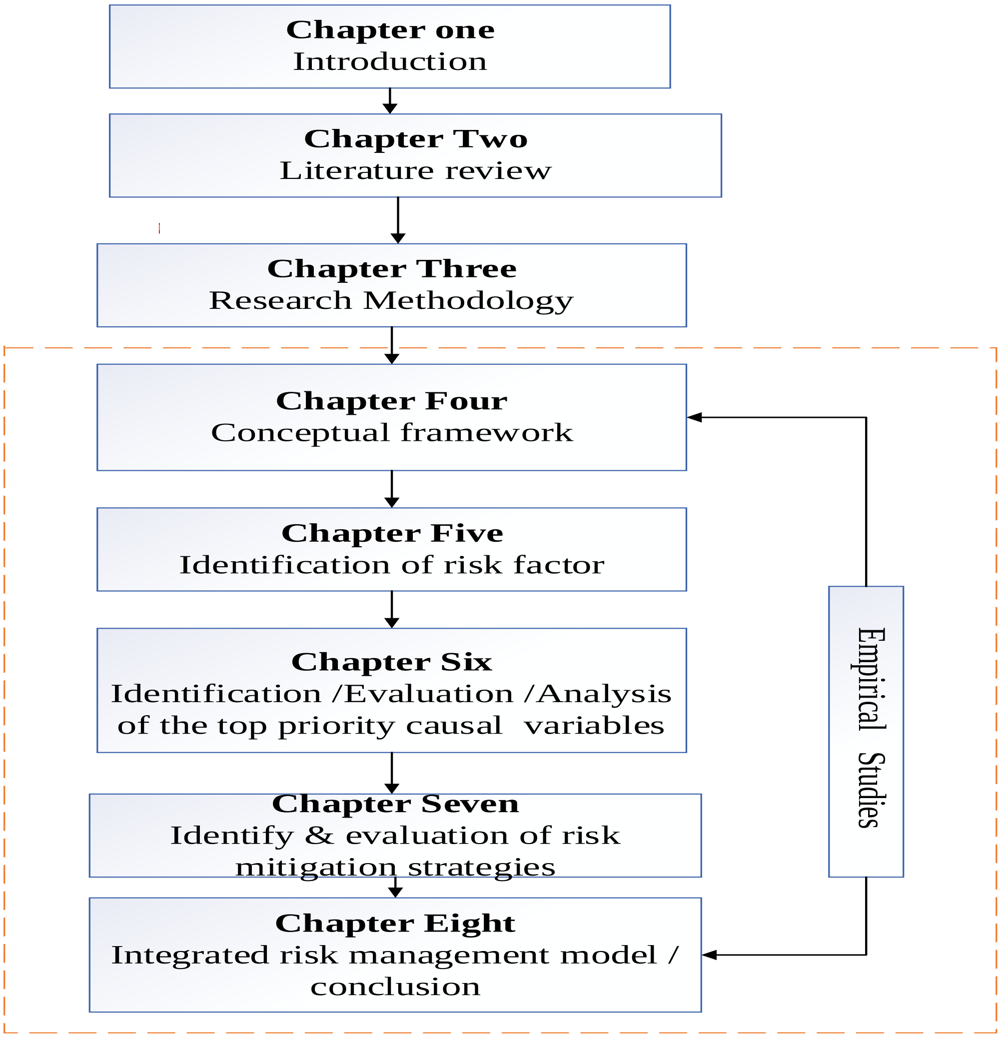

Figure 1. 1 The structure of the thesis

Chapter one - Introduction: This chapter introduces the background of the research area followed by the motivation of the research, research problem and research questions.

Furthermore, the research aims and objectives are followed by summarized research methods and thesis structures.

Chapter two - Literature Review: This chapter outline the literature review on the concept of food supply chain risk management, the research gaps, and drawbacks in the risk management of the AFTL chain and the advanced risk assessment tools. This chapter discusses the literature review on the causal variables to service quality risk and the review on the mitigation strategies

Chapter three - Research Methodology: This chapter explains the research methods it explains the rationalisation of how the research methodological process was designed to achieve the research aims and objectives. It explains the research philosophy assumptions and the different philosophical stands underpinning the research strategies, the data collection method chosen in the study as part of the strategy, followed by the justification for the selection of the study Philosophy approach, the study research design, and the research methodological choice.

Chapter four - Conceptual framework: This chapter proposes a novel integrated risk management framework in the Agro-food transport logistic (FTL) network that incorporates the basic four steps of an effective risk management process, namely risk identification and classification, risk assessment, risk cause, and effect evaluation and risk mitigation strategies.

Chapter five – AFTL risk factor identification and classification and ranking: This chapter presents the first steps in the risk management process, “Risk hazard identification and classification. This chapter highlights the various risk factors associated with the AFTL chain and discusses the Delphi techniques adopted to verify the concerned risk factors in a real-life scenario. This chapter also presents the hierarchy structure of the validated AFTL risk factors based on the data responses from the experts. It presents the assessment and priority ranking of the risk hazards based on the fuzzy- rule based and Bayesian network methodology.

Chapter six –The top AFTL priority risk factor causal variables identification and assessment

This chapter identifies the causal variables of the top AFTL priority risk hazards and presents them in a hierarchy structure. The chapter outlines the research method process and explains the procedural steps to analyse the cause-and-effect interdependency relationship among the causal variable indicators using AHP, DEMATEL techniques and evidential reasoning algorithm. The chapter also discussed the empirical study adopted in collecting primary data from the top three countries (The republic of Vietnam, China, and Thailand), handling and supplying Agro-food products into the global market and the methodological process in using the ER algorithm to aggregate multi-criteria CVI's with incomplete or vague data and presents a detailed discussion on the assessment of the CVI's on the service quality performance of various real-life case AFTL companies handling different agro-food products

Chapter seven - Identification and evaluation of AFTL Service quality mitigation strategies: This chapter discusses the final stage of the AFTL risk management process. It highlights the identification, validation, and evaluation of the mitigation strategies for the service quality risk in the AFTL chain. The chapter discusses the evaluation of the service quality control measures /indicators reviewed from the literature verified by industry experts based on a structured questionnaire to validate the identified service quality control measure and the exploration of the new service quality mitigation strategies. The chapter also presents the prioritization assessment of the verified risk control measure using the Fuzzy TOPSIS method.

Chapter eight – AFTL integrated risk management and conclusion: This chapter summarizes the main research findings of the identification, classification, causal variables indicators, assessment and mitigation of the risk hazards associated with AFTL with various advanced risk modelling and analysis tools. It also highlights the research limitation and provides suggestions and recommendations for further studies

CHAPTER TWO: LITERATURE REVIEW

Summary

This chapter provides an overview of how the systematic literature review was conducted. The research gaps identified in this chapter clarify the research problem to be addressed in the subsequent chapters. The review of the literature comprises four key areas which are critical to the risk management of food transport and logistic risk hazards. It begins with a review of the research trend in the food supply network assessment published over the last twenty-five years in the academic literature. The published articles were reviewed and analysed based on the evolution of their publications concerning author field and geographical location, research area, the evolution of the significant hazardous risk factors in the food supply chain network, the trend in methodology and risk modelling. This was followed by the identification of research drawbacks in the food supply networks particularly concerning food transport and logistic. Thereafter. This chapter reviews the trend in the investigation on the risk hazard identification and analysis, overview of the top priority risk hazard cause and effect investigation and the top priority risk hazard mitigation strategies to provide an insight into the integrated risk management for food transport and logistic risk hazards.

2.1 An overview of food supply network assessment -A systematic review and next-generation research

A comprehensive review of the research papers associated with risk assessment in the food supply chain published in the past twenty-five years was undertaken between January to June 2019. The web of science core collection database was used as the foremost comprehensive source to identify all the relevant English-written academic Journals about food supply network research. Considering the scope and objectives of the study, search strings and substrings of the study variables - food safety, supply chain safety, food supply, risk factors, risk assessment and risk models, were selected as topics and sub-topics to collate the relevant papers for review. The search strings were limited only to academic journals, excluding all conference proceedings and book citations. The collated papers combined with the 'AND' functions and a total of 231 academic papers from different academic journals in food science technology, agriculture, business economics, and engineering covering topics on food supply networks between the period from 1995 to Q2 2019 were retrieved. These articles were then thoroughly reviewed to ensure their quality and relevance to the research subject. The author carefully screened the papers using the criteria including 1) relevant titles, keywords, and abstracts so they can make relevant contributions to the study and 2) cover one or more food supply chain risk analysis topics. Articles that do not meet the filtration criteria were excluded. Finally, the reference list of the shortlisted article was evaluated to ensure that there are no other relevant articles omitted.

2.1.1. Evolution of Food supply network research

2.1.1.1. Overall Trend

A total of 171 articles on food supply network research published from 1995 until 2019(Q2) were reviewed, summarized, and grouped in five-yearly intervals as shown in Table 2.1. The result shows a sharp increase in the number of articles that had published findings on risk assessment of food supply networks in the last decades. Out of the overall article reviewed, 85 articles (49.71%) were published during the most recent five-year period, and 130 (76.02%) were published in the last ten years. Such an increment denotes the increasing interest from academia and researchers in the subject of protecting the integrity of food production and improving global awareness of the various risk hazard affecting the food supply networks. The top 20 journals that had published articles on risk assessment in the food supply network was presented in Table 2.2 out of the 171 articles reviewed in the literature, 100 articles (58.48%) were published in these journals. The journal on food control, international journal of food microbiology, Journal of food science technology, British food journal and Journal of food research international are ranked among the top five Journals that published articles about food supply network risk, out of the top five journals, the Journal of food control was ranked first with 25 articles, out of which 16 articles were published within the last ten years. Another noticeable change was the increasing number of articles published in journals such as quality assurance and safety of crops food, food protection, food safety, food security and industrial management data services. This indicates that the research on the risk assessment of food supply networks had received wider attention from researchers.

Table 2. 1 Five yearly grouping of the reviewed papers on of food supply network

	1995-1999	2000-2004	2005-2009	2010-2014	2014-2018
Numbers of papers	6	9	26	45	85
Av. number of papers per year	1.2	1.8	5.2	9	17
% Paper reviewed	3.51%	5.26%	15.20%	26.32%	49.71%

Table 2. 2: Top 20 Journals on food supply chain network from 1995 – 2019(Q2)

Article Title	Number of articles	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Food Control	20	1		1	2	16
International Journal of Food Microbiology	10			3	5	2
Trends In Food Science Technology	8		2		1	5
British Food Journal	6			2	2	2
Food Research International	6				3	3
Journal of Food Protection	6	1	1		3	1
Journal of Food Safety	4			1		3
Current Opinion in Food Science	3					3
Food Policy	3	1		1		1
Preventive Veterinary Medicine	3			1		2
Quality Assurance and Safety of Crops Foods	3			1	1	1
Risk Analysis	3				2	1
Asian Australasian Journal of Animal Sciences	2		2			
Comprehensive Reviews in Food Science and Food Safety	2				1	1
Critical Reviews in Food Science and Nutrition	2			1		1
Food Security	2					2
Frontiers in Public Health	2					2
Industrial Management Data Systems	2					2
International Journal of Life Cycle assessment	2				1	1
Journal of food composition and analysis	2			1		1
Journal of food engineering	2				1	1
Journal of food science	2			1	1	
Meat science	2				1	1
PloS one	2					2
Agriculture ecosystems environment	1					1
	100	3	5	13	24	55

2.1.1.2. Evolution of the geographical study location of the top twenty-five food supply networks researcher

The number of articles presented in a country on a particular study area can indicate the number of active researchers and the popularity of such topics in that field. Table 2.3 show the geographical study location of the top twenty-five authors that have published articles on food supply chain risk hazard assessment. Findings denote that most of the authors are based in the USA, Europe, Africa, and Canada as determined by the location of their institutions. These authors publish eighty-five of the reviewed articles. Ranked first was Lunning PA from the USA with a total count of 8 articles published in the last ten years, followed by Jacxsens and Vander Flex from Europe. Out of the top authors, 15 originated from Europe, reflecting that the European institution had a broader interest in food supply chain research. It was also noted that the number of authors from Africa and the Asian region was relatively low, and this could also be an indicated direction for further development.

Table 2.3: The geographical location of the top twenty-five authors that published articles on food supply chain assessment

Author	No of count	Location	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
Lining PA	8	USA				4	4
Jacksons L	7	Netherlands				5	2
Van Der Fels-Klerx Hj	6	Netherlands			1	3	2
Rijgersberg H	5	Netherlands			1	4	
Franz E	4	Netherlands				4	
Graced	4	Kenya				2	2
Uyttendaele M	4	Netherlands				4	
Delaquis P	3	Canadian				2	1
Duret S	3	France				1	2
Gulliver L	3	France				1	2
Hasler B	3	England					3
Hoang Hm	3	France				1	2
Kirezieva K	3	Netherlands				2	1
Laguerre O	3	France				1	2
Rushton J	3	England					3
Tromp SO	3	Netherlands				3	
Van Der Vorst Jgaj	3	Netherlands				2	1
Zwietering MH	3	Netherlands			1	1	1
Accorsi R	2	Italy				2	
Astley S	2	England			1	1	

Beck AJ	2	England		2			
Beni LH	2	Canadian				1	1
Bouzembrak Y	2	Netherlands					2
Fazil A	2	Canadian					2
Flick D	2	France				1	1
Total				2	4	45	34

2.1.1.3. Evolution of the main topic in the food supply chain research

Table 2.4 illustrate the main research topic in the food supply chain assessment. Prior to 1999, microbiological assessment and Hazard Analysis and Critical Control Point (HACCP) regulatory control on food safety was the most popular research topic. Research on the control and consequence of hazardous organisms on food products gradually gained popularity from 2000 until 2004, resulting from the increased environmental awareness and its detrimental effect on public health reported by the author during such a period. From 2005, it was interesting to see the emergence of a broader range of research topics on food safety, food quality, food security, food traceability, food sensor technology, and food risk hazard assessment being studied. This indicated that the researcher had shown interest in food supply chain assessment and that future research will be more focused on the ways to manage some of the various challenges and issues affecting the safety of activities in the food supply network

2.1.1.4. Evolution of the major risk/hazard in the food supply networks

Food safety risks result from the combination of risk hazards present within the food supply networks. To systematically understand and analyse hazards affecting the food industry, the author first examined how the food risk hazards were grouped in the academic literature. These hazards were grouped into tri-categorization in the context of classic food safety vocabularies and previous academic definitions of hazard, i.e. The microbiological, chemical and physical factors potentially harming the actors and processes within the food supply networks (Aruoma, 2006; FAO, 2017). The trend of the significant hazardous risk factors in the food supply network as found in the literature over the last 25 years is presented in Table 2.5. findings show that researchers had mainly focused on either microbiological, chemical, or physical risk hazards. The overall importance of these hazards had not been measured and comparable on the same plate. This created a research gap. Hence, for a proper managerial assessment of a food safety risk hazard, an overall assessment application of all the risk hazards presented on that particular food product from farm to fork needed to be assessed (Wang et al., 2012a). Similarly, it was noted that most of the food supply chain researchers focused their research on the assessment of risk hazards present during the food harvesting and food production with limited consideration of those risk hazards present during the transportation and logistics Phase, only a single paper was found in the literature assessing some of the risk hazards during the transportation of food products (Ackerley et al., 2010). The reason was insufficient data on food safety failures directly attributable to transportation (Keener, 2003). Similarly, the methods and techniques used in the literature in the assessment of food supply chain risk have shown some drawbacks and insufficiency in their practical applications. For instance, previous studies on the safe transport of food products only consider risk as a random variable (Ackerley et al., 2010), added into existing supply chain models with a limited focus on the interdependency, interrelationship between these multiple risks on food transportation safety and their impacts on the supply chain performance (Ho et al., 2015; Garvey et al., 2015; Dong and Cooper, 2016; Rathore et al., 2017). Hence, for the best quality and safety of food, risks presented from source to end consumer need to be assessed in a uniform format (Wang et al., 2012a). Secondly, the techniques used to assess the risks in the previous studies, work on the basis that risk is a combination of consequence severity and the probability of occurrence (Manning and Soon, 2013). Arguably, more risk parameters (e.g. probability of failure undetected) should be incorporated to avoid the loss of useful information (Aven, 2012). Hence, considering the volume and vulnerability of food products transported globally, it is crucial to identify and evaluate food risks through a coordinated approach under the challenge of uncertainties and develop integrated multi-criteria decision-making (MCDM) risk quantification methodology for risk control.

Moreso, a review of risk hazard control measures of a few food products, i.e., Seafood, Dairy, Fresh vegetables, and Wheat products in the literature over the past years are presented in Figure 2.1. Findings show that there is a need for an effective risk control mechanism and risk management decision tools that will enable stakeholders and/or food supply managers to effectively manage the risk hazards. The conceptual understanding of the management of the hazardous risk factors in an end-to-end supply chain of an individual food product has emerged as a significant concern and a knowledge gap for future studies (Marvin et al., 2009; van der Fels-Klerx et al., 2010; Fegan and Desmarchelier, 2010; Fernandez-Piquer et al., 2013; Van der Spiegel et al., 2013; Chen et al., 2014)

Table 2. 4: Evolution of the main topic in the food supply network

2000 - 2004	2005 - 2009	2010- 2014	2015 - 2019
▪ Food safety and human health (2)	▪ Microbiological hazard assessment in meat and poultry products (1)	▪ Modelling chemical hazards in winter wheat (1)	▪ The credibility of food standards (1)
▪ Controlling organic chemical hazards (1)	▪ Information system in food safety management (1)	▪ Climate change impact on food safety and quality (2)	▪ Food Safety (General) (6)
	▪ Genetically Modified Food (GMO) (1)	▪ Logistic challenges in fresh vegetables (1)	▪ Food production and processing constraints (2)
	▪ Risk assessment and modelling (2)	▪ Food packaging (2)	▪ Microbiological risk assessment on green vegetables (2)
		▪ Risk assessment and modelling (8)	▪ Food safety and nutritional quality (3)
		▪ Nanotechnology material (1)	▪ Food packaging (1)
		▪ Traceability in meat and Poultry (2)	▪ Food Compliance verification (1)
		▪ Microbial risk assessment in pork (1)	▪ Food Science support system (1)
		▪ Microbiological risk assessment in fresh vegetables (3)	▪ Food Sensor Technology (6)
		▪ Pharmaceutical transfer in the food production system (1)	▪ Food Defence (2)
		▪ Food safety and quality (General) (2)	▪ HACCP assessment (1)
		▪ Microbiological risk assessment in pacific Oyster (1)	▪ Plant disease (1)

▪ Contamination in the food system (1)	▪ Post-harvest losses (1)
▪ Food safety software (1)	▪ Microbiological hazard assessment in peach supply (1)
▪ Food Allergen detection and testing (1)	▪ Water Quality (2)
▪ Food distribution issue and challenge (1)	▪ Risk modelling and assessment (4)
	▪ Food Fraud (3)
	▪ hazard identification (2)
	▪ Hygiene Practice (1)
	▪ Contamination in a ready-to-eat salad (1)
	▪ Food database-driven safety (3)
	▪ Chemical hazard safety assessment (2)

Table 2. 5:Evolution of the major risk/hazard factors in food supply networks

Hazard Group	Type		Food product	Source
Microbiological factors- Agents in food supply networks, caused by biological diversity, among micro-organisms, climatic, and ecological factors	Food-Borne Pathogens	Salmonellosis Campylobacteria Enterohaemorrhagic E. coli Infection Tuberculosis Brucellosis Mycobacterium	Wheat, Iceberg Lettuce. Dairy products. Fresh Produce Seafood Sterile Food Beef Cattle	(Attenborough and Matthews, 2000; Singer et al., 2007; McMeekin et al., 2006; van der Fels-Klerx et al., 2008; Hiller et al., 2013; Healy and Brent, 2007; van der Fels-Klerx et al., 2010; Franz et al., 2010; Van Boxstael et al., 2013; Krystallis et al., 2007; Marvin et al., 2009; Krystallis et al., 2007; Tamplin, 2007; Van Boxstael et al., 2013; Savov

		Paratuberculosis		and Kouzmanov, 2009; Bouwknegt et al., 2015; Jacxsens et al., 2010; Anderson et al., 2011)
		Staphylococcus Aureus		
		Listeria Monocytogenes		
		Bacillus Cereus		
		Yersinia enterocolitica		
		Coccidiosis		
		Enterobacter Sakazaki		
		Non-pathogenic epiphytic bacteria.		
		Brucellamelitensis		
		Tick-Borne Encephalitis virus		
		Unauthorized Genetically Modified Organism (GMO)		
		Saturated fat		
		Cholesterol		
		Native Microbial Flora		
		Mycotoxins		
		Fusarium Head Blight		
		Parasites		
		Viruses		
Chemical factors: Agents arising from those chemicals, introduced intentionally/unintentionally throughout the food supply network	**Residual chemical**	Pesticide	Dairy products, Salmon	(Marvin et al., 2009; van der Fels-Klerx et al., 2012; van Asselt et al., 2017; Ropkins and Beck, 2000; Krystallis et al., 2007; Valeeva et al., 2005 Chen et al., 2014; Healy and Brent, 2007)
		Growth Hormone		
		Fumigant		
		Natural Toxin		
		Antibiotics		
		Dioxin		
		Toxic oxidation		
		Aflatoxin		
	Applied Chemical	Food additives		
		Food preservatives		
		Sanitiser Spray		
		Organic acid spray		
		Heavy metals		
		Micronutrients		
		Natural and Plant Toxins		
		Allergens		
		Organic pollutant		
		Manure for irrigation		
		Fertilizing		

	Accidental Chemicals	Disinfectant		
		Machine lubricant		
		Paints		
		Solvent fumes		
		Cleaning Agents		
		Radionuclide		
	Environmental Chemicals	Polychlorinated dibenzodioxins and furans		
		Toxic metabolites of moulds		
		Metalloid accumulation, e.g., arsenic (As), Lead (Pb) Cadmium (Cd)		
		Migrants from food contact material		
		The residue of environmental organochlorine		
		Residue from veterinary drug		
Physical factors: Agents within the food supply network that can cause harm with or without contact with food products either on their own or as a source of microbiology or chemical hazard	Poor food handling practices		Meat (Beef and Chicken), Tuna, Dairy products Fresh products, Sprouted Seeds Herbs,	(Ropkins and Beck, 2003; Sperber, 2005; Prandini et al., 2009; Faour-Klingbeil et al., 2016; Yee et al., 2006; Chen, 2008; Chen, 2012; Van Boxtel et al., 2013; Dani and Deep, 2010; van den Heuvel et al., 2011; Raspor and Jevšnik, 2008; Haslberger, 2006; van der Fels-Klerx et al., 2010; Healy and Brent, 200; Raspor and Jevšnik, 2008; Rijgersberg et al., 2010; Membré et al., 2008; Prandini et al., 2009; Jongman and Korsten, 2017)
	Inappropriate Storage			
	Inadequate refrigeration			
	Damage to protective food packaging			
	Poor thermal processing			
	In advert burning of foodstuff			
	Consumer trust			
	Cross product contamination			
	Poor Purchasing Requirement			
	Poor pest control			
	poor labelling			
	Poor facility and equipment design			
	Improper Handling Practises			
	Poor Agricultural practices			
	Inadequate transportation			
	Lack of product identification and traceability			
	Work Health and Hygiene			
	Sub Standard packaging materials			
	Poor Argo environmental practice			
	Temperature abuse			
	post-production contamination			
	Storage time abuse			
	Raw Material contamination			
	Inadequate sanitation			
	Lack of access due to terrorism			
	Loss of Access due to protest			

	Loss of supplier		
	Transportation strike		
	Loss of power		
	Flooding		
	Climate change		
	Globalization		
	Changing Consumption Pattern		
	Business Malpractices		
	Perception of responsibility		
	Nano Materials		
	A poor-quality control strategy		
	Food Fraud		
	Incorrect fertilization		
	Extreme Weather		
	Insect Damage		
	Water and Manure for irrigation		
	Access of domestic and grazing animals to fields crops and stream		
	Inadequate structural facilities		

1) Wheat Product

Hazard factors

- Fusarium Head Bligh
- Mycotoxin
- Mould Incorrect fertilization
- Extreme Weather
- Insect Damage
- Inappropriate Storage
- Climate change
- Pesticide residue
- Foodborne pathogens

Control Measures

- Growers' application of fungicide
- Early monitoring of mould and Mycotoxin formation using a predictive monitoring tool

2) Fresh vegetables

Hazard factors

- Foodborne pathogens
- Temperature abuse
- Climate change
- Globalization of trade
- Inadequate sanitation
- Hygiene Deficiencies
- Water and manure
- Poor Agricultural practices
- Fertilizing
- Improper Handling
- Inadequate transportation
- Inappropriate Storage

Control measure

- Adequate pre/post-harvest practice
- Classy packaging condition
- Enhancing competence by training
- Setting best practice to support people and setting standards
- Water source, water quality and water treatment technologies)
- Treating contaminated irrigation water that does not meet the standard required before use for crop production

3. Dairy products

Hazard factors

- Food Borne Pathogens
- Residue from veterinary drug
- Climate change
- Disinfectant
- Pesticide
- Food Fraud
- Organic pollutant
- heavy metal
- Work Health and Hygiene
- Migrant from food contact material

Control Measures

- Using effective information technology for supply chain integration, to systematically monitor and control information flow
- Enforcing a high-quality standard with strict monitoring and control system among supplier
- Establishing the right experience and trustworthy local suppliers
- Creating a culture that encourages employee's participation and implementation of a quality management system
- On-farm management and good Husbandry practices
- Ensuring Performance pasteurization to prevent further contamination
- Ethical Manufacturing and hygiene practices such as effective cleaning, sanitation, equipment maintenance and personal hygiene
- Prevention of Fungi growth in Agricultural commodities used for animal
- Following the correct procedure for antibiotic treatment in animals

4) sea food

Hazard Factors

- Foodborne pathogen
- Parasitic agent
- Viral
- abuse
- Climate change
- Poor traceability of information

Bacterial
Poor Transport facilities
Temperature
Insufficient capacity of cold storage
Poor handling
Poor packaging

Control measure

- Usage of wireless tracking technology for real-time microbiological monitoring
- Providing a refrigerated transport system
- Maintaining adequate and stable electricity supply
- Increase training of labour and certify the handling process of seafood products
- Improve service quality

Figure 2. 1: Control measures to the review risk hazard

2.1.1.5. Evolution of trend in research methodology choice /research design strategies

Qualitative, quantitative, and mixed-method approaches are the three dominant research methodology choices frequently used in food supply chain network research. Out of the peer articles reviewed, the quantitative approach is the dominant research method, 50.85% of the peer articles were conducted using a quantitative approach, 38.98% were conducted using a qualitative approach and 10.17% were conducted using multiple methods. Quantitative methods involve the use of data collection techniques or analysis procedure that generate or uses numerical data (Bell et al., 2018). The technique is mostly associated with a deductive approach but might incorporate an inductive approach within an interpretive or pragmatist philosophy based on the data collection strategies and purpose (Saunders et al., 2015). Quantitative methods employ the use of a questionnaire or semi-structured interview or observation as an instrument for data collection, examine the relationship between variables and allow for the numerical measurement and analysis of the survey data using various statistical tools (Saunders et al., 2015). The quantitative method has critics such that, the method to analyse the relationship between variables creates a static view of the social life of a sample population that is independent of the natural world, and the data measuring process possesses an artificial and spurious sense of precision and accuracy (Bryson, 2018).

Qualitative methods involve data collection techniques or analysis procedures that generate or use non-numerical data (Bell et al., 2018). Qualitative research is mostly associated with an interpretive philosophy using either an inductive or deductive approach. Its process involves collecting non-standardized data and using various analytical tools to develop the research conceptual framework (Saunders et al., 2015). The method has drawbacks such that is too subjective, and research findings rely on the unsystematic views of the respondent. The data collection and interpretation are influenced by the subjective leaning of the respondent because of the unstructured and lack of standard in the data collection procedure making the findings of the research difficult to replicate. It is sometimes impossible to understand how the scope of the research findings is generalised as the process lacks transparency on how the research was conducted and is often not obvious how the analysis was conducted (Bryman and Bell, 2011). The mixed-method uses an approach that integrates both qualitative and quantitative methods, with a pragmatism research philosophy (Creswell and Creswell, 2017). The method allows the researcher the option of using either more than one data collection technique with an associated analytical procedure (multi-method) or a combination of both the qualitative and quantitative methodologies (Mixed method) during the research process. Although the techniques allow a richer data collection, analysis and interpretation, the process might involve the collection of two separate data in response to the research question, and using separate analytic tools in analysing and avoiding diluted data (Saunders et al., 2015). Similarly, the dominant research design strategies (Lau et al., 2018; Zoellner et al., 2018.; Tsakanikas et al., 2018.; Duret et al., 2019) used for the generation of evidence and collection of data in food supply network research over the past twenty-five years was presented in Figure 2.2. Case studies and surveys are the most dominant strategies with 65% of the reviewed paper using either case study or survey in collecting their research data, The case study strategy is unique in its ability to deal with a full variety of evidence documents, artefacts, interviews and observations (Yin, 2009). Case studies have proven to be useful for demonstrating cognitive behaviour, the probable possibility and contingency effects that further provide empirical grounds for data explanation (Voss, 2010). Although the case study strategy has a full application in food supply network research, it has a significant drawback in terms of the limited generalizability of the findings (Singh and Sharma, 2014).

The survey research design has an advantage such that once the procedure for data collection and analysis are specified, replicability is enhanced. Food supply network researchers adopted this approach for the collection of a large amount of quantitative data from a large population in an economical way. The designs give the researchers more control over the research process (Saunders et al., 2015). The drawbacks of the survey research design are 1) the internal validity of this approach is weak due to the difficulty in measuring the stability of the population sample data overtime; 2) the process is time-consuming; and 3) the progress may be delayed by the dependence of others for information (Walliman, 2017). In addition to research methods and strategies, a noteworthy common concern to most of the researchers in this field is the unavailability and uncertainty of data. Knowledge of how to overcome this challenge has emerged as a primary concern in the food supply chain.

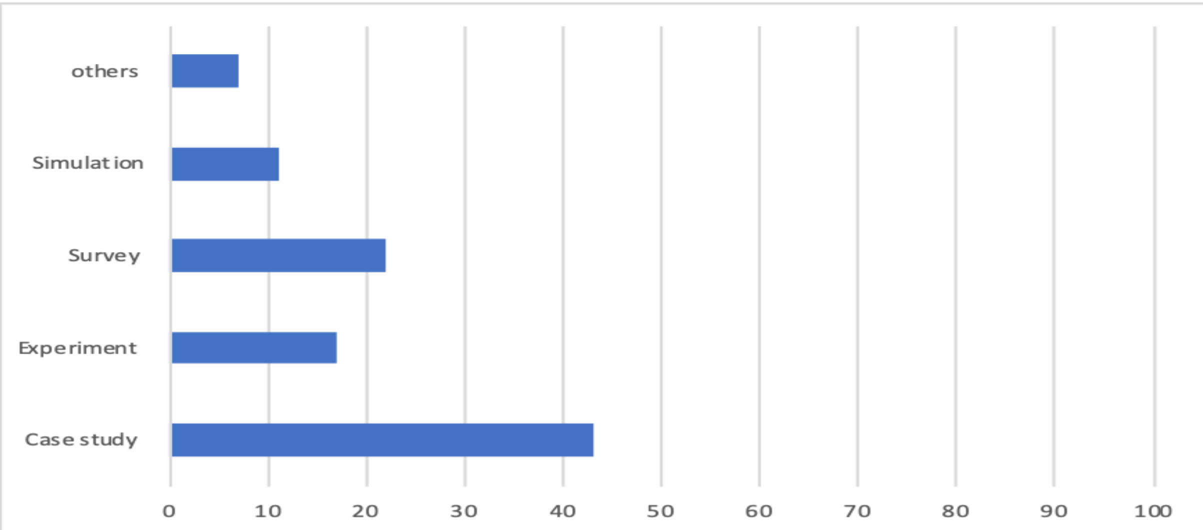

Figure 2. 2: Categorization of articles based on research design strategies

2.1.1.6. Evolution of the model used for assessing risk hazards in the food supply chain

The risk hazards present in the food supply chain had been assessed using different risk models in the literature. Over the past decades, the researcher adopted either qualitative or quantitative risk models to analyse the risk hazard in the food supply chain and provided details for subsequent consideration of their control measures. Qualitative risk assessment models are purely descriptive. The use of these models in risk assessment mostly resulted in a range of definitions of risk levels from lowest to highest without a clear mathematical definition of what constitutes low, medium or high-risk categories (Manning and Soon, 2013). In contrast, quantitative risk assessment models use mathematical modelling to quantify the relationship between the risk variables. The process can be complicated, detailed and able to model the effect of different risk interventions (Manning and Soon, 2013).

Figure 2.3 presents an overview of the qualitative and quantitative risk assessment models over the past twenty-five years. Hazard Analysis Critical Control Points (HACCP) model (Kim et al., 2010; Stanley et al., 2011) and Interpretative Structural (ISM) model (Pfohl et al., 2011) are the most common qualitative risk models in assessing risk in the food supply chain. Quantitative assessment models such as the regression model (Van der Fels-Klerx et al., 2010), Conceptual model(Dani and Deep, 2010), Principal-agent model (Souza-Monteiro and Caswell, 2010), Quantitative Micro Biological (QMRA) model (Janevska et al., 2010) (Franz et al., 2010), Multi-Criteria Decision Making (MCDM) models such as Analytical Hierarchy Process (AHP), Grey Dematel, Failure Mode and Effect Analysis (FMEA), Fuzzy theory and Bayesian Network (Van der Fels-Klerx et al., 2008; Nguyen et al., 2013; Tadic et al., 2014; Bai and Liu, 2016; Bai et al., 2018) are becoming more popular in food supply network research over the last decade. Despite the wide application of these models, most of the models have their drawbacks and researchers over the years have adopted different methods to improve them. For instance, the HACCP model had been criticized for lacking a definitive critical control point and could not eliminate or control any identified hazard in providing food safety assurance (Sperber, 2005). HACCP model targets end product control and corrective actions but do not integrate the initial product processing design (Nguyen et al., 2013). Hence, such a reactive approach is less efficient in food supply network risk hazard assessment because, by the time the hazards are identified, they might be hard to recall or trace (Wang et al., 2012a).

ISM model is an interpretive model which generates solutions for the complex problem through discourses based on the structural mapping of the complex interconnection of an element. The conceptual framework for applying ISM techniques in the food supply networks research is found in the study of Pfohl et al., (2011). Although the ISM model was proven as a useful tool to structure food supply chain risk and help in providing insight into whether a risk driver influences another, its approach shows drawbacks. ISM Model does not provide information about the extent of influence between two risk drivers or the performance measures (Srivastava et al., 2015). To overcome such shortcomings, quantitative fuzzy ISM approaches were proposed as seen in the study of (Srivastava et al., 2015).

QMRA model is another model that has been used in the last decade to promote food supply network science-based decision-making processes, assess human health risks associated with foodborne hazards and analyse the microbial hazardous fate of food products using a mathematical expression (Franz et al., 2010; Janevska et al., 2010). The model had a drawback in its practical application. QMRA is very resource demanding and it is usually difficult to underpin outcomes of the model estimations with data from the industry (Van der Fels-Klerx et al., 2008; Manfreda and De Cesare, 2014).

AHP Modelling is another popular tool in risk assessment. AHP is effective for evaluating complex multiple criteria alternatives by using a pairwise comparison scale that helps decision-makers to make rational decisions through a structured comparisons process AHP is eased to use. However, it uses a discrete scale of pair comparison, which cannot handle uncertainty and vague patterns of human judgement while deciding the weight of different attributes (Wang et al., 2012b). To address the drawbacks of the AHP application, fuzzy set theory has been combined into the AHP application (Lau et al., 2018). The DEMATEL model is used to analyse the cause-effect relationship and inter-influenced degree within criterial dimensions and intervals. Its wide application was found in the study of Debnath et al., (2017). The Failure Mode and Effect Analysis (FMEA) is one of the most popular safety and reliability analysis tools used for products and processes. Its wide application is documented by Braglia et al., (2003). FMEA models in food supply network studies are used to identify the potential failure mode of the hazard components (Nguyen et al., 2013). FMEA techniques use three fundamental attributes, occurrence probability, severity, and detectability to develop each hazard risk priority number (RPN). RPN of a hazard is the value obtained by the product of the three components. Although FMEA techniques have shown much attractiveness to the researcher in the past decades (Nguyen et al., 2013), its method still reveals some applicable problems, especially concerning critical analysis (Xu et al., 2002; Braglia et al., 2003). Researchers have criticised the FMEA model assessment process. For instance, the FMEA model does not take into consideration the relative importance of the risk attributes while using them in determining RPN values, FMEA techniques assume all three risk attributes are of equal weight (Liu et al., 2013). Other critics of the FMEA application model can be found in (Liu et al., 2013; Yang et al., 2008). To overcome such intrinsic drawbacks and enhance the performance of the *FMEA* model, it is interesting to see that many new methods based on uncertainty treatment theories such as Bayesian nets (Lee, 2002), Fuzzy logic (Xu et al., 2002), Dempster-Shafer theory (Liu et al., 2005) have also emerged in food supply network research. Bayesian Network (BN) has strength in demonstrating the interaction between parameters with limited available data and incorporating new resources for model optimization (Zhang et al., 2013). The researcher has used BN techniques to capture the non-linear causal relationship between the individual risk attributes in the food supply network and predicts the effect of the unexpected factor changes on each attribute of interest (Williams et al., 2011). Although BN techniques provide essential support in risk-based decision-making (Yang et al., 2009a). However, BN techniques on their own cannot provide a complete solution for a broader decision problem in which a systematic assessment exercise inevitably fits. Because the BN process requires too much data in the form of prior probabilities, which are difficult or impossible to obtain (Yang et al., 2008), and due to its lack of empirical data, a risk condition probability table (CPT) is generated on expert judgment. Thus, a large-scale BN model will be time-consuming, impractical, and inconsistent (Mkrtchyan et al., 2016). Although, according to (Yang et al., 2008) BN model is best used if complemented with other decision-making techniques. Fuzzy logic sets and fuzzy comprehensive evaluation models are widely used in literature in assessing food supply network risk (Tadic et al., 2014, Bai et al., 2018). The model allows hazard evaluation and prioritisation using expert judgment (Meng and Peng Lim, 2006). Hence, the model poses some difficulties in its practical application. For instance, many rules must be developed, and the process of obtaining the full set of rules from domain experts is a tedious task. Other critics of the Fuzzy logic model can be found in (Yang et al., 2008). Another trend in the food supply network research model is the full application of combined models such as Fuzzy FMEA, fuzzy *TOPSIS*, fuzzy rule-based Min-Max, and evidential reasoning operations, fuzzy AHP to achieve the best risk assessment result (Wang et al., 2012; Tadic et al., 2014; Lau et al., 2018). Fuzzy FMEA model address the question of vague estimation of the three attributes used in composing the original RPN value of hazard. The attractiveness of this model lies in the combination and simplification of the complex rule (Yang et al., 2008). Although Fuzzy FMEA improves the accuracy of the FMEA, by compromising the easiness and transparency of the conventional RPN method, due to difficulties in its industrial application, Fuzzy FMEA techniques have been criticized (Yang et al., 2008). The fuzzy

TOPSIS method has the advantage of ranking failure mode but shows insufficient ability in expressing true riskiness for each failure mode. Hence, such complex fuzzy calculations contribute to the development of more precise failure criticality analysis but render themselves vulnerable by losing advances in the conventional method, visibility, and easiness (Yang et al., 2008). Consequently, publications in safety and reliability studies have indicated that it is beneficial to combine fuzzy logic and Bayesian reasoning to compensate for their disadvantages (Huang et al., 2006; Eleye-Datubo et al., 2008). The application of combined fuzzy and Bayesian models is a new research direction that will fill the gap and enhance the food supply network research study.

2015-2019

2010 -2014

2005-2009

2000-2004

1995- 1999

- HACCP (3)
- Monte Carlo modelling (2)

- Tiered approach (1)
- HACCP (2)

- Predictive software (1)
- HACCP (2)

- Monte Carlo (3)
- Multiple regression analysis(1)
- GIS approach (2)
- Bayesian Network (2)
- Markov Chain Monte Carlo (MCMC) (1)
- Life Cycle Assessment (LCA) (2)
- QMRA (3)
- Mixed integral linear programming (2)
- HACCP (3)
- QMRA- SLP (1)
- Fuzzy Logic (2)
- Stochastic model (2)
- FMECA (2)

- Mann- Whitney U Test (1)
- Independent sample T-Test (1)
- Simulation and planning tools (2)
- Conceptual models (3)
- LCA (3)
- Network Analysis (1)
- Correlation Analysis (2)
- Grey Dematel (1)
- Fuzzy theory (3)
- Bayesian Network (2)
- Fuzzy AHP (2)
- ELECTRE (3)
- Unified Spectra analysis (1)
- Modified partial least squares (MPLS)
- Comprehensive and evaluation model (1)
- QMRA (2)
- Threat assessment critical control point (TACCP) (1)
- Vulnerability assessment critical control point (HACCP) (1)

Descriptive Statistic (1)
GIS approach (3)
Principal- Agent-based model (2)
NACCP (1)
ALOP (2)
HACCP (3)
Hierarchical Cluster analysis (1)
MABAC model (1)
Fuzzy ANP (1)
Fault Tree Analysis (FTA) (1)
TOPSIS (1)
Cluster Analysis (2)
Cost-Benefit Analysis (CBA) (1)
Monte Carlo simulation (2)
Fuzzy FMEA (1)
AHP (3)

Figure 2. 3: Assessment models used for food supply network research

2.2. An overview of the food transport logistic risk hazards

It is estimated that the world's population may grow to over nine billion by 2050 (UNITED NATION, 2011) and the global food demand is expected to increase by 70% by 2050 to meet up with the population growth (Bell and Horvath, 2020). The global food supply chain will require an integrated level of global transport logistic activities to coordinate the safety and quality distribution of food products from the production site to the final consumers. Food transport logistic activity is the movement of food products from their original point of departure to the point of arrival using a different vehicle with varying characteristics between each supply phase and the provision of ancillary logistic services. It is a process that begins with the receipt of a food transport order either from the food product manufacturer or the logistic company, in which they specify the kind of food product, amount, the date, and address for the loading and unloading, and the specific requirement that the product requires during transit. The company issue the shipping order with the necessary information: number of vehicles, type, loading time and loading station address, the type of product, the weight, delivery note, the number of pallets, consignee's address and delivery details (Renko et al., 2019), followed by proper storage of the product in line with the specific product requirement, the company then arranges to load the food product into the road, rail, waterways, air, or multimodal transport refer to as vehicles ensuring that all product conditions are met as per prescribed for its final transportation and distribution. Once the food product reaches her destination, via unloading vehicle, a dispatch form containing the date, time, information of product damage if any, type and quantity of goods is provided, the product is then unloaded and stored in the company warehouse, load onto a mean of transport for the final delivery of the goods (Renko et al., 2019). However, due to the operational running cost and the need for global coordination, almost all the food production company had outsourced their transportation activities to a third-party logistics service provider, which helps to ensure all the transportation processes run smoothly and enables a coordinated response to meet up with the requirement of its stakeholder needs**.** The transport logistic process in the food chain is shown in Figure 2.4. As global food demands increase, the transport logistic activities become more diversified and vulnerable to disruption caused by contractual conditions becoming more sophisticated and vulnerable to some risk hazards (Ottemöller and Friedrich, 2016; Fan, 2019) i.e. disruption caused by political instability, natural disaster, technical failure, dishonest entrepreneurs with little legal awareness, illegal chemical additives added to food, deficiency in food safety knowledge, polluted production environment, inadequate food storage, failure in keeping and maintaining the food product at a certain temperature. These have a safety and quality effect on food integrity and signify a need for a proper risk assessment in the food transport and logistic chain. In an attempt to identify the risk influencing hazard in the transport and logistic network, a thorough academic literature review was done as shown in Table 2.6, to comprehensively and structurally identify the risk influencing the hazard from source and dominate a classification for their assessment

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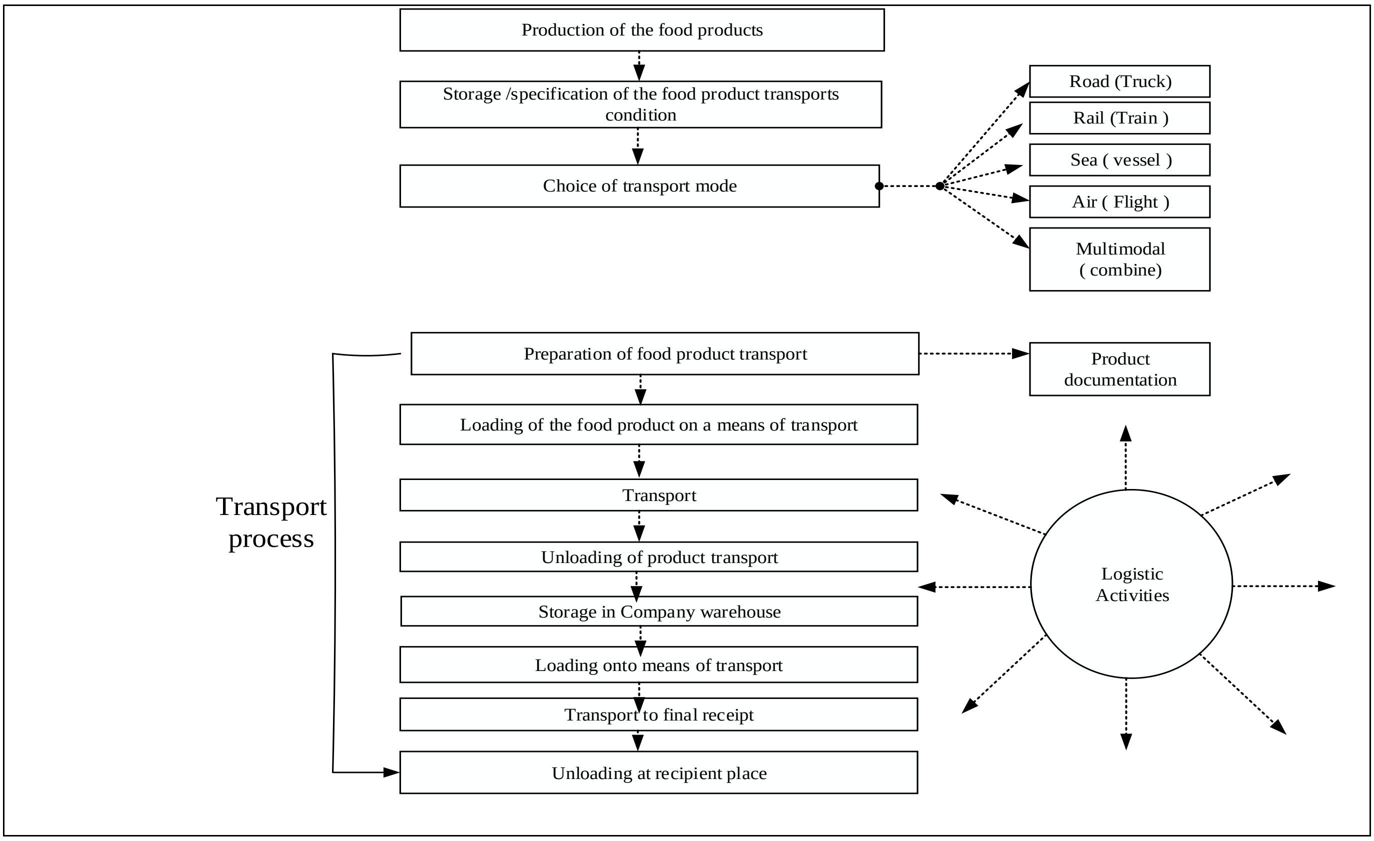

Figure 2. 4: Transport Logistic process

Table 2. 6: Present an overview of the transport and logistics risk review from the literature

	Author																				
Risk factors	Rao and Goldsby, (2009)	Tuncel and Alpan (2010)	Ackerley Serkaya (2010)	Vilko and Hallikas (2012)	Tummala and Schoenherr	Pfohl, Gallus and Thomas	Diabat et al., (2012)	Samvedi et al (2013)	Radivojevic and Gajovic	Yeboah et al (2014)	Mangla et al (2015)	Garvey et al (2015)	Sharma and Pai, (2015)	Srivastava et al (2015)	Ho et al (2015)	Dong and Copper (2016)	Rathore et al (2017)	Nyamah et al (2017)	Wu, Hu, and Zhu (2017)	Yan et al (2018)	Najmi and Makui, (2010)
▪ Natural Disaster uncertainties	√				√	√	√		√	√				√	√	√	√				√
▪ Diseases							√													√	
▪ Political unrest	√						√	√		√					√	√					
▪ War/terrorist attack					√	√	√	√							√	√					
▪ Government Regulation	√		√		√		√			√			√	√	√			√			
▪ Labour strike					√	√	√		√								√	√			
▪ Lack of skilled personnel			√				√		√												
▪ Financial crisis																√					
▪ Social and cultural grievances								√							√						
▪ Severe Thunderstorm									√												
▪ Tsunami									√												
▪ Natural Forces (Flood, storm, weather changes)				√					√	√		√						√	√		
▪ Union and labour relation									√									√	√		

▪ Fire Accident				√											√						
▪ External Legal issues															√						
▪ Sovereign Risk															√						
▪ Periodic deficit/ Excess Rainfall				√														√			
▪ Slipperiness in wintertime				√																	
▪ Terrorism				√																	
▪ Climate change				√																	
▪ Temperature																			√		
▪ Humidity																			√		
▪ Season																			√		
▪ Economic downturn							√								√						
▪ Volatile demand							√			√								√			
▪ Changes in customer tastes		√					√			√											
▪ Customer communication failure					√		√	√					√	√			√				
▪ Market change							√	√													
▪ Broken contract																√					
▪ Inaccurate demand forecast					√										√	√	√	√			
▪ Demand uncertainty					√					√					√						
▪ Sudden shoot-in demand															√		√				
▪ Demand quantity																					
▪ Supplier bankruptcy					√		√	√	√	√						√		√			
▪ Inaccurate shipment from supplier																√					
▪ Low supplier transparency														√		√					
▪ Raw part scarcity																√					
▪ Security Information sharing																√					

▪ Supply interruption					√									√		√					
▪ Low supplier integration									√	√						√					
▪ Communication failure							√														
▪ Failure of the partnership							√														
▪ Poor quality of the supplied goods					√	√	√			√							√	√			√
▪ Inability of supply						√	√										√				
▪ Market requirement transformation																√					
▪ Inaccurate shipment to the customer																√					
▪ Order Fluctuation																√		√			
▪ Urgent Order																√					
▪ Product damaged in transit									√							√					
▪ Supplier fulfilment error					√																
▪ Selection of wrong partners					√																
▪ Supplier inflexibility																					
▪ Traceability													√	√							
▪ Lack of supplier visibility														√							
▪ Perishability														√							
▪ Raw parts scarcity		√																			
▪ Customer defection																√					
▪ Lacked skilled workers				√		√									√	√					
▪ Employee wages																√					
▪ Excessive inventory							√		√			√								√	
▪ Underutilised Capacity							√														
▪ Quality Problem		√			√		√		√	√				√						√	
▪ Exchange rate fluctuation (macroeconomic uncertainty)	√				√			√								√		√			

▪ Non-availability of procurement centre																	√				
▪ Poor Handling – loading and unloading at different locations																	√				
▪ Poor packaging and preservation																	√				√
▪ Long-term production downtimes						√													√	√	
▪ Short-term production downtimes						√															
▪ The poor performance of subcontractors						√							√								
▪ Temperature Abuse													√	√						√	
▪ Transaction cost													√	√							
▪ Poor Sourcing Contract														√							
▪ Cross-contamination										√		√		√				√			
▪ Sabotage														√							
▪ Tampering														√							
▪ Monitoring of Water quality																				√	
▪ Seedling quality										√										√	
▪ Using Fodder and feed Additives																				√	
▪ Insufficient holding space									√											√	
▪ Imperfect yields									√												
▪ Pest and disease							√			√											
▪ Overburden employee												√									
▪ Labour strike in the port				√	√	√	√		√								√	√			
▪ Ship collision and sinking				√																	
▪ Poor Motivation among the workforce				√																	
▪ Harvesting time																			√		

▪ Forecast Error							√	√	√						√			√			
▪ Information distortion				√	√		√									√					
▪ Technology obsolete					√			√	√					√		√	√			√	
▪ Lack of IT compatibility among SC partners					√	√				√			√								
▪ Storage and warehouse						√											√			√	
▪ Lack of sufficient cargo handling equipment				√		√				√			√	√				√		√	
▪ Lack of intermodal /multimodal equipment				√																	
▪ Power system																			√		
▪ Irrigation and road condition																			√		
▪ Transportation providers fragmentation															√	√		√			
▪ Transportation route bottleneck			√	√						√						√					
▪ Excessive handling due to border crossing or change in transport mode					√										√						
▪ Port capacity and congestion		√			√										√						
▪ Customs clearance at the port				√	√										√						
▪ Transportation breakdown					√	√								√							√
▪ Paperwork and scheduling					√																
▪ Port strike					√										√						
▪ Delay in port due to port capacity					√				√												
▪ Late deliveries					√	√														√	
▪ The higher cost of transportation					√					√											
▪ In transit loss																	√				

▪ Timely availability of Vehicle																	√				
▪ Poor Logistic Contract														√							
▪ Refrigerator Car usage																				√	
▪ Risk of Network coverage																				√	
▪ Risk of applying sensing technology																				√	
▪ Temperature Monitoring /control			√																	√	
▪ Risk of security																				√	
▪ Quality of drivers			√																	√	
▪ Remote highway theft									√						√						
▪ Pilferage									√												
▪ Accident									√												
▪ Damage to handling/transportation									√												
▪ Rerouting									√												
▪ Labour dispute affecting transport										√											
▪ Port congestion										√											
▪ Capacity constraint										√											
▪ Lack of security			√																		
▪ Improper holding practices for products awaiting shipment			√																		
▪ Improper management of transportation unit			√																		
▪ Improper Loading practices			√																		
▪ Poor pest control			√																		

▪ Poor Transportation unit design and construction			√																		
▪ Poor employee Hygiene																					
▪ . Lack of traceability												√									
▪ Delay in shipment												√									
▪ Truck accident												√			√						
▪ Poor packaging and preservation																	√				√
▪ Deterioration of product quality due to delivery delays																					√
▪ Lack of outbound effectiveness															√						
▪ No transport solution alternatives															√						
▪ On-time /on-budget delivery															√						
▪ Damage in transport															√						
▪ Maritime pirate attack															√						
▪ Long Working times															√						
▪ Negligently Maintenance															√						
▪ Transportation breakdown		√													√						
▪ Global sourcing network															√						
▪ Human error		√																			
▪ The capacity problem in railroad traffic				√																	
▪ Permit of the transportation company				√																	
▪ Drunken drivers				√																	

2.3. Overview of the risk classification

Risk classification is an essential step in the risk assessment process, as it attempts to structure the various risk hazards from their source (Tah and Carr, 2000). In the literature, food supply chain risks are classified into different categories, some researchers categorise the risks either from the source or root causing deviation. The overview of the various risk hazard classes and their definitions within the general perspectives of food supply chain risk management is presented in Tables 2.7 and Table 2.8

Table 2. 7: Food supply chain risk classification

Author	Risk categories	Risk type/source
Jüttner et al., (2003)	3	Environmental risk,
		Supply chain risk
		Internal risks
Cavinato, (2004)	5	Physical risk
		Financial risk
		Informational risk
		Relational risk
		Innovation risk
Wu et al., (2006)	2	Internal risks
		External risk
Tang, (2006)	2	Operational risk
		Disruption risk
Bogataj and Bogataj, (2007)	5	Process risk
		Control risk
		Demand risk
		supply risk
		Environmental risk,
Manuj and Mentzer, (2008)	6	Supply Risk
		Demand risk
		Security risk
		Macro risk
		Policy risk
		Operational risk
McCormack et al., (2009)	2	Internal risks
		External risk
Ackerley et al., (2010)	4	In-transit product risk
		Equipment-related risk,
		In-transit process risk,
		The organization or policy-related risk
Ravindran et al., (2010)	2	Operation risk
		Disruption risk
Kumar et al., (2010)	2	Internal risks
		External risk
Tang and Nurmaya Musa, (2011)	3	Material flow risk
		Financial flow risk
		Information flow risk
Diabat et al., (2012)	6	Supply risk,
		Demand risk
		Operational risk

		Product/service management risk
		Macro-level risk
		Information management risk
		Supply risk
Vilko and Hallikas, (2012)	6	Security risk
		Operational risk
		Macro risk
		Policy risk
		Environmental risk
		Supply risk
Samvedi et al., (2013)	4	Demand risk
		Process risk
		Environmental risk
		Internal risk
Bachev, (2013)	5	External risk
		Natural risk
		Technological risk
		Human behaviour risk
		Operational risk
Radivojević and Gajović, (2014)	5	Technological risk
		Economic risk
		Social risk
		Natural risk
		Macro risk
Ho et al., (2015)	2	Micro risk
		Internal risk
Dong and Cooper, (2016)	2	External risk
		Supply risk
Vilko et al., (2016)	6	Security risk
		Operational risk
		Macro risk
		Policy risk
		Environmental risk

Table 2. 8: Food supply chain risk classification definition

Risk Classification	Definition	Reference
Physical risk	The risk is based on the actual movements and flow of goods within and between firms	Ackerley et al., (2010)
Financial risk	The risk associated with the flow of cash between the organisation, the incurrence of expenses and the use of investment for the entire chain	Bachev (2013)
Informational risk	The risk associated with the processes and electronic system, access to key information, market intelligence, capture, and use of data	Bachev, (2013)

Relational risk	The risk is due to the appropriate linkage between the supplier, the organization and its customer for maximum benefit	Diabat et al., (2012)
Innovation risk	The risk associated with the process and linkage across the firm, its customers, suppliers, and resource	Bachev, (2013)
Supply risk,	The risk resides during the movement of materials, from the supplier to the firm	Samvedi et al., (2013)
Operational risk	The risk that affects the firm, internal ability to produce goods and services, ultimately affecting the profitability of the company, are associated with inherent uncertainties	(Radivojević and Gajović, 2014; Diabat et al., 2012)
Disruption risk	The risk associated with the major disruption caused by natural or man-made risk	Bachev, (2013)
Demand risk	The risk associated with the movement of goods, from the firm to the customer	Samvedi et al., (2013)
Macro risk.	An external event or situation that might hurt companies' activities, it is either occur naturally or man-made	Ho et al., (2015)
Micro risk	Referring to a recurrent event that originated directly from internal activities of companies or relationships within the partners in the entire supply chain, it is divided into four categories, demand risk, manufacturing risk, supply risk, and infrastructure risk.	Ho et al., (2015)
Manufacture risk	are adverse events within the firm that affect their internal ability to produce goods and services, quality and timeliness of production and profitability	Tang and Nurmaya Musa, (2011)
Economic risk	The risk associated with the macroeconomics of the business terms such as effective state regulation, and political instability on business operation	Radivojević and Gajović, (2014)

2.4. Conclusion

Understanding how the food supply chain had evolved over the years can help researchers identify research gaps. This study summarized the evolution of the different food supply network research studies in the last 25 years using 171 peers – reviewed papers from academic journals published in English. It was identified that there is a global awareness of the scope and magnitude of the various risk hazard risk that affects the safety, quality, efficiency, and sustainability of food products in the business and global economy. Based on the analysis conducted in this chapter, the drawbacks found in the literature had been identified and the thesis proposed research question will address the research gaps and bridge the existing literature in food supply chain risk management. The identified research gaps in the literature are summarized as follows:

- The review of the literature indicated due to the wide geographical spread of the various actors that are involved in the transport and logistic phase in the food supply chain, there is a high complexity of risk hazards shrouded with uncertainty and imprecise data information that threatens the smooth flow of the food product with a severe consequence on the global economy, and there is lack of integrated risk hazard management framework to assessed and support management decision making during the transport and logistic activities. Previous studies had only focused on the assessment of risk hazards from the production, post-harvest, and processing phase in the food supply chain.
- The risk hazards had only been considered as a random variable with a limited focus on the assessment of their cause-effect interdependency relationship in the food supply networks.

- There are deficiencies in the risk assessment model techniques previously used in food supply network research. Review shows that most of the previously used models have shown some drawbacks and insufficiency in their practical applications. Hence, considering the volume and vulnerability of food produced and transported globally, there is a need for a more flexible and more comfortable to use model, that can evaluate these hazardous risk factors in a coordinated approach and under the challenge of uncertainties, and prioritize them without losing their easiness and vagueness, for a proper management decision making and effective risk control
- There are no studies that had examined the causal variables affecting the top priority risk hazards in the food transport and logistic chain and developed benchmarking tools for the management of the risk hazard causal indicators.
- There are no studies that had examined the transport and logistic chain risk mitigation strategies in the food supply networks.

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CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter reflects the reason for choosing the research methods, it explains the rationalisation of how the research methodological process is designed to achieve the research aims and objectives. The study encompasses the four steps of an effective risk management process namely risk identification and classification, risk assessment, risk cause and effect assessment and risk mitigation strategies. Typically, one research method is not sufficient to cover the entire risk management study, rather an appropriate selection of the research methods and methodology that is suitable for each of the processes will be more desirable in developing the proposed integrated risk management model for Agro-food transport logistics (AFTL) chain. This chapter begins by presenting the research philosophy assumptions and the different philosophical stands underpinning the research strategies and the data collection method chosen in the study as part of the strategy, followed by the explanation of the two main approaches adopted in the study. The next session highlights the justification for the selection of the study Philosophy approach, the study research design, and its methodological choice. It is worth mentioning that this research conducts empirical studies among the global Agro-food handling companies in Thailand, the Republic of China and the Republic of Vietnam and questionnaire surveys and interviews were implemented to collate survey data. An overview of the methodological framework upon which the study methodology is developed is presented in Figure 3.1.

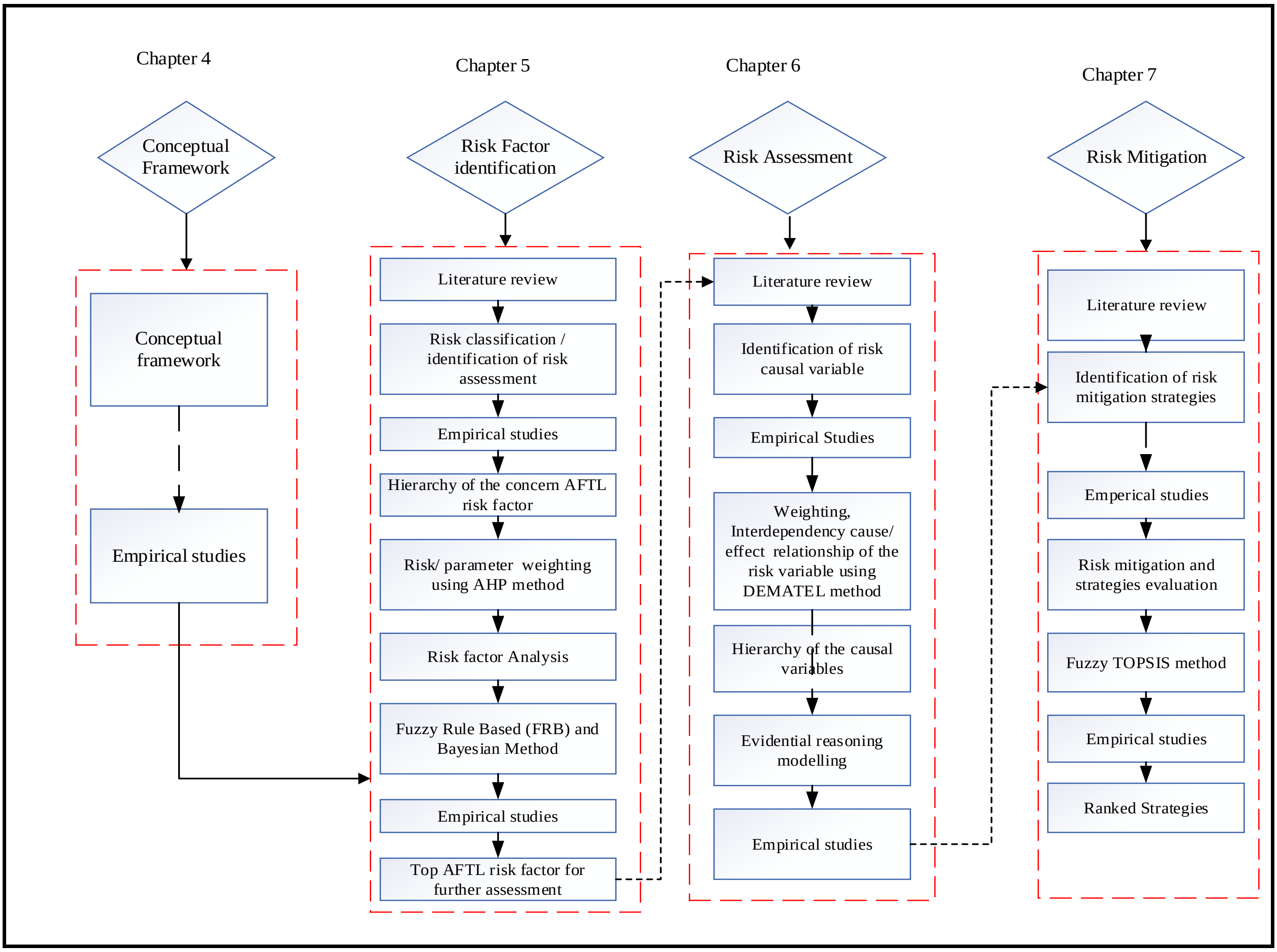

Figure 3. 1: Proposed methodology framework of AFTL integrated risk management

3.2. Research philosophy

The term "Research philosophy" is associated with the techniques of critical analysis of "what is reality" and "what constitutes the knowledge of that reality" It contains an important assumption on how researchers examine the world, this assumption is the foundation to research design and the appropriateness of the method of data collection and analysis that will be used to interpret the research result (Williams et al., 2011).

3.2.1. Research philosophy assumptions

Every research study has a philosophical orientation about the world and the nature of research. This philosophical assumption is the critical analysis of the central belief system or worldview that underpins the research strategy and the choice of methods as part of that strategy for data collection (Saunders et al., 2015). Epistemology, Ontology and Axiology are the three main types of research assumptions, they help the researcher to better understand the research philosophies. The epistemology assumption is a basic set of beliefs regarding what constitutes acceptable knowledge in any field of inquiry. It is the answer to the researcher's question of “how can I understand a reality” (Bell et al., 2018). Ontology is concerned with the nature of reality. It raises the question of the assumptions research would have about the way the world operates and the committee held on a particular view (Bell et al., 2018). Axiology, on the other hand, is more concerned about the value in all stages of the research process, with the thought that researcher need articulate their value as a basis for making a judgement on their research process (Bell et al., 2018).

3.2.2. Research paradigm

The term “Research Paradigm” refers to a set of philosophical assumptions that are inherently coherent about the nature of reality and the researcher's role in constructing it, which had been agreed upon by a community of scholars (Creswell and Creswell, 2017). Paradigm enables a researcher to clarify assumptions about their views, develop a useful way to understand their work approach and pilot their research route by way of examining a social phenomenon and generating a fresh insight into real-life issues and problems (Creswell and Creswell, 2017). There are three major philosophies in business and management 1) Positivism, 2) Pragmatism and 3) Interpretivism.

Positivisms

Positivism is a natural scientist holding a deterministic philosophy in which causes determine effects, with an assumption that only real phenomena can produce "knowledge". A positivist researcher's major concern is to collect data on observable and measurable variables in a controllable condition and describe the regularities and causal relationships among the variables (Saunders et al., 2015). Their belief promotes the idea of experimentation and testing to prove or disprove hypotheses (Martelli and Greener, 2015)

Pragmatism

Pragmatism is social scientists with the view that is unrealistic in practice to adopt a single philosophical stand in a research study. They believe that the research question is the most important determinant of the research process, and the researcher could use a mixed variety of thought to gather such data for the research (Saunders et al., 2015).

Interpretivism

Interpretivism is a social scientist promoting subjective thought, and they see the world through the eyes of the people being studied and allowed multiple perspectives of reality. An interpretivism researcher has an interpretive understanding of social action to arrive at a causal explanation of its course and effects using an inductive research process to generate meaning from data collected (Bell et al., 2018). Table 3.1 shows the distinction between the three research philosophies

Table 3. 1: Distinction between the three research philosophies

	Pragmatism	**Positivism**	**Interpretivism**
***Ontology**: the researcher's view on the nature of reality or being*	External, Multiple, views chosen to best enable answering of a research question	External, objective, and independent of social actors	Socially constructed, subjective, may change, multiple
***Axiology**: the researcher's view of the role of values in research*	Values play a large role in interpreting results. The researcher adopts both objective and subjective points of view	Research is undertaken in a value-free way. The researcher is independent of the data and maintains an objective stance	Research is value bound, the researcher is part of what is being researched, cannot be separated and so will be subjective
***Epistemology:** the researcher's view regarding what constitutes acceptable knowledge*	Depending on the research question, either or both observable phenomena and subjective meanings can provide acceptable knowledge. Focus on practical applied research, integrating different perspectives to help interpret the data	Only observable phenomena can provide credible data and facts. Focus on casualty and law-like generalisation, reducing phenomena to simplest elements	Subjective meanings and social phenomena. Focus upon details of the situation, a reality behind these details, subjective meanings motivating actions
Data collection techniques	● Mixed or multiple method design ● Quantitative and /or qualitative ● Action research	Highly structured, larger samples, measurement, quantitative but can use qualitative	Small samples, in-depth investigation, qualitative

Source: Saunders et al. (2012, p.140)

3.3. Research Approach

All research has a theoretical view to clearly explain how advanced knowledge in a particular field has been developed (Creswell, 2018). Nevertheless, to appreciate the theoretical reasoning that concerns the choice of a research design, one needs to distinguish between the two primary research approaches (Deductive and Inductive) that form the basis of the theoretical view. The deductive approach advanced an existing theory derived from the academic literature and used data collected for the research to evaluate prepositions or hypotheses related to an existing theory. An inductive approach develops a theory based on the result of the analysed data collected for the research. The process of deduction involves moving from general to specific and the process of induction demonstrates a move from specific to general (Saunders et al., 2015). Researchers can opt for either of the approaches, depending on the nature of a research topic and the available information present in the literature. A research topic with a wealth of literature to define a theoretical framework will adopt a deductive approach while a research topic with less existing literature will adopt an inductive approach (Saunders et al. 2012). Table 3.2 shows the distinction between the two research approaches.

Table 3. 2: Distinction between the two-research approach

	Deduction	**Induction**
Theory	In deductive inference, data is collected to test an existing theory derived from the academic literature	In inductive inference, the development of theory is a result of the analysed data collected for the study
Generalisability	Generalising from the general to the specific	Generalising from the specific to the general
Risk indulgent/timing	The deductive research approach has a low-risk strategy in the data collection process and is easier to accurately predict the research time frame	The inductive approach could last longer based on a longer period of data collection and analysis with a fear that no useful pattern and theory will emerge

Source: (Saunders et al. 2012)

3.4. Justification of choice of study research Philosophies and approach

The study aims to develop an integrated risk management model for the agro-food transport logistic chain. The study plays an important role in ensuring the safety in the logistic of agro-food products in the end to the end link of the supply chain. Globally, during the transport and logistic process of agro-food products, the emergent risk factors from the organisation's external to internal processes are present. Although, the vulnerability and consequences of these risk factors remain unclear due to the lack of detailed information and unavailability of process data from the various participant in the chain. The study had an ontological view on the existence of these risk factors and their potential consequence on the global economy with an epistemologist belief, that the AFTL factors are measurable, and their risk level could be identified, prioritised, and mitigate to facilitate an effective management decision. The study uses a deductive approach in the research process and begins by identifying the risk factors and establishing the interdependency relationship between the risk factors based on uncertain treatment models derived from the literature. Consequently, develops a series of hypotheses on the risk factors and collects quantitative data to test the proposition of the hypothesis. In view, the study employs the practices and norms of a natural scientist with a positivist strand. This Philosophical strand allows a careful observation and measurement of reality with a highly structured methodology approach that can facilitate replication of the research study (Saunders et al., 2015).

3.5. Research Design

Research design is the conceptual framework used in collecting shreds of evidence, identifying and generating solutions to the research questions and meeting the objectives of the research (Kothari, 2004). The research design involves the various process adopted in the study. It explains the rationale behind the research methods and the techniques used in the context of the research study, starting from research methodological choice, the study theoretical perspective, the choice of research strategies, methods of data collection, and data analysis (Kothari, 2004).

3.5.1. Research Methodological choice

The research methodological choice is a general orientation used in the collection, interpretation, and analysis of data. Qualitative, quantitative, and Mix-method research are the three choices to design research (Saunders et al., 2015). Qualitative methods involve the use of data collection techniques or analysis procedures that generate or use non-numerical data (Bell et al., 2018). A qualitative research design may use a questionnaire survey to gather data in a natural setting, to learn about some aspects of the social world and to generate new knowledge that can be used. A qualitative researcher accumulates a representation of real data and then transforms the data through analysis and interpretation into information that can be used to address a recurring social issue. They gather data from fieldwork, face-to-face interaction with real people, through interviews, observation, the gathering of documents, and examination of material cultures (Bell et al., 2018). Qualitative research is mostly associated with interpretative philosophy using either an inductive or deductive approach. Its process involves collecting non-standardised data and using various analytical tools to develop the research conceptual framework (Saunders et al., 2015).

Quantitative methods involve the use of data collection techniques or analysis procedure that generate or uses numerical data (Bell et al., 2018). The technique is mostly associated with a deductive approach and a positivist research philosophy but might incorporate an inductive approach within a pragmatist philosophy based on the data collection strategies and purpose (Saunders et al., 2015). Quantitative methods employ the use of data collection techniques such as questionnaires or semi-structured interviews or observation as an instrument for data collection, examine the relationship between variables and allow for the numerical measurement and analysis of the data feedback with different statistical tools (Saunders et al., 2015). The quantitative method has critics such that, the method to analyse the relationship between variables creates a static view of the social life of a sample population that is independent of the natural world, and the data measuring process possesses an artificial and spurious sense of precision and accuracy (Bryman and Bell, 2011).

Mixed methods use an approach that integrates both qualitative and quantitative methods, with a pragmatism research philosophy (Creswell and Creswell, 2017). The method allows the researcher the option of using either more than one data collection technique with an associated analytical procedure (multi-method) or a combination of both the qualitative and quantitative methodologies (Mixed method) during the research process. Although, the techniques allow a richer data collection, analysis and interpretation, the process might involve the collection of two separate data in response to the research question and using separate analytic tools in analysing and avoiding diluted data (Saunders et al., 2015).

Consequently, based on the dynamic approach to the research process a mixed-method methodological choice will be employed in the study to direct the phases of data collection and analysis. The mixed-method approach provides the researcher with the option of using more than one data collection technique with an associated analytical procedure or a combination of both qualitative and quantitative methodologies during the research process (Creswell and Creswell, 2017).

3.5.2 Theoretical perspective in quantitative research

Theory in quantitative research is an interrelated set of constructs formed into prepositions that specify the relationship between variables (Creswell, 2018). Uncertain treatment theories, that incorporate Fuzzy set theory, Bayesian Network, the DEMATEL model, the Evidential reasoning model and fuzzy TOPSIS will be employed in the study to design the integrated risk management model in the AFTL chain.

3.5.3 Research Strategy and research methods

Strategy is the plan of action to achieve the study objectives (Saunders et al., 2015). Three distinct conceptual frameworks are principally linked with the research methodological choice based on the research question and objectives as discussed in the subsequent sections. Moreover, a review of the academic literature shows the various risk factors present during the transportation and logistics of Agro-food products and there is no need to conduct an actual experiment to engender trustworthiness of their presence in theory and practices. Thus, the study approach is not amenable to experimental findings (Bell et al., 2018). However, due to the problem associated with the uncertainty of data about the risk factors and the introduction of the uncertainty treatment theory to support the data collection process, four different research methods namely 1) Survey research, 2) Mathematical modelling, 3) Questionnaire and 4) Case study research method was employed to achieve the study objectives.

3.5.3.1. Survey

The survey strategy is usually associated with a deductive approach used for exploratory and descriptive research to answer "who" "where" and "how" research questions (Saunders et al., 2015). The survey strategy is adopted in the study to gather information from the population samples. The advantage of this approach is that, once the procedure for data collection and analysis are specified replicability can be enhanced (Bell et al., 2018). The survey strategy approaches allow the collection of a large amount of standardising data that can be analysed quantitatively from a large population in an economical way. In addition, its approach gives the researcher more control over the research process, minimises bias and maximises response rate (Saunders et al., 2015). The drawback with the survey approach is that over time it might be difficult to measure the stability of the population sample data, and analysing such large data might be time-consuming (Walliman, 2017)

3.5.3.2 Mathematical model

Mathematical models are very useful tools in the process of human enquiry. As mentioned by Nering and Ostini, (2011). The mathematical model "elucidates the conceptual grounding and explicates the framework for a project, and in doing so, provides a context from which to conduct analyses and interpret results". Ultimately, the difficulties associated with the vagueness and the collection of information data on the study variables which are not directly measurable and needed to be studied indirectly through the measurement of other observable activities, led to the study adoption of a mathematical modelling approach to quantify the AFTL risk variables of interest. The drawbacks of the mathematical model are the ideal of errors in measurement (Nering and Ostini, 2011).

3.5.3.3 Interview

The term "Interview" is mainly used purposely for securing research data information and corroborating evidence from sources incorporating a self-administered form within a face-to-face, telephone or questionnaire means of collecting sensitive information about the study variables (Nandi and Platt, 2011). A face-to-face and telephone interview method was adopted in the study to offer more flexibility, cheapness and easier to administer data collection and generate a higher response rate. The Phase began by following the survey instrument process as discussed in section 3.6 below.

3.5.3.4. Case study

According to Tight, (2021), a case study research method refers to a "research design whose focus is on an in-depth of a specific and limited variable, measuring and exploring their variation and relationship with other variables for a given sample of cases". It is holistic, allowing a careful delineation of the variables for which a shred of evidence is being collected to be studied in their real-life context. A case study is unique in its ability to deal with a full variety of evidence documents, artefacts, interviews, and observations. Its techniques prove to be quite appropriate in understanding the complexity of real-life events and supporting the theoretical proposition in collecting and analysing data (Yin, 2009). A case study strategy is employed in the study not to represent a sample, but to empirically investigate the imprecise real-life data information on the study variables and to expand and generalise the uncertainty treatment theories developed to analyse the AFTL risk factors. The major drawback of using a case study-focused strategy is in terms of the limited generalizability of the findings (Singh and Sharma, 2014). However, to overcome the drawbacks, the study survey data are collected from multiple organisations.

3.5.4 Sampling Design

Sampling design represents the techniques the researcher develops to obtain samples from their field of inquiry. It is usually designed before data are collected to enable a proper selection of the population and the required optimum sample sizes that fulfil the requirement of efficiency, reliability, and representation of the study. The procedures for selecting a research sample must be viable in the context of time and the cost available for the study and be such that reduce sampling error and help control systematic bias (Kothari, 2004). The study employs a combination of different sampling techniques with a purposive sampling size of the organisation whose operation involves the transport and logistics activities of agro-food products in each risk management phase. In the first phase of data collection, a sample frame of agro-food production companies with a logistic department recommended by the Socialist Republic of Vietnam Ministry of industry and trade was selected, to conduct the AFTL risk assessment in their real-life context and to generalise information for further evaluation. In the second phase of data collection, a sample population of agro-food experts from the Asia and UK food industry will be selected, to access their perception of the causes and mitigation control on the top risk factors. Table 3.3 summarizes the sample design process adopted in the study.

Table 3. 3: Research Sampling design

Procedure	Definition	Adopted study process
Defining the population sampling unit	Represent the universal unit in which the study samples are to be selected.	The study chose the Republic of Vietnam, China, and Thailand as the sample population country due to their great importance on agro-food products. For instance, taking the Republic of Vietnam example- The Republic of Vietnam had become the global hub for Agri-food products with a high volume of products transported across borders.[1] The agri-food processing industry in Vietnam according to foodexport.org, had enjoyed a more than a 10% average growth rate per annum with authority attracting foreign investors with more relaxed paperwork and transparent regulation. The cheap cost of labour makes it relatively easy for the Vietnamese Agri-food producer to enter the global food supply chain. However, according to the 2011/2020 FAO guideline for ASEAN countries on the categorisation of global industry and risk-based food[2], Vietnam's agri-food processing industries are categorised as high-risk industries because of the presence of various risk factors in their supply chain network that can affect the safety, quality, and sustainability of the agri-food produce to the global market. For example, the high-country usage of chemical additives added to their primary agro products have a detrimental effect on health, food quality and safety.
Selecting the sampling method	The selection process depends on the study scope and objectives with a consideration of the time and budgetary constraint	Surveying the entire population is a doubtful task in research due to the time and limitation of resources (Bell et al., 2018). This study considered it appropriate to take data samples from a representative population that represents its scope and objectives (Kothari, 2004), using a combination of different sampling techniques to collect a piece of more detailed data information and devote more time to check and test their data for accuracy before analysis (Saunders et al, 2012).
Sample frame selection	The list of the population from which the research sample will be selected.	Companies in China, the Republic of Vietnam and Thailand, handling the transportation and logistics of Agro-food products to the global markets are targeted.
The decision on the sample size	Represent the organisation whose values and operation characteristics are in line with the study objectives without any variance.	Based on the research purpose and the research question of inquiry, an embedded multiple case study design with a purposive sampling size is adopted with the ideal to analytically generalise data results to broader theories and examined the study phenomenon in its real-life context (Korzilius, 2012).
Implementing the sample plan	The final step in the sampling process comprises the survey.	As discussed in section 3.9

[1] Jeffrey Hays, (2014); Fact and details. Agriculture in Vietnam, available at: http://factsanddetails.com/southeast-asia/Vietnam accessed 24 June 2019

[2] Dedi Fardiaz: RAP publication 2011/2012. Guidelines for risk categorisation of food and food establishments applicable to ASEAN countries. Food and Agriculture organisation of the United Nations Regional office for Asia and pacific. Available at: http://www.fao.org/3/i2448e/i2448e00.htm accessed on 24 June 2019

3.6. Survey Instrument development

The survey technique is adopted to elicit information from the sample respondent. This study adopts multiple survey instruments i.e. in-depth, semi-structured and structured interviews and surveys questionnaires throughout the data collection process (Bell et al., 2018). The in-depth interview technique is used to engage the domain experts in a group discussion and explore a deeper understanding of the literature-reviewed risk factors, the risk assessment parameters, the risk causal variables and the risk control mitigation strategies. The semi-structured interview is used to understand the relationship between the study variables and provides the flexibility of asking a series of questions during the interviewing process, with a latitude to ask further questions based on the interviewee's responses. Although, the semi-structured and in-depth interview techniques have drawbacks with standardisation in the data collection process, making it a challenge to aggregate and process interview responses (Bell et al., 2018). The structured interview instrument is adopted to promote standardisation in the data collection and measurement process. By asking each respondent precisely the same context of questioning and recording the responses it can minimise the differences in interviewer responses, ensure the interviewee response is of identical cues, reduce the potential source of error and greatly facilitate the process for quantitative data analysis (Bell et al., 2018). The survey questionnaire is used to generate valuable data needed to meet the research objectives. To receive quality information data from the population sample, the study survey questionnaires were properly designed following Kenneth and Karen, (2014) five recommended questionnaire design processes outlined in Figure 3.2.

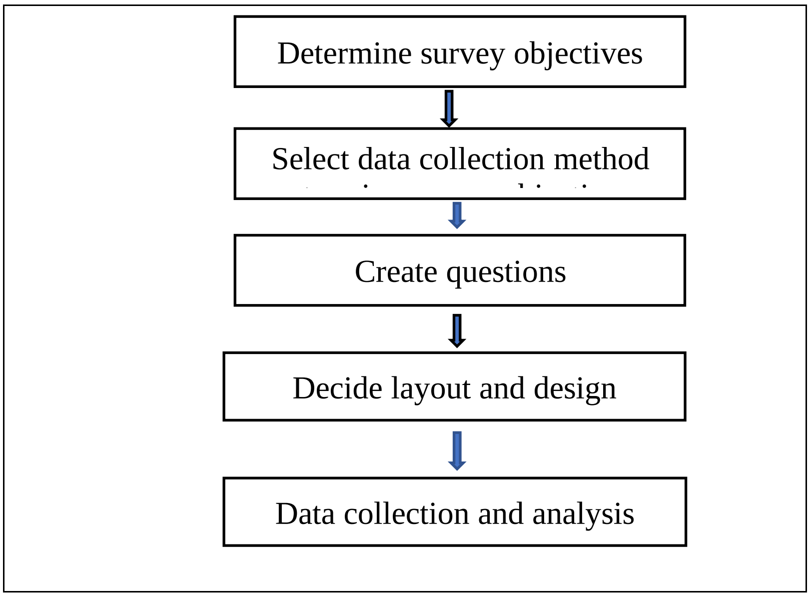

Figure 3. 2: Steps for developing questionnaire design

Source: Adapted from (Kenneth and Karen, 2014)

3.6.1. Determine survey objectives

The first step employs in line with Kenneth and Karen (2014), is to spell out the kind of information data the questionnaire would generate using the research objectives as a guide. To establish the study's purpose, a constructive literature review was carried out to identify the existing AFTL risk factors and the risk assessment parameters. Also, industry experts were consulted to explore other risk factors that are not discussed in the previous studies.

3.6.2. Selection of data collection method

A self-completed questionnaire approach was employed in the study to collect data needed to evaluate the risk factors using the proposed modelling tools from the senior management team of each sample frame organisation. The questionnaire survey is based on a pre-piloted closed question that covers all the risk and core activities factors affecting the safety and sustainability of agro-food products during the transportation and logistics phase. This approach allows a standardised process of asking a question and recording the answer, minimised interviewer variability and allows the question to be asked as they appear in sequence and keeps the response error minimal (Bell et al., 2018). To establish the study purpose, a constructive literature review together with a consultation with industry experts was conducted in each phase of the risk management process. The first phase of the questionnaire survey was to verify and validate the literature review on risk factors that apply to the AFTL chain, the initial risk assessment parameters, and the rationality of the proposed risk classification framework. The second phase of the questionnaire was conducted to quantify the risk level of the verified AFTL risk factors. The third phase of the questionnaire was conducted to identify and validate the causal factors of the top priority risk and evaluate the cause-and-effect interrelationship of the risk variable indicators. The fourth and fifth phases of the questionnaire were carried out to quantify the top priority risk variable indicators and extract the mitigation strategies

3.6.3. Creating questions

The questions used in measuring the survey objectives were developed using closed-ended questions. The closed-ended question format is suited for the study, because of the advantage it possesses such as allowing respondents the option of responses to choose from, reducing interview bias, allowing data to be coded efficiently, saving a great deal of time during data processing, and limiting the possibility of process error (Kenneth and Karen, 2014).

3.6.4. The questionnaire layout and design

The layout of the questionnaire was based on the proposed risk management models, which incorporate the uncertainty treatment models-based survey questionnaires designed as explained in the subsequent chapters. The questionnaires were initially developed in English and translated using a professional translator into the Vietnamese language (first data collection phase), Thailand and Chinese language (second data collection phase), to make it easier for experts from the participating countries to understand the questionnaire in their local language.

3.6.5. Data Collection and analysis

During each phase of the risk management process, numerical data, expert thought, and opinions were used to generalize data from a sample to a larger known population (Bloor and Wood, 2016). During the data collection process, each data collection phase was subjected to a focus group of experts, to explore the viability of the research process and to gain a deeper understanding of the research problem, followed by pilot testing of the survey questionnaires, to check the reliability and validity of the possible survey question as explained below.

3.7. Survey data analysis method

The survey data collected in each phase of the risk management process were used as input for the chosen decision-making tools. The reviewed uncertainty treatment models were used to analyse the feedback of survey questionnaires and to ensure reliability and consistency in data gathering, consistency checks and sensitivity analysis were conducted for each of the data received and noisy data were properly eliminated before the data analysis.

3.8. Survey instrument evaluation

The purpose of the survey instrument evaluation was to pre-test the survey instrument and check that the survey questions are understandable, reliable, and valid. Hence, as noted by Saunders et al., (2015) evaluation using a focus group and pilot studies are the two common approaches to organise survey instruments. Both approaches have the advantage to increase the survey response rate, the effectiveness of follow-up actions and ensuring that the data analysis techniques match the expected responses (Saunders et al., 2015). The study employs a group of experts knowledgeable in the study area to evaluate the design survey instrument. After a review of the developed questionnaire, it was sent via email and with a cover letter to the expert group to complete and identify any potential problems, unnecessary questions, and instructions. The experts were briefed on the importance and purpose of the study and information on how to complete the survey was provided. Also, the experts were made aware that participation is anonymous, and their personal information will not be collected.

3.9. Measurement Evaluation

3.9.1. Validity

Validity is concerned with the extent to which the survey instrument measures what it supposes to measure, by ensuring that the questionnaire represents the reality of what the study intends to measure (Saunders et al., 2015). According to Bryman and Bell (2015), content validity is the most widely recognised type of validity, employed to measure the concepts of the survey questions. Content Validity refers to the extent to which the questionnaire provides adequate information to answer the research question and meet the research objectives (Saunders, 2012). In this study, the questionnaire items are measured using a group of experts, that is knowledgeable in the study area, to assess whether each measurement question in the questionnaire has good content validity. The experts were asked to give their comments concerning the rationality, structure, and reliability of the questionnaire design. A positive response from all the experts shows that the content of the questionnaire is valid and will generate enough data to meet the research objectives.

3.9.2. Reliability

Reliability is a concern with the robustness of the study survey instrument and the extent to which it will produce consistent findings if replicated under different conditions (Saunders et al., 2015). Hence, due to the technicality of the questionnaire design and inter-observer reliability and quality checks were conducted with the expert group, to measure the consistency of all the questions in the questionnaire and to ensure all questions are designed without any research bias or researcher error. The experts were requested to complete the questionnaire and evaluate the real-life industry concern of the study variables. Based on their observation, descriptive statistics and comparative response checks were then conducted to verify if experts give a similar answer to the same question. A generic response from the expert group confirmed the study instrument is reliable.

3.9.3. Ethical considerations

The study ensured ethical conduct by following the ethical standards laid down by the Liverpool John Moore University Research Ethics Committee. Consent to gain access to the organisation was obtained via a gatekeeper and from the project company partners. All the participant that took part in the survey was sent a recruitment letter with an attached participation and consent sheet. The participants are required filled the participant information sheet (Appendix seven) and an implied consent form (Appendix eight). All the participants were assured of confidentiality, and it was made clear that no personal data will be collected throughout the survey.

CHAPTER FOUR – CONCEPTUAL FRAMEWORK AND RISK MANAGEMENT MODEL

4.1. Introduction

A review of the literature reveals there was a gap of knowledge in the management of risk hazards in the food transport logistic chain. Majority of studies in the food supply network focus on the management of risk from the post-harvesting and production phase with a limited focus on the transport logistic activities. Hence, there is a lack of an integrated risk management framework in the food transport logistic network that would support management decision-makers. The objective of this chapter is to develop an integrated food transport logistic risk management conceptual framework. The chapter is structured as follows. Firstly, the overview of the current transport and logistic activities is discussed, followed by the development of a risk management framework in the context of the food transport logistic network. This approach follows the four basic steps of an effective risk management process namely risk identification and classification, risk assessment, risk cause and effect evaluation and risk mitigation strategies.

4.2. Overview of the current transport and logistic activities

Increased globalization and a growing world population greatly impact the sustainability of supply chains, especially within the food industry. In the food industry, manufacturing/processing/ transport and logistics activities play a growingly important role in ensuring food safety. Specifically, transportation and logistics are likely the most critical step throughout the food journey from farm to fork, because of the potential stress that affects the food products during transport and storage activities, such as the perishable nature and efficiency requirement of food products, optimization of the best quality and nutritional delivery, optimization of delivery cost, environmental impacts and sustainability (Nakandala et al., 2016). In today's global economy, most firms work together as a network instead of working as an isolated entity (Carvalho et al., 2012). For instance, Transport logistic firms combine the physical integration of the various modes to facilitate seamless door-to-door transportation of goods. In a typical food product chain, after production, the bulk goods are transported hinterland using either truck, rail, sea, or intermodal (Bendickson, 2007) from the port of origin located in the vicinity of the farm or production factory to a port of destination and upon arrival, the products are unloaded and distributed hinterland either for further processing or to a local distributor. However, considering the various chain of participants involving the food supply chain (i.e harvester, manufacturer, producer, packaging, distribution team), there is a high complexity of safety risk hazards that threaten the smooth flow and safety of the food products along with the supply networks with a severe consequence on the global business (Tang and Nurmaya Musa, 2011). To name a few, In 1989, the multiple outbreaks of staphylococcal food poisoning caused by canned imported mushrooms from the Republic of China were attributed to the practice of the participants during post-harvest, pre-processes and transportation activities (Keener, 2003). In 1994, the salmonellosis outbreak that affected

224,000 people was due to the cross-contamination of pasteurized ice cream transported in tanker trailers that had previously hauled non-pasteurized liquid eggs (Keener, 2003). In 1995, there was a reported case of contaminated vegetable oil during shipment due to improper segregation of the heat transfer medium used for heating the railway tankers (Keener, 2003). In 1997, several bodies of deceased stowaways personnel were found on vessels carrying cocoa beans and raw sugar (Keener, 2003). In 1999, a major illness outbreak among children and young adults in the European Economic Community was attributed to fungicide-contaminated pallets used during the transportation and logistics of product packaging materials, which resulted in the recall of millions of cases of the contaminated product (Keener, 2003). Similarly, between the 1st of August and the 15th of September 2003, there were 361 reported cases *of Salmonella enterica Sarovar Typhimurium* virus found in the vegetable salad distributed in various food outlets in England and whales (Horby et al., 2003). In May 2005, there was a nationwide outbreak of multi-resistant *Salmonella Typhimurium* in Finland, due to contaminated lettuce transported from Spain (Takkinen et al., 2005). In November 2007, unwanted particles such as razor blades, sewing needles and other metal objects were found in George Weston Foods cakes and cases of botulism outbreak were reported in bumblebee Seafood. In November 2008, numerous cases of food safety incidents were reported in the Chinese food industry i.e Melamine contamination in milk products that lead to the death of six infants and sickness to 300,000 victims in the Republic of China (Shears, 2010), around January to April 2016 more than 1700 tons of Vietnamese rice transported to the United States was rejected by the America officials due to safety concern (Toan Doa, 2016), the information about the subjective probability of the significant risk factors and its consequence that lead to the safety issue was unclear. Considering the global demand, and the safe transport logistics of the food product distributed globally, the international food trade agreement highlighted the importance of risk analysis for the international elaboration of food supply chain safety standards (Joint FAO/WHO Codex Alimentarius Commission. and Food and Agriculture Organization of the United Nations., 1998). However, the major challenge in the assessment of risks in the food transport and logistic chain is that the objective data are limited and often only available to a certain level. To address such uncertainty in the assessment of risk it is paramount to develop an integrated risk management framework in the context of food transport and the logistic chain.

4.2.1. Development of conceptual risk management framework in the context of food transport logistic chain.

Risk is defined as an uncertain event or set of situations that which the likelihood of occurrence will have a consequence effect on the achievement of one objective (Tuncel and Alpan, 2010). Risk analysis is a decision-making process for assessing, managing, and communicating the risks occurrences, likelihood, and severity consequences (Marvin et al., 2009). Risk analysis allows a proper estimation of risk to identify and implement the appropriate risk control measures that will facilitate the stakeholder decision-making process. The risk analysis process comprises three risk components that interact with each other: risk assessment, risk management and risk communication. Risk assessment involves understanding the risk hazards, the likelihood of their occurrence and their consequences if they should occur. Risk management analyses the policy alternatives and identifies and implements the appropriate risk control and risk communication involves the exchange of information and opinion concerning the risk hazards. It includes company risk assessment and management information (Manning and Soon, 2013). In the context of transport logistics of the food supply chain, the risk analysis objective is to determine what can go wrong during the transport of food products. how likely is that to happen?' and what is the consequence if it happens? (Kaplan and Garrick, 1981) so that rational mitigation strategies can be developed to ensure overall safety in the transport logistic network of the food supply chain. Over the last two decades, various academia and researchers had provided insight into the assessment of food transportation safety and food supply chain risk (Keener, 2003; Whiting et al., 2000; Jedermann et al., 2014; Wang et a., 2012a; Ackerley et al., 2010; Bouwknegt et al., 2015; Ge et al., 2016). However, their method and approach have shown some drawbacks and insufficiency in industrial application. For instance, previous studies, on the safe delivery of food products from farm to fork, analyze risk from a single firm perspective, i.e. Production (Rijgersberg et al., 2010, Fegan and Desmarchelier, 2010; Souza-Monteiro and Caswell, 2010; Van der Spiegel et al., 2013), Harvesting(Van der Fels-Klerx et al., 2010; Jacxsens et al., 2010; Erdem et al., 2012), Distribution (Hong et al., 2011), Transport (Ackerley et al., 2010) using few risk parameters of occurrence probability, the likelihood of event and severity of the consequence (Ackerley et al., 2010; Nguyen et al., 2013) in the assessment of risk. These few parameters might not provide sufficient information needed for management decisions due to " risk complexity and interdisciplinary concept of the parameters that might still be involved in addition to probability and consequence" for instance uncertainty, variation and resilience (Aven, 2012). Thus, relying on a few risk parameters could lead to a loss of useful information while investigating transport and logistic risk hazard under a highly uncertain environment within the food supply chain (Wang et al., 2012). Furthermore, as reviewed in the literature (chapter 2) different definitions have been developed to define and describe the risk influencing hazards in the food supply chain. However, it remains to be further investigated how these reviewed risk hazards under the highly uncertain environment in the transport logistic network can be assessed. How do the reviewed assessment parameters (i.e. Likelihood probability; Resilience, Probability of the risk hazard undetected; Consequence severity of the risk to time, quantity/volume, and operational quality influence the risk analysis? How do the analytical methods play a role in risk evaluation, and how the risk hazard causal effects can be estimated and evaluated? The proposed risk management conceptual framework is developed to manage and evaluate the risk hazards through a coordinated approach under the challenges of uncertainty, complexity, and regulatory oversight across a global economy and to find appropriate risk control measures (RCM). The framework for assessing AFTL risks is based on the review of the literature on risk factors identification, risk assessment parameters, risk assessment techniques, risk causal variables and risk mitigation strategies. The framework has four components as illustrated in figure 4.1 and each step is explained in detail below

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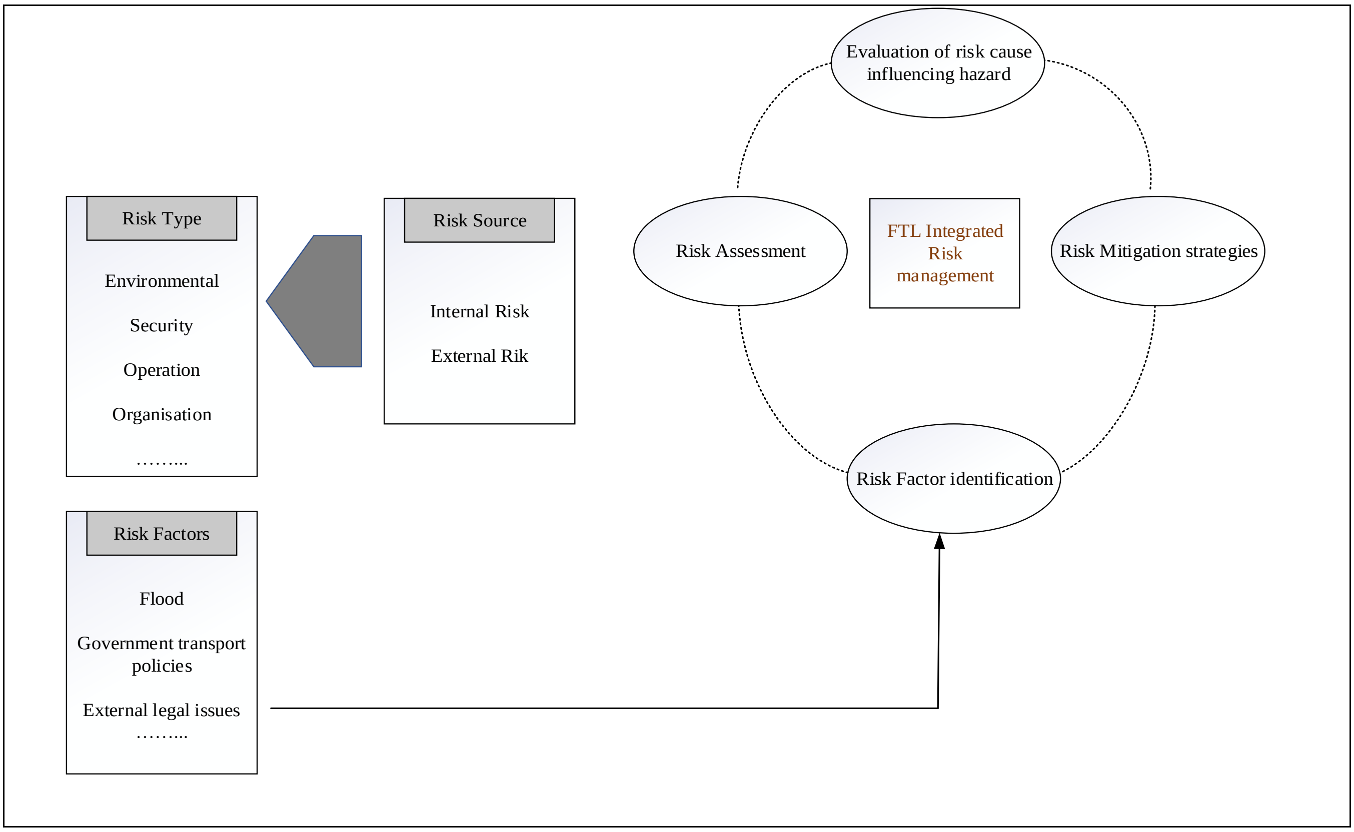


Figure 4. 1: Food transport logistic integrated risk management conceptual framework

4.2.1.1. Identification and classification of the risk hazard from the source

The proper identification of risk is an essential step in supply chain risk management (Tah and Carr, 2000). The process involves finding, defining, and communicating the various hazardous risk factors that may lessen the performance of the supply chain activities. According to Aqlan and Lam, (2015), supply chain risk factors are better identified by grouping them into distinct categories based on the activities structure and operation mode**.** Therefore, in managing the literature review on food transport and logistic risk influencing hazards as presented in chapter 2 (Table 2.6), it is essential to define and propose a dominant risk classification for their assessment. Hence, the study adopts Dong and Cooper, (2016) two suggested rules to classify supply chain risk factors. 1) To adapt an existing classification method based on the specific situation and 2) Seek judgement from industry experts.

4.2.1.2. Classification of food transport and logistic risk hazard

All the transport and logistic chain risk emerge from either a micro or macro risk source. Micro risks are the internal occurrences or situations that might harm the transportation chain process; Macro risk types refer to recurrent events that originated directly from external activities of the transportation chain or relationships within the partners in the chain process (Ho et al., 2015). An overview of the sub-categorisation of the AFTL risk from different distinct sources in the transport chain process as reviewed from the literature is presented in Figure 4.2. The framework comprises four levels (I, II, III, and IV). The top level represents the framework title; the second level represents the risk types. The third level represents the risk source, and the fourth level represents the risk factors from distinct sources

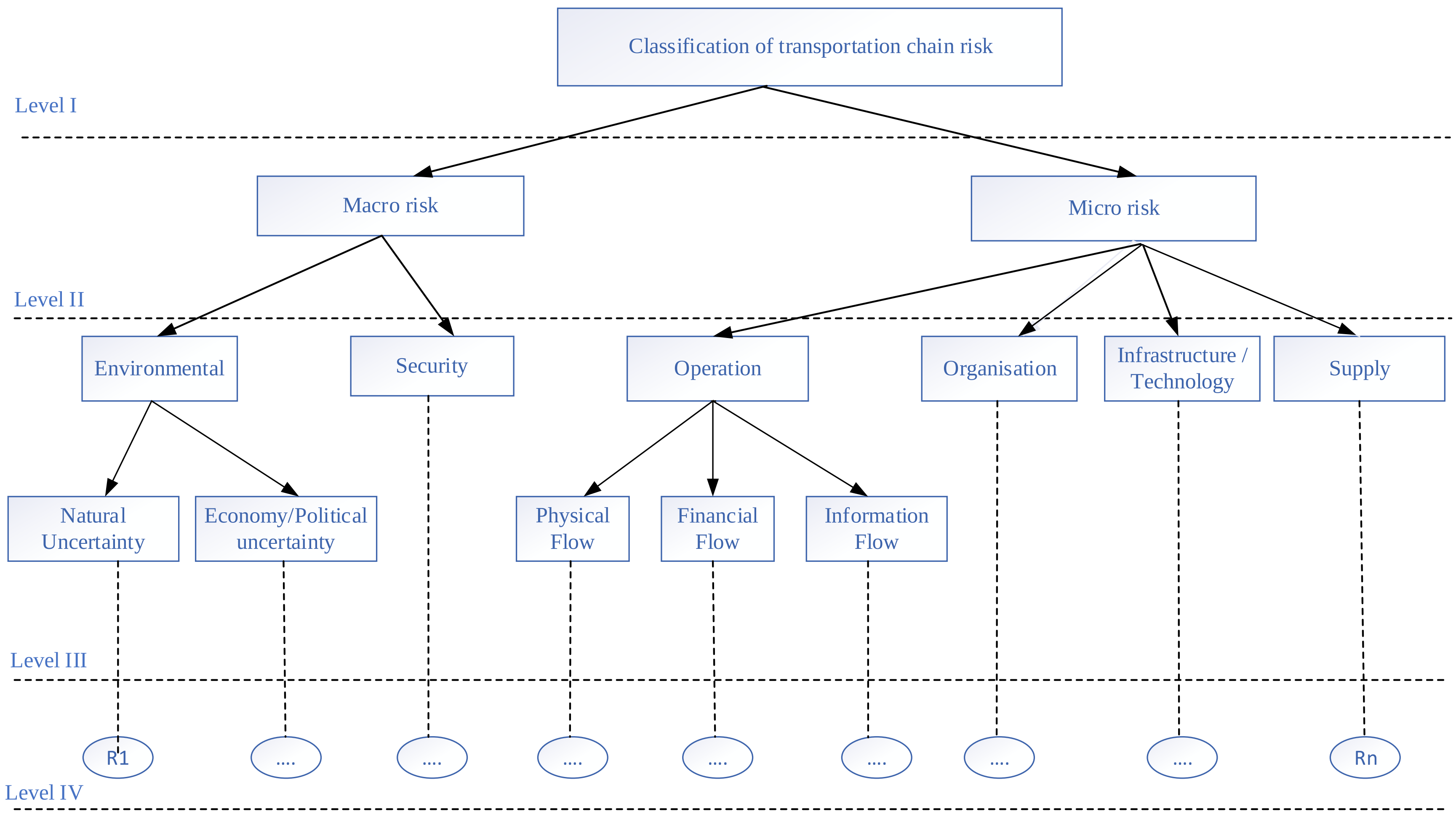


Figure 4. 2: An overview of the risk hazard from different distinct sources in the transport and logistic chain process

4.2.1.3. Macro and Micro risk type

Micro risks are recurrent events that originated directly from the internal activities of companies or relationships within the partners in the entire supply chain Radivojević and Gajović, (2014). Internal risk is derived from four distinct sources,

- Internal operation risk arising from physical flow, financial flow and information operation flow
- Internal organization activities
- Internal Supply processes
- Internal operation infrastructure and technological

Macro or external risk types are the events or situations that might have a negative impact on companies' activities, it is either occurs naturally or human-made (Ho et al., 2015), External risk is derived from two distinct source

- Environmental risk due to Natural uncertain or government /political uncertain
- External security threat.

A summary of all the AFTL risk factors identified from the literature as explained in chapter two are presented in Table 4.1 and discussed in the below section

Table 4. 1: Overview of the literature review on FTL risk factors

Macro (external) risk factor			Author
Environmental		Security	
Natural uncertain	Economy and Political uncertain		
Severe Thunderstorm (R1)	Political unrest (R5)	War (R11)	Rao and Goldsby (2009), Ackerley et al. (2010), Tummala and Schoenherr (2011), Pfohl et al. (2011), Vilko and Hallikas (2012), Samvedi et al . (2011) Diabat et al. (2012), Yeboah et al. (2014), Radivojević and Gajović(2014) Garvey et al. (2015), Vilko et al. (2016), Lam and Bai (2016)
Tsunami (R2)	Government Regulation(R6)	Terrorist attack(R12)	
Weather changes (R3)	Social and cultural grievances(R7)	Piracy attack(R13)	
Flood (R4)	External legal issues(R8)	Theft(R14)	
	Labour strike (R9)	Sabotage(R15)	
	Worker Union relation(R10)	Tampering(R16)	
		Pilferage and non-delivering(R17)	
		People Smuggling(R18)	
		Cyberattack (R19)	

Micro (internal risk) factors			Author
Operation			
Finance flow	Physical Flow	Information flow	
Changes in the currency exchange rate(R20)	Port Strike (R27)	Lack of IT compatibility among partners(R61)	Rao and Goldsby (2009), Ackerley et al. (2010), Tuncel and Alpan, (2010), Tummala and Schoenherr, (2011), Pfohl et al., (2011), Vilko and Hallikas, (2012), Diabat et al., (2012), Samvedi et al., (2013), Radivojević and Gajović, (2014), Chang et al.(2014) ,Yeboah et al. (2014) Ho et al., (2015), Garvey et al.(2015), Hernandez Nopsa et al., (2015), Dong and Cooper, (2016) Rathore et al. (2017) Yan et al. (2018)
Payment delay from shippers(R21)	Port Congestion (R28)	Communication failure among partners(R62)	
Shipper going into bankruptcy(R22)	Excessive inventory(R29)	Lack of security information sharing(R63)	
Unrealised contract with partners(R23)	Deterioration in Service quality (R30)	Information Distortion(R64)	
Shippers breaking the contract (R24)	Improper loading /discharging practices (R31)	Risk of Network Coverage(R65)	
Partners with bad credit (R25)	Delay due to port capacity (R32)		
Higher Transportation cost (R26)	Damage to ship or quay due to improper berth operation(R33)		
	Ship collision and sinking (R34)		

	Underutilized Hold space capacity (R35)		
	Poor Handling (R36)		
	Fire Accident(R37)		
	Product Damage in transits(R38)		
	Temperature Abuse(R39)		
	Cross contamination(R40)		
	Insufficient holding space(R41)		
	Transportation providers fragmentation(R42)		
	Transportation route Bottleneck(R43)		
	Excessive handling due to a border crossing or change in transport(R44)		
	Customer clearance at port(R45)		
	Paperwork and scheduling(R46)		
	Late truck Deliveries(R47)		
	In-transits Loss(R48)		
	Timely availability of vehicle(R49)		
	Truck Accident(R50)		
	Lack of outbound effectiveness(R51)		
	Human Error(R52)		
	The capacity problem in railroad traffic(R53)		
	Permit of the transportation company(R54)		
	Infringe of traffic regulation(R55)		
	Improper holding practices for products awaiting shipment. (R56)		
	shipment delay (R57)		
	Transport solution alternatives(R58)		

	Improper sanitation and backhauling hazardous material(R59)		
	Poor pest control (R60)		
Internal risk factors			Author
Organization	Infrastructure/technology	Supply	Ackerley et al., (2010), Pfohl et al. (2011),Tummala and Schoenherr (2011), Diabat et al. (2012), Yeboah et al. (2014), Hernandez Nopsa et al.(2015), Dong and Cooper (2016), Rathore et al. (2017), Yan et al., (2018)
Labour skilled personnel (R66)	Obsolete Technology (R75)	Poor packaging (R87)	
Employee wages (R67)	Storage and warehouse (R76)	Poor Preservation (R88)	
Overburden Employee(R68)	Lack of sufficient cargo handling equipment (R77)	Inaccurate shipment from the supplier(R89)	
Poor Motivation among the workforce(R69)	Lack of intermodal /multimodal equipment (R78)	Low Supplier transparency(R90)	
leadership in food safety (R70)	A breakdown at a critical railway crossing or yard(R79)	Low supplier integration(R91)	
Stress on the workforce(R71)	Irrigation and road condition (R80)	Failure of the partnership (R92)	
Long employing working time(R72)	Transportation breakdown(R81)	Order Fluctuation (R93)	
Adaptation to food standard regulation change (R73)	Risk of applying sensing technology (R82)	Urgent ordering (R94)	
Poor employee hygiene(R74)	Humidity monitoring /control(R83)	Traceability(R95)	
	Negligently equipment maintenance(R84)	Long-term production downtimes(R96)	
	Poor Transportation unit design and construction (R85)	Short-term production downtimes(R97)	
	Power system(R86)	The poor performance of the sub-contractor (R98)	
		Poor logistics contract(R99)	
		Global sourcing network(R100)	

4.2.1.3.1. Operation risk source

These are the risk influencing the hazard related to the realization of the internal activities of the firm, ultimately affecting the profitability of the company. Such risks are associated with inherent uncertainties in the transportation of products, and delivery of services and connected with the physical, financial and information processes as presented in Figure 4.3

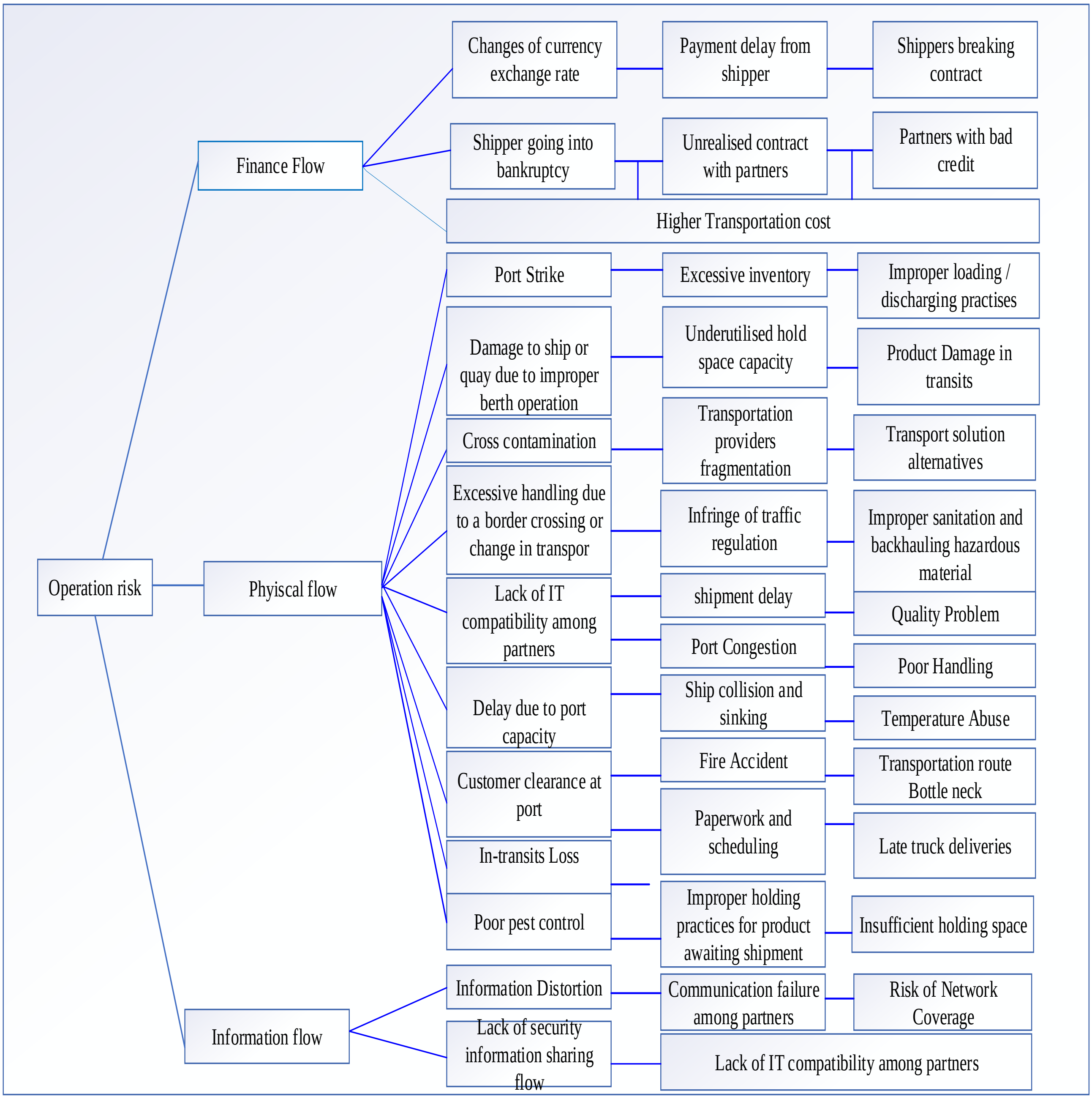


Figure 4. 3: The transport and logistic operation risk hazard source

4.2.1.3.2. Environmental risk source

These are external risk factors that disrupt organisational flows of goods and services (Samvedi et al., 2013). They either occur due to a natural disaster such as a tsunami, or flood, or economic disasters such as political unrest, labour strike, or government regulatory policies. Such a disaster can impact the transport and logistic process of agro-food production.

4.2.1.3.3. Security risk source

These are risks associated with the security movement of food products from farm to fork influenced by external actors that threaten the smooth movement of products, including War, piracy attacks, thefts, tampering, smuggling and cyber-attacks (Samvedi et al., 2013).

4.2.1.3.4. Organisation risk source

These are the risks that are internal to the firm, and that affect the organization's timeliness delivery of the product (Samvedi et al., 2013). These risks include unskilled personnel, poor motivation in the workforce, stress, and others as presented in Appendix nine

4.2.1.3.5. Infrastructure/Technology risk source

These are risk factors associated with the facilities, equipment and technology that disrupt the smooth flow of food products. The facility, equipment internal risks role throughout the transport and logistic process (Zhang and Zhang, 2016). The main infrastructure and technology risks include obsolete technology, lack of sufficient cargo

handling equipment, irrigation and road condition, and others are presented in appendix nine

4.2.1.3.6. Supplier risk source

These are risks emanating from the smooth flow of products from the supplier to the firm. With the globalization of the food supply chain activities, a host of supply risks have become attached to the players in the transport and logistics process of food products (Samvedi et al., 2013). Such supplier risks include low supplier transparency, supply interruption, and poor quality of supplied goods, others are presented in appendix nine

4.3. Validation of the literature review FTL risk factors

The various risk factors associated with the FTL chain were identified through a careful review of the literature. To form a holistic view of the impact of the identified risk hazard, an industry expert's opinion was held to explore the viability of the identified risk, the risk classification, and risk assessment parameters and to explore other industry concern risk hazards in the transport and logistic chain. The preliminary session for the reviewed risk factors took place in March 2019 in the UK in a brainstorming exercise with domain experts (five academic and two industry members, each with more than 15 years of working experience in the FTL industry) during a workshop until a consensus was reached. Based on their feedback, the literature-reviewed risk factors were categorised and subdivided into classes according to their risk source.

4.3.1. Screening of AFTL risk factors

In June 2019, five experts from the Republic of Vietnam (the world-leading agro-food product export country) as shown in Table 4.2, were selected to screen the risk factors in a real-life industry. The agro-food product was chosen as a case study because it was reported as a key product with high global demand. (Wasilewski et al., 2018). Although, the five industry experts had a variance in knowledge based on their qualification and their experience in the field of study. To account for the knowledge difference, the study developed a weighting scale to anticipate the differences in the character of the structure of knowledge held about the experts as presented in Table 4.3

Table 4. 2: Agro-food expert weighting profile

Expert	organization	Title	Weight Value %	Years of experience
A	Transport and logistic firm	Logistic manager	66.7%	12
B	Rice producing company	Logistic manager	66.7%	15
C	Rice producing company	General Manager	100%	>20
D	Rice producing company	General Manager	100%	>20
E	Cashew producing firm	Trading Manager	100%	>20

Table 4. 3: Expert weighting criteria

Expert weighting criteria		
Weight value	Experience ranking	Description
100%	Very experienced	Expert in food supply chain management, with more than twenty years of experience in food supply chain activities and always holding a top management position
66.7%	Experienced	Expert with a minimum of ten years of experience, holding a line manager position minimum in a department dealing with food supply chain activities
33.3%	Moderately experienced	Expert with up to five years of working knowledge of food supply chain activities with a focus on transport and logistic activities
0%	No experience	Without any experience

Based on the expert weighting criteria, the trading manager, general manager, and production managers are assigned 100% weighting and have held more than twenty years of experience in handling and dealing with agro-food products. The other two logistic experts were assigned a weighting of 66.7% because of their working experience level in the agro-food industry.

Furthermore, a questionnaire survey Part A (Appendix one) was designed and distributed among the five experts to verify and rank the relative importance of the reviewed risk factors in a real industry concern using a five-point Likert scale with a response option ranging from 1= no concern, 2= minor concern 3= moderate concern 4= high concern 5= extreme concern. The survey measures the one hundred literature-reviewed risk factors using descriptive statistics around the mean, weighted average, and standard deviation. The mean, weighted average and standard deviation are employed to represent the statistical estimation of the risk factors and reduce bias that might result in having a risk factor that is not relevant to the study. These descriptive statistics are the most standard measures of data distribution, used in measuring dispersion and understanding sampling error (Smith-Woolley et al., 2018). The calculated mean, weighted average and standard deviation of the risk factors are presented in Table 4.4

Table 4. 4: Comparison risk factor table

Identified risk factors			How important are the risk factors to food transport and logistic activities			
			Sum	Mean	WA	SD
Environmental	Natural Disaster	R1. Severe Thunderstorm	6	1.2	1.23	0.45
		R2. Tsunami	7	1.4	1.31	0.55
		R3. Weather changes	6	1.2	1.23	0.45
		R4. Flood	**20**	**4**	**4.08**	0.71
	Economy Disaster	R6. Political unrest	8	1.6	1.54	0.55
		R7. Government transport policies	**21**	**4.2**	**4.23**	0.84
		R8. External legal issues	**20**	**4**	**4.00**	0.00
		R9. Labour strike	**25**	**5**	**5.00**	0.00
		R10. Worker union relation	**23**	**4.6**	**4.62**	0.55
Security		R11. War	11	2.2	2.15	0.45
		R12. Terrorist attack	9	1.8	1.92	0.84
		R13. Piracy attack	11	2.2	2.23	0.45
		R14. Theft	11	2.2	2.15	0.45
		R15. Sabotage	10	2	2.00	0.00
		R16. Tampering	12	2.4	2.31	0.55
		R17. Pilferage and non-delivering	**20**	**4**	**4.00**	0.71
		R18. People Smuggling	8	1.6	1.69	0.55
		R19. Cyber attack	**20**	**4**	**4.00**	0.00
Operation	Finance flow	**R20. Changes in the currency exchange rate**	**23**	**4.6**	**4.62**	0.55
		R21. Payment delays from shippers	**20**	**4**	**4.08**	0.71
		R22. The shipper is going into bankruptcy.	12	2.4	2.31	0.55
		R23. Unrealized contract with partners	11	2.2	2.23	0.45
		R24. Shippers breaking contract	16	3.2	3.15	0.45
		R25. Partners with bad credit	13	2.6	2.54	0.55
		R26. Higher Transportation cost	**23**	**4.6**	**4.54**	0.55
	Physical flow	R27. Port Strike	13	2.6	2.69	0.55
		R28. Port Congestion	13	2.6	2.62	0.55
		R29. Excessive inventory	**22**	**4.4**	**4.46**	0.55
		R30. Service quality deterioration	**23**	**4.6**	**4.62**	0.55
		R31. Improper loading /discharging practices.	8	1.6	1.54	0.55
		R32. Delay due to port capacity	12	2.4	2.31	0.55
		R33. Damage to ship or quay due to improper berth operation	14	2.8	2.85	0.45
		R34. Ship collision and sinking	12	2.4	2.46	0.55
		R35. Underutilized Hold space capacity	13	2.6	2.62	0.55
		R36. Poor Handling	**20**	**4**	**4.00**	0.71
		R37. Fire Accident	**23**	**4.6**	**4.69**	0.55
		R38. Product Damage in transits	**21**	**4.2**	**4.08**	0.84
		R39.Temperature Abuse	**23**	**4.6**	**4.54**	0.55
		R40.Cross-contamination	**21**	**4.2**	**4.15**	0.45
		R41. Insufficient holding space	**21**	**4.2**	**4.23**	0.45
		R42.Transportation providers fragmentation	11	2.2	2.23	0.45
		R43.Transportation route Bottleneck	10	2	2.00	0.00
		R44.Excessive handling due to a border crossing or change in transport	12	2.4	2.46	0.55
		R45.Customer clearance at the port	11	2.2	2.15	0.45
		R46.Paperwork and scheduling	13	2.6	2.69	0.55
		R47.Late truck Deliveries	14	2.8	2.85	0.45
		R48.In-transits Loss	12	2.4	2.31	0.55
		R49.Timely availability of the vehicle	**23**	**4.6**	**4.62**	0.55

		R50.Truck Accident	**20**	**4**	**4.00**	0.00
		R51.Lack of outbound effectiveness	12	2.4	2.46	0.55
		R52.Human Error	**23**	**4.6**	**4.69**	0.55
		R53.The capacity problem in railroad traffic	13	2.6	2.69	0.55
		R54.Permit of the transportation company	10	2	2.00	0.00
		R55.Infringe of traffic regulation	15	3	3.00	0.00
		R56.Improper holding practices for products awaiting shipment.	12	2.4	2.31	0.55
		R57. shipment delay	13	2.6	2.69	0.55
		R58.Transport solution alternatives	8	1.6	1.69	0.55
		R59.Improper sanitation and backhauling hazardous material	**23**	**4.6**	**4.69**	0.55
		R60. Poor pest control	**23**	**4.6**	**4.54**	0.55
	Information flow	**R61.Communication failure among partners**	**20**	**4**	**4.15**	1.00
		R62. Lack of security information sharing	8	1.6	1.69	0.55
		R63.Information Distortion	12	2.4	2.46	0.55
		R64.Lack of IT compatibility among partners	12	2.4	2.46	0.55
		R65. Risk of Network Coverage	9	1.8	1.69	0.84
Organisation		**R66.Labour skilled personnel**	**21**	**4.2**	**4.08**	1.10
		R67. Employee wages	20	4	3.92	0.71
		R68.Overburden Employee	**23**	**4.6**	**4.62**	0.55
		R69 Poor Motivation among the workforce	**23**	**4.6**	**4.62**	0.55
		R70. leadership in food safety	**22**	**4.4**	**4.31**	0.55
		R71. Stress on the workforce	13	2.6	2.54	0.55
		R72. Long employing working time.	10	2	1.85	1.00
		R73.adaptation to food standard regulation change	**23**	**4.6**	**4.54**	0.55
		R74. Poor employee hygiene	**21**	**4.2**	**4.08**	0.84
Infrastructure /Technology		**R75. Obsolete Technology**	**22**	**4.4**	**4.31**	0.55
		R76. Storage and warehouse	**22**	**4.4**	**4.54**	0.89
		R77. Lack of sufficient cargo handling equipment	**22**	**4.4**	**4.38**	0.55
		R78. Lack of intermodal /multimodal equipment	12	2.4	2.38	0.55
		R79. A breakdown at a critical railway crossing or yard	13	2.6	2.62	0.55
		R80. Irrigation and road condition	14	2.8	2.92	0.84
		R81. Transportation breakdown	17	3.4	3.38	0.55
		R82. Risk of applying sensing technology	**22**	**4.4**	**4.31**	0.55
		R83.Humidity monitoring /control	**21**	**4.2**	**4.38**	1.10
		R84. Negligently equipment maintenance	20	4	3.92	0.71
		R85. Poor Transportation unit design and construction	12	2.4	2.31	0.55
		R86. Power system	**21**	**4.2**	**4.31**	0.84
Supply		**R87. Poor packaging**	**21**	**4.2**	**4.08**	1.10
		R88. Poor Preservation	**21**	**4.2**	**4.15**	0.45
		R89.Inaccurate shipment from the supplier	**21**	**4.2**	**4.31**	0.84
		R90. Low Supplier transparency	**23**	**4.6**	**4.54**	0.55
		R91. Low supplier integration	**23**	**4.6**	**4.54**	0.55
		R92.Failure of the partnership	11	2.2	2.23	0.84
		R93.Order Fluctuation	11	2.2	2.00	1.30
		R94. Urgent ordering	12	2.4	2.38	0.55
		R95.Traceability	14	2.8	2.85	0.84
		R96.Long-term production downtimes	15	3	2.85	1.00
		R97.Short-term production downtimes	14	2.8	2.69	0.84
		R98.The poor performance of sub-contractor	**23**	**4.6**	**4.62**	0.55

	R99. Poor logistics contract	**20**	**4**	**4.00**	0.71
	R100.Global sourcing network	**23**	**4.6**	**4.54**	0.55

The result of the analysis shows that the standard deviation(s) range from zero (0) to 1.10. The higher the standard deviation, the more the measurement data provided by the expert on the individual risk factors are spread around the mean (Smith-Woolley et al., 2018). Also, the mean and the weighted average mean (WA) of each risk factor are close to each other. This denotes that the study developed reliable weighting criteria (Smith-Woolley et al., 2018). The study followed the risk matrix ALARP principle to determine the AFTL risk factors' screening cut-off point. As illustrated in Figure 4.4, a risk factor above the 80% threshold is considered to be within an organization's intolerable risk region and such risk factor needs to be reduced to an acceptable risk level. Thus, AFTL risk factors with a calculated weighted average value of 4 (80%) or more are the intolerable risk factors of concern to the industry that required urgent attention and those risk factors with a weighted average mean value below 4 (80%) are of less concerned to the industry and therefore ignored in the study. Figure 4.5 presents a hierarchy structure of the AFTL risk factors with a weighted average of 4.0 or more that form the basis of the study

	Severity index (SI)				
	1	2	3	4	
Likelihood Index (LI)	Minor	Moderate	Severe	Catastrophic	ARI
7- Very frequent	7	8	9	10	Intolerable region
6-frequent	6	7	8	9	
5- Likely	5	6	7	8	
4- Possible	4	5	6	7	The ALARP region
3- Unlikely	3	4	5	6	
2- Rare	2	3	4	5	
1- Extremely Rare	1	2	3	4	
	Acceptable region				

Figure 4. 4: Risk categories level in the risk matrix

Source: Developed by authors based on Wang and Foinkins (2001)

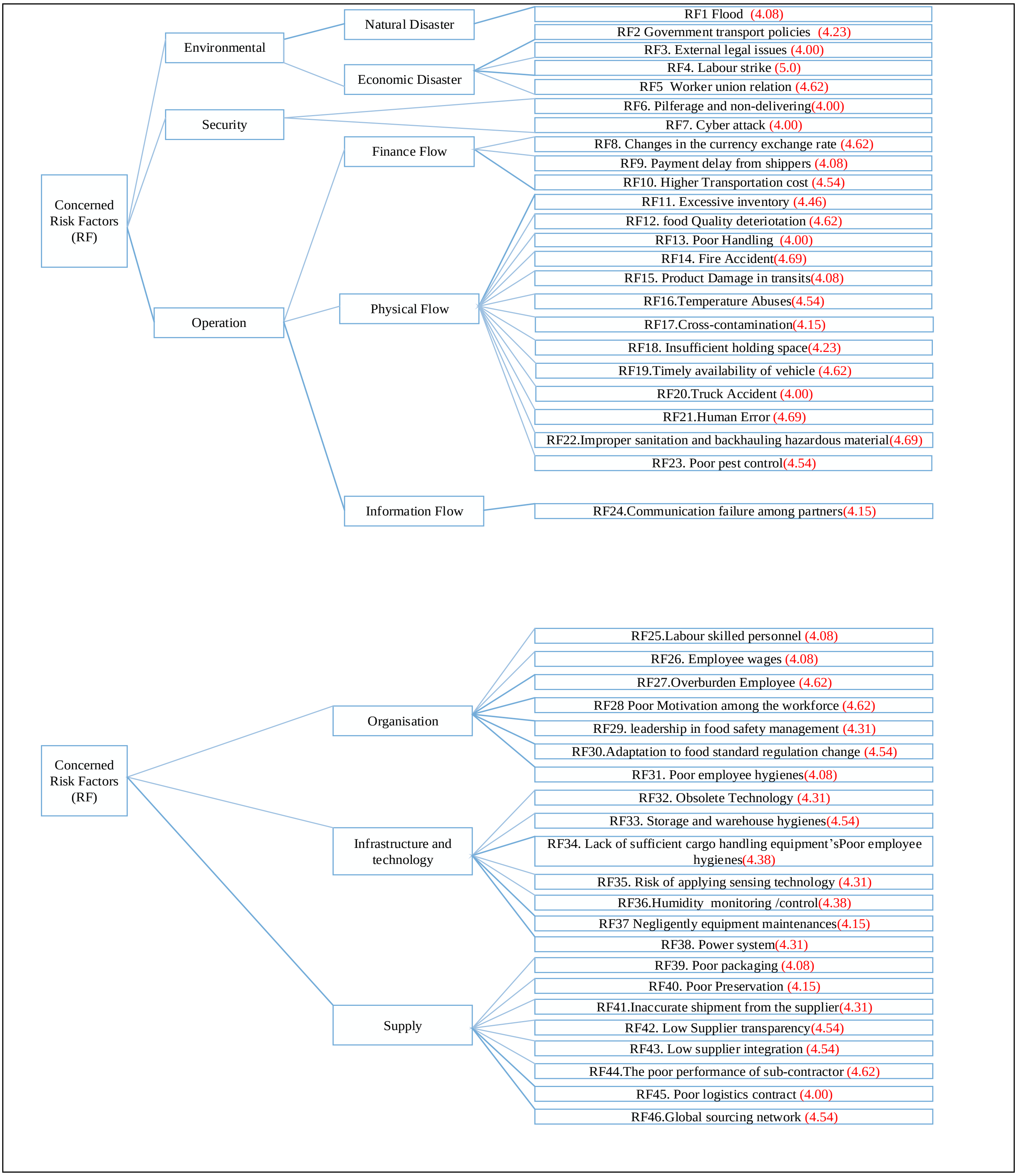


Figure 4. 5: Hierarchy of the forty-six verified AFTL Risk factors

4.4 Selecting the most suitable parameters for the assessment of the concerned AFTL risk hazards

Assessing the level of risk hazard in the food transportation and logistics chain is a complex subject, shrouded by the problem associated with data uncertainty and vagueness (Tah and Carr, 2000). Thus, this complexity arises from the imprecise non-numerical definitions of the common languages used in describing the risks. Over the years, researchers have used different risk parameters to describe and achieve consistent quantification of risk in the food supply chain as summarized in Table 4.5

Table 4. 5: An overview of the risk assessment parameters.

Variable factors for risk assessment	Tah and Carr (2000)	Tzannatos (2003)	Hallikas et al. (2004)	NPSA (2008)	Wu et al., (2006)	Tuncel and Alpan (2010)	Ackerley et al., (2010)	Tang and Musa (2011)	Vilko and Hallikas (2011)	Tummala and Schoenherr (2011)	Wang, Li and Shi (2012)	Weber et al., (2012)	Bacher (2013)	Revoredo Giha (2013)	Samvedi et al. (2013)	Chang et al., (2014)	Aglan and Lam (2014)	Yeboah et al. (2014)	Alyami et al. (2014)	Garvey et al., (2015)	Sharma and Pai, (2015)	Ho et al. (2015)	Dong and Cooper (2016)	Parenreng et al., (2016)	Rathore et al., (2017)	Qazi et al. (2017)	Yeboah et al., (2014)	Ali et al., (2017)	Bai et al. (2018)	Total
Consequence severity	1		1	1		1	1	1	1	1	1		1			1		1	1				1	1	1	1	1	1	1	20
Effect of hazard	1									1	1																			3
Consequence Impact on performance	1	1							1					1	1		1		1			1			1		1			10
Increase in activity cost																									1					1
Increase in activity duration																									1					1
Level of risk effect															1															1
Likelihood	1		1	1	1	1	1	1	1	1	1				1	1	1	1	1			1	1	1		1	1	1		22
The probability of hazards undetected												1	1						1	1	1			1	1	1	1		1	10
Risk categories																									1					1
Visibility										1																				1
Vulnerability		1												1																2
Resilience														1				1											1	3

However, taking into account the most common risk parameters widely applied in the literature in assessing food supply chain risk and with the opinion of the domain experts during the brainstorming exercise as discussed in section 4.3, a six risk assessment parameters of 1) Likelihood probability (L), 2) Resilience (R), 3) Probability of hazard detection(P), 4) Consequence severity on time(C_T), 5) Consequence severity on product quantity/Volume (C_{QV}), and 6) Consequence severity on operational quality (C_Q) were employed to assess the AFTL risk factors.

4.4.1. Likelihood probability (L)

This refers to the likelihood probability of the risk during food transportation and logistics activities. Likelihood probability of risk is usually described using various conceptual Likert scales, from minor to high (Vilko and Hallikas, 2012), highly unlikely to definite (Wang et al. 2012), rare to very certain (NPSA, 2008) and Low to the extreme (Rathore et al., 2017). The study employs a five-point Likert scale proposed by Wang et al. (2012) as shown in Table 4. 6

Table 4. 6: Linguistic grade of the likelihood probability of a risk hazard

Ranking Level	The grade of Likelihood Probability (L) of the risk factor	Definition
1	Highly unlikely	Hard to observe this risk
2	Unlikely	A low probability level of this risk to occur (Rarely happens)
3	Likely	A medium probability level of this risk to occur (sometimes happens)
4	Highly Likely	Highly Probability level of risk to occur
5	Definite	Very High level of this risk to occur

Source: Wang et al. (2012)

4.4.2. Consequence severity of the risk

This refers to the effect of risk hazards after the occurrence. Based on the known history of performance and expert suggestions, the consequence severity of AFTL risk factors can be categorised into three based risk effects: time-based, quantity/ volume-based, and operational quality-based effect. The time-based effect could either delay or disrupt the flow of agro-product, i.e., if the risk hazard occurs it will have a consequence severity on the expected delivery time of the agro-food products. Similarly, the quantity and quality-based consequence severity will significantly affect the quantity and quality of the agro-food products on arrival or en route to their destination. There are various ways to grade and describe the consequence of the severity of risk in food supply chain activities, such as 'extremely mild, mild, slightly mild, moderate, slightly severe, severe, extremely severe' (Wang et al., 2012), 'Very low, low, medium, high, very high (Tzannatos, 2003), ‘insignificant, minor, moderate, major and catastrophic' (Chang et al., 2014). The study employs a five-point Likert scale proposed by Tzannatos, (2003) as presented in Table 4.7.

Table 4. 7: Linguistic grade of the consequence severity of AFTL risk factors

Ranking level	The grade of the consequence severity (C) of the risk factor	Definition
1	Very Low	Risk does not influence the unit of performance, negligible disruption of an operation, or negligible damage to property and environment.
2	Low	Risk cause minor problems to the unit performance but slight damage to the system. Little or no environmental damage. Require minor intervention
3	Medium	Risk causes disturbance to unit performance, but the effect on unit performance is relatively small
4	High	Risk causes a decrease in the performance of the unit and a loss
5	Very High	Risk causes a severe effect on the damage to unit performance and causes a significant loss

Source : Tzannatos (2003)

4.4.3. Probability of hazard undetected

This refers to the probability of a risk hazard being undetected during transport and logistic activities. Table 4.8 shows the description grade to measure undetected hazardous events.

Table 4. 8: Linguistic grade of an undetected risk hazard

Ranking Level (Likert scale)	The grade of hazard undetected	Definition
1	Highly unlikely	Risk damage is easily detected
2	Unlikely	Risk damage can be detected from the low performance of the unit
3	Likely	Risk damage can be detected from the very low system performance of the unit
4	Highly Likely	Most risk damage can be detected after examination and test
5	Definite	Almost all risk damage can be detected after examination and test

Source: Alyami et al., (2014)

4.4.4. Resilience impact of the hazard on performance

Resilience refers to the ability of AFTL firms to recover from some disruption and unpredictable risk events during the transport and logistic process and return to their original or a better state after the risk hazard had occurred (Heckmann et al., 2015). Table 4.9 shows the description grade to measure the resilience impact on performance

Table 4. 9: Linguistic grade of Resilience impact of the hazard on performance

Ranking Level (Likert scale)	The grade of risk Impact on performance	Definition
1	Very Low	No impact /Insignificant concerning the whole operation
2	Low	Minor impact / degraded operation capabilities
3	Medium	Causes short-term difficulties to accomplish the operation
4	High	Causes long-term difficulties in accomplishing the operation
5	Very High	Discontinue of operation

Source : Vilko and Hallikas, (2012).

4.5 AFTL risk assessment techniques

The assessment of risk involves the measurement of the risk, in other to enable decision-makers to understand the quantitative assessment and prioritization level of the individual risk hazards. The study verified risk hazards under such uncertain transport and logistic environments would be assessed using the combination of the uncertain treatment models that incorporate the fuzzy set theory, Bayesian Networks (BNs) algorithm, the DEMATEL techniques and evidential reasoning algorithm

4.5.1 Fuzzy set theory

The concept of the fuzzy theory was introduced by Zadeh (1978). The theory provides a fundamental basis of possibility, allowing the problem of imprecision due to uncertainty and ambiguity associated with human thinking to be solved. Fuzzy theory is used to model vagueness and uncertainty in the decision-making process due to a lack of complete information by using linguistics terms to represent decision-maker preferences (Awasthi et al., 2011). The fuzzy theory has provided a great contribution to the research of unclear data when complete information is not available to make a decision (Samvedi et al., 2013).In the literature, the application of fuzzy theory has been widely used in the food supply chain network study. Awasthi et al. (2011) used fuzzy logic in evaluating and selecting of food supply chain sustainable transportation system under an uncertain environment. Wang et al. (2012) use the fuzzy theory model for aggregative food safety risk assessment in the food supply chain. Tadic et al. (2014) used a fuzzy theory model for deciding the inherent safety index of industrial food processes, and Djekic et al., (2018) used fuzzy logic to assess transportation sustainability footage in terms of environmental, economic and social impacts in the dairy industry. Bai et al. (2018) used the fuzzy theory model for assessing the uncertainty of food quality using various independent risk factors and indicators in the food supply chain. The application process and definition of various fuzzy set theories are presented (Kozarević and Puška, 2018). However, the framework for the assessment of risk based on fuzzy theories has been found in the studies of Hong et al., (2011); Samvedi et al., (2013); Radiovojevic and Gajovic., (2014); Abdul Rahman et al., (2015); S.K. et al., (2015a); Lower et al., (2016); Salleh et al., (2017); He et al., (2017); Xiang et al., (2017); Sahin and Yip, (2017); Sivamani et al., (2018); and Wan et al., (2018). Although fuzzy theories contribute to the development of more precise failure analysis and enable better risk hazards evaluation and prioritization (Meng and Peng, 2006). However, the model renders itself vulnerable in its practical application. For instance, its application involves a large number of rules, and the process of applying the set of rules with domain experts is a tedious task. Other critics of the Fuzzy logic model can be found in the research conducted by Yang et al. (2008).

4.5.2. Bayesian Theory

Bayesian Network (BN) theory is a graphical model that presents probabilistic relationships among a set of variables to represent expert knowledge reasoning under the challenge of uncertainty and concluding based on the data information available (Bouzembrak and Marvin, 2019). BN theory model has a structure that comprises nodes, arc and probabilities. The nodes (Parent or child) have several values called states that are either discrete or continuous. The relationship between the nodes is represented by an arc. Similarly, the BN's model has been used to capture the non-linear causal relationship and the interdependency between risk factors in the form of prior probabilities (Yang et al., 2008). The BN's also show drawbacks in their application - it requires too much data in the form of prior probabilities, which are difficult if not impossible to obtain in risk assessment (Yang et al., 2008). Consequently, earlier work in safety and reliability studies has indicated that combining fuzzy logic and Bayesian reasoning will be beneficial to compensate for both models 'disadvantages' (Eleye-Datubo et al., 2008). This study combined the fuzzy rule base (FRB) and BN model to effectively evaluate the AFTL risk hazard. Although the combination of the FRB and BN models facilitates the study risk assessment process, its application in the AFTL chain is new and poses some challenges. For instance, a large FRB belief structure will be required, given the multiple risk parameters employed for AFTL chain risk assessment. Chapter 5 describes a new mechanism for the use of the combined FRB and BN to assess the AFTL risk hazard.

4.5.3. The DEMATEL model

The Science and Human Affairs Program of the Battelle Memorial Institute of Geneva 1972 introduced the DEMATEL technique to solve a complicated problem involving multi-interactive criteria (Shieh et al., 2010). DEMATEL is unique in its ability to measure the direct and indirect causal relationship and influence between multi-criteria and map their interdependency relationship via a causal digraph (Ha and Yang, 2017). It has a wide application in the literature such as in higher education support systems (Chen and Chen, 2010), Airline safety measurement (Liou et al., 2007), quality assessment (Tadić et al. 2014) port performance assessment. Compared to other traditional MCDM tools, DEMATEL allows a better understanding of the cause-and-effect relationships between multi-criteria, use a causal digraph to represent such a relationship and enable stakeholder to predict their management behaviour by considering their interdependent strength of influence. Although, the DEMATEL model has its drawbacks with the inability to handle the human bias and uncertainty in the data, however, it allows a better understanding of the cause-and-effect relationships of multiple criteria and is capable of knowing the strength of the relationship. The study employs DEMATEL techniques (Chapter six) to evaluate the strength and determined the cause-and-effect interdependency relationship between the identified multi-criterial causal variables indicators of influence on the top priority risk hazards in the AFTL chain.

4.5.4 Evidential reasoning Algorithm

The Evidential Reasoning (ER) modelling was first developed in 1994 for dealing with MADA problems characterized by both qualitative and quantitative nature that are either imprecise, incomplete, or vague (Liu, 2013), is based on the decision theory and Dempster-Shafer (D-S) theory with a distributed modelling framework, capable of handling both precise data and subjective judgments with uncertainty under a unified framework (Yang et al, 2001). The multiple attribute decision analysis (MADA) based on the evidential reasoning (ER) algorithm had been proven to be a powerful model to analyze multiple attributes under the challenge of data uncertainty (Yang et al, 2004; Huynh et al., 2006). Its application has wider use in the academic literature, to name a few, The ER algorithm was adopted in marine safety and synthesis system safety analysis (Wang et al., 1995), organization quality management self-assessment (Yang et al., 2001), performance assessment (Yang and Xu, 2002), risk assessment (Liu et al., 2013) and green port development(Wan et al., 2018). The ER algorithm was adopted in the study to analyze the problem of vagueness, uncertainty and inadequacy of data associated with the casual variable indicators that influence the top priority risk hazard in the AFTL chain. The detailed methodology steps in the application of the ER algorithms are discussed in chapter six.

4.5.5. Risk mitigation strategies tools.

Risk mitigation strategies represent the method decision-makers adapt to minimize the adverse risk impacts. The various tools to analyze and mitigate multi-criteria risk hazards were identified in the literature. Fuzzy TOPSIS (Technique for Order Preference by similarity to an ideal solution) was one of the most practical and ideal models to handle imprecision and subjectiveness while ranking and choosing the best risk mitigation strategies based on their largest distance from the negative ideal solution (NIS) i.e solution that maximizes the cost strategies and minimizes the benefits strategies and the shortest distance from positive ideal solution (PIS) i.e solution that maximize the benefit criteria and minimize the cost criteria). The practical application of this method in solving multi-criterial- decision making (MCDM) problems had been published in various academic journals such as in the innovative performance in higher education (Cai et al., 2010), cold chain performance improvement (Joshi et al., 2011) transportation system (Awasthi et al., 2011), and third party logistic selection (Singh et al., 2018). However, the study adopts the Fuzzy TOPSIS algorithm in evaluating and selecting the best mitigation strategies for the CVIs influencing the top AFTL priority risk hazards. The detailed methodology steps in applying the Fuzzy TOPSIS are discussed in chapter seven.

4.6. Conclusion

This chapter presents a conceptual framework in the AFTL chain, taking into consideration the key four steps of an effective risk management process. In the literature, there is a dominant risk management method used to support food supply chain safety assessments with many approaches, including qualitative, quantitative or a combination of both methods. The proposed framework offers a solution to integrated risk management that enable the multi-layers risk hazards present in the AFTL supply chain network to be identified and assessed thereby enabling the experts or decision-makers to assess and profile the various alternative mitigation strategies

CHAPTER 5 – AN ADVANCED RISK MODEL FOR THE SAFETY EVALUATION OF AGRO-FOOD TRANSPORT LOGISTICS RISK HAZARDS

5.1. Introduction

This chapter deal with the in-depth- assessment of the identified and verified risk hazards influencing Agro-food transport logistic chains and prioritise them under uncertain environment using the combination of Fuzzy Rule-Based and Bayesian Network (FRB-BN). Compared to other uncertainty treatment models, the proposed model integrates FRB and Bayesian Networks (BN) in a complementary manner. The FRB was established to evaluate the AFTL risk hazard under the challenge of data uncertainty. The FRB comprises a fuzzy rule belief structure that has an antecedent (IF) part and a consequent (THEN) part. The relationship between both parts was modelled in the Bayesian Network (BN). A real case study of seven agro-food transport logistics chains from the Republic of Vietnam was investigated to demonstrate the feasibility and reliability of the proposed model.

5.2. Overview of the FRB and BN Model

As revealed in the literature, the risk influencing hazards in the AFTL chain originated from the environment, security, operation, organisation, technology and supply chain activities. (Tummala and Schoenherr, 2011; Yeboah et al., 2014; Radivojević and Gajović, 2014; Dong and Cooper, 2016; Rathore et al., 2017; Yan et al., 2018). The vulnerability to these risk factors has a severe consequence on the global economy (Tang and Nurmaya Musa, 2011). However, considering the chain of participants involved during the transportation and logistics phase, the risks' subjective probability and potential consequences are shrouded with data uncertainty and vagueness (Tah and Carr, 2000). To conduct a risk assessment under such conditions, the study proposed an advanced risk modelling methodology that incorporates a Fuzzy rule base and Bayesian network approach.

5.2.1. Fuzzy rule Base (FRB) and Bayesian Network method and its application

The combination of the Fuzzy Rule-Base (FRB) and the Bayesian network (BN) approach forms the novelty in the risk management model developed to evaluate and prioritise the AFTL risk events in uncertain conditions. The FRB theory was used to model vagueness and uncertainty in the decision-making process due to the lack of complete information, by using linguistics terms to represent decision-maker preferences (Awasthi et al., 2011). BN technique was applied to facilitate and synthesize the rule base structure (Bouzembrak and Marvin, 2019) The combined FRB and BN have the advantage to model the interrelationship between the attribute of the risk parameters and risk status flexibly and process and transform the information into subjective conditional probabilities to handle the imprecise information challenge and calculate the risk priority valves of all the identified AFTL risk factors. The combination of FRB and BN had been applied successfully to solve many complex real-world problems in an uncertain environment (e.g. (Alyami et al., 2014)).

5.2.1.1. Application of FRB and BN techniques

The FRB used a traditional IF and Then rule-based to define the linguistic terms with an incorporated degree of belief (DoB) concept in its consequent part. The concept enables an expert to better represent and deal with the situation where the shreds of data evidence are vague (Yang et al, 2006). The FRB structure comprises 1) all the possible consequent rules associated with the belief degree that would indicate the expert opinion to a consequence value, 2) an attribute weight, that signifies the influence level of importance of the consequence of a rule and 3) the weight of the rule that reflect the relative importance and reliability of the rules (Tang et al., 2011). The possible consequents associated with belief degrees applicable to assess the AFTL risk factors can be established using equation (5.1)

R_K : IF A_1^K and A_2^K and……A_M^K,

THEN $\{(D_1, \beta_1^k), (D_2, \beta_2^k), \ldots\ldots\ldots\ldots\ldots (D_N, \beta_N^k)\}$

$$\left(\sum_{j=1}^{N}, \beta_j^k \leq 1\right) \quad \text{Eq (5.1)}$$

Where A_1^K (i= 1,2,…., M) is the linguistics variables of the risk parameters, β_j^k (i =1,2,…, N) is a belief degree distribution to the grades used to describe risk, D_j is consequent in the *k*th packet rule, M is the number of all the possible risk parameters, N is the number of all the possible risk grades and $\sum_{j=1}^{N} \beta_j^k = 1$ satisfies that the *K*th packet rule is considered a complete rule base otherwise, it is incomplete. Similarly, the BN technique would be incorporated to facilitate and synthesize the FRB belief structure and aggregate all the based rules in assessment and prioritising the AFTL risk factor.

The FRB- BN approach, is modelled and represents the relationship between the risk assessment parameters and the risk level of each of the AFTL risk factors in the form of a belief degree which is then transformed into a subjective conditional probability in the Bayesian Network. To assess the AFTL risk factors, the scholars and industry experts verified six risk assessment parameters with five Likert assessment grades as the major consideration in the AFTL chain risk management, Hence the application of the traditional FRB-BN model would pose some difficulties due to a large number of rules that will be required to incorporate the six assessment parameters and their five linguistic variables in an FRB structure. For the traditional fuzzy rule-based approach, the required number of rules is obtained as the power of the linguistics grade to the assessment parameters. i.e for the assessment of AFTL risk factors with six assessment parameters and five linguistic grades a 5^6 equivalent to fifteen thousand six hundred and twenty-five rule based structure will be required. However, the study established a new mechanism to reduce the FRB rule structure needed to assess AFTL risk factors by adopting a variable elimination method and introducing a separate DoB structure to instantiate the conditional probability table of a few risk assessment parameters (consequence severity) thereby reducing the required FRB from 15625 to 750 ($5^4 + 5^3$) rule-based belief structure.

5.3. The methodology for modelling AFTL risk evaluation

The necessary steps needed for modelling the AFTL chain risks are based on the proposed combined FRB and BN approach are outlined in the step below and illustrated in Figure 5.1

Step 1. Identification of the risk factors in the AFTL chain

Step 2. Establishment of risk parameters for AFTL chain risk hazard evaluation

Step 3. Establish the relative weight of the risk parameters

Step 4. Establishment of FRB structure with DoBs for modelling risk factors

Step 5. Estimation of risk factors and data collection

Step 6. Risk inference using BN techniques

Step 7. Prioritization of the risk factor with a unity function

Step 8. Validation of the model by using sensitivity analysis techniques.

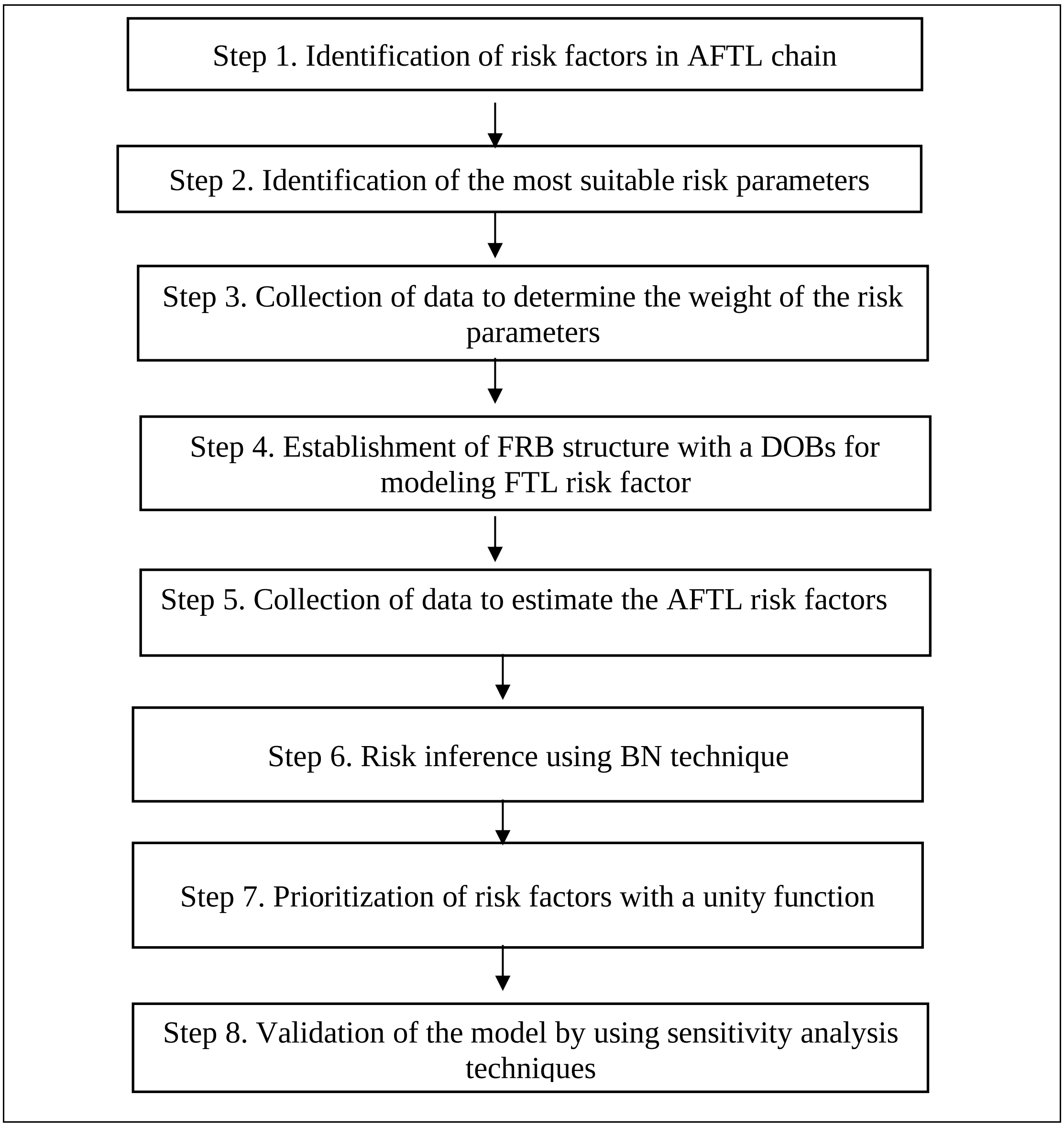


Figure 5. 1: Methodology for modelling the risk hazard prioritization in AFTL chain

5.3.1. Identification of AFTL Risk factors

Risk identification is the first step in the risk assessment process and is vital to the management of risk hazards in the AFTL chain. The risk factors were identified through a careful review of the literature based on the various risk type that originated from different sources during the transport and logistic activities. The identified risk factors were verified by the experts in a real-life industry concern as explained in chapter 4.

Table 5.1 presents the verified forty-six (46) risk factors influencing the AFTL chain. These risk factors will be considered for further assessment.

Table 5. 1: The verified 46 AFTL chain risk factors

Risk Factors
Natural uncertain
R1. Flood
Economy /political uncertain
R2. Government transport policy/banking seasonal interest rate
R3. External legal issues
R4. Labour strike
R5 Worker Union relation
Security
R6. Pilferage and non-delivering
R7. Cyberattack
Operation finance flow
R8. Changes in the currency exchange rate
R9. Payment delay from the shipper
R10. Higher Transportation cost
Operation physical flow
R11. Excessive inventory
R12. Deterioration of service quality
R13. Poor handling
R14. Fire accident
R15. Product damaged in transits
R16 Temperature abuse
R 17.Cross-contamination
R18.Insufficient holding space
R19. Timely availability of the vehicle
R20.Truck accident
R21.Human error
R22.Improper sanitation and backhauling hazardous material
R23. Poor pest control
Operation information flow
R24.Communication failure among partners
Organisation
R25.Labour skilled personnel
R26. Employee wages
R27.Overburden employee
R28. Poor motivation among the workforce
R29. Leadership in food safety management
R30. Adaptation to food standard regulation change
R31. Poor employee hygiene
Infrastructure / Technology
R32. Obsolete technology
R33 Storage and warehouse
R34. Lack of sufficient cargo handling equipment
R35. Risk of applying sensing technology
R36. Humidity monitoring /control
R37. Negligently equipment maintenance
R38. Power system
Supplier
R39.Poor packaging
R40 poor preservation
R41. Inaccurate shipment from the supplier
R42. Low supplier transparency
R43. Low supplier integration
R44.The poor performance of sub-contractor
R45. Poor logistics contract
R46.Global sourcing network

5.3.2. Identification of the most suitable risk assessment parameters for AFTL risk evaluation

Identifying the most suitable risk parameters to assess the AFTL risk factors is highly subjective due to the problem associated with their data uncertainty and vagueness. In this study, risk assessment parameters of likelihood probability (L), resilience (R), probability of hazard detection (P), and disintegration of the consequence of the risk factors into three categories based on consequence severity of the risk on time-delayed while transporting agro-food products (C_T), the consequence severity on the product quantities (C_{QV}) and the consequence severity on the product qualities (C_Q) were identified as discussed in section two and verified by scholars and industry experts as the major consideration in the AFTL chain risk management. Table 5.2 present the grading scale for the six verified risk assessment parameters and the risk status (RS) of the particular risk factor.

Table 5. 2: The risk parameters and their grading scales

Risk Parameters	Linguistic Grade	Definition
Likelihood Probability (L)	Highly unlikely	Hard to observe this risk
	Unlikely	A low probability level of this risk to occur (rarely happens)
	Likely	A medium probability level of this risk to occur (sometimes happens)
	Highly likely	Highly probability level of risk to occur
	Definite	A very high level of this risk occurs
Resilience impact (R)	Very low	No impact /insignificant concerning the whole operation
	Low	Minor impact / degraded operation capabilities
	Medium	Causes short-term difficulties to accomplish the operation
	High	Causes long-term difficulties in accomplishing the operation
	Very high	Discontinue of operation
The probability of risk undetected (P)	Highly unlikely	Risk damage is easily detected
	Unlikely	Risk damage can be detected from the low performance of the unit
	Likely	Risk damage can be detected from the very low system performance of the unit
	Highly likely	Most risk damage can be detected after examination and test
	Definite	Almost all risk damage can be detected after examination and test
The consequence of severity (CT, CQV, CQ)	Very low	Risk does not influence the unit of performance, negligible disruption of an operation, or negligible damage to property and environment.
	Low	Risk cause minor problems to the unit performance but slight damage to the system. Little or no environmental damage. Require minor intervention
	Medium	Risk causes disturbance to unit performance, but the effect on unit performance is relatively small
	High	Risk causes a decrease in the performance of the unit and a loss
	Very high	Risk causes a serious effect on the damage to unit performance and causes a significant loss

Risk status (RS)	Very low	Satisfactory with no impact
	Low	Above average with minor impact
	Medium	Average influence and cause a short-term difficulty to accomplish the operation
	High	Poor influence causes long-term difficulty in accomplishing the operation
	Very high	Very poor influence and causes operation discontinuation

5.3.3. Collection of data to determine the weight of the risk parameters

A survey questionnaire (Appendix two) was distributed among the relevant experts to compare the relative importance of the risk parameters in the assessment of AFTL chain risks. A total of 50 questionnaires were sent out to random food transportation and logistics companies in the three countries and three weeks later, a reminder email was sent to the companies and by the cut-off period, and a total of 20 valid questionnaires representing 40% response rate were used to obtain the weight values of the individual risk assessment parameters using AHP techniques. AHP technique is a multi-criteria decision-making tool proposed by Satty (1980), widely used to compare and quantify multi-criterion decision-making problems as seen in the study of Joshi et al., (2011), Prabhu Gaonkar et al., (2013); Goerlandt and Montewka (2015); Lau et al., (2018) and Jakhar and Srivastava, (2018) to obtain the relative weight of the risk assessment parameters. The below steps were followed to obtain the relative weight of the risk assessment parameter based on the AHP methodology.

Step 1 Designing a Hierarchical structural model. The hierarchy structure consists of the risk parameters, which represent the top goal, the likelihood probability (L), Resilience (R), Probability of risk undetected (P) and consequence severity (C) which represents the second level criteria, and the sub-criteria of the consequence severity (time, quantity /volume and process quality) are the lower-level criteria as shown in Figure 5.2.

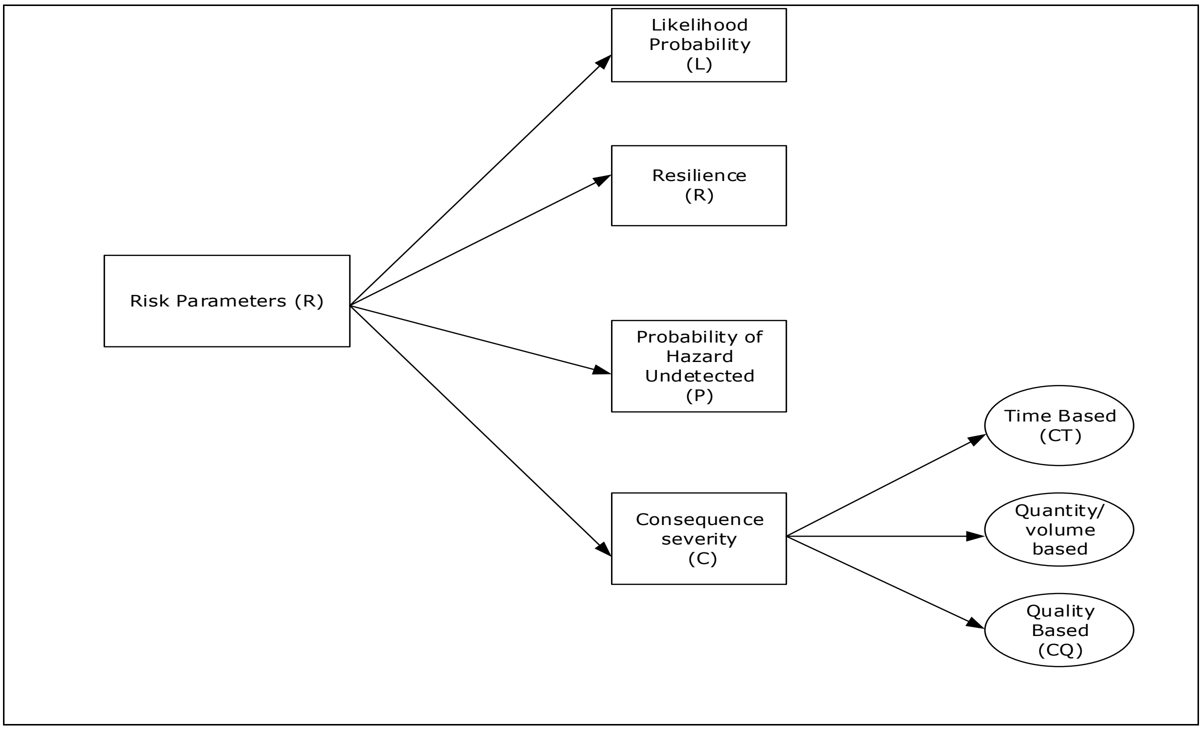


Figure 5. 2: Hierarchy structure of the risk parameters

Step 2 *Pairwise comparison*. A pairwise comparison between the risk parameters was conducted to determine the relative importance of each risk parameter in the assessment of AFTL risk factors. a pairwise comparison scale presented in Table 5.3 that satisfies the normalization condition as defined by (Joshi et al., 2011) was used in making the comparison. Similarly, the risk assessment parameters $X_1 \dots\dots\dots X_M$, and their normalized weighting vector $W_1 \dots\dots W_M$ were determined using equation (Eq) 5.2

$$\sum_{j=1}^{m} w_j \qquad with\, w_j \geq = 0 \text{ for j} = 1, \dots., \text{m} \qquad \text{Eq (5.2)}$$

Furthermore, the experts' comparison judgement on the individual risk assessment parameter was composed in the form of a pairwise comparison matrix A using equation 5.3.

$$A = \left(a_{ij}\right)_{mxm} = \begin{matrix} C_1 \\ C_2 \\ \vdots \\ C_3 \end{matrix} \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \qquad \text{Eq. (5.3)}$$

Where (a_{ij}) represent the relative importance of a_i and a_j . the pairwise comparisons between the (m) decision factor can be conducted on a scale (1-9) by asking questions to an expert on the relative importance of the risk assessment parameters whose responses form an (mxm) pairwise comparison matrix

Table 5. 3: Fundamental scale for making the pairwise judgement

Level of importance	Rating
Extreme importance	9
Between very strong, and extreme importance	8
Very strong importance	7
Between strong and very strong importance	6
Strong importance	5
Between moderate and equal importance	4
Moderate importance	3
Between moderate and equal importance	2
Equal importance	1

Step 3. *Calculating the relative weight of the risk parameters*. The weigh vector (W) of each of the risk, parameters were obtained using Eq (5.4)

$$AW = (\lambda_{max} W) \qquad \text{Eq (5.4)}$$

Where, λ_{max} is the maximum eigenvalue of (A). The mathematical expression of the eigenvalue was obtained using Eq (5.5)

$$\lambda_{\max} = \frac{\sum_{k=1}^{n} \frac{\sum_{k=1, j=1}^{n} w_k a_{kj}}{w_k}}{n} \qquad \text{Eq.(5.5)}$$

Where W_k is the weighting vector of the specific risk parameters in the pairwise comparison. The pairwise comparison matrix (A) should have an acceptable consistency. This can be checked by the following consistency ratio (CR) using Eq. (5.6)

$$CR = \frac{\frac{(\lambda_{max} - n)}{(n-1)}}{RI} \qquad \text{Eq (5.6)}$$

Where (RI) is an average random index value obtained from (Table 5.4), (n) represents the total number of parameters compared in the comparison matrix

Table 5. 4: Average random index values

(n)	1	2	3	4	5	6	7	8
(RI)	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Source: Based on Satty (1994)

If $CR \leq 0.1$, the pairwise comparison matrix is considered to have an acceptable consistency; otherwise, it is said to be inconsistent and needs to be revised (Satty,1994).

Tables 5.5 to 5.6 present the calculated weight value of the individual risk assessment parameters following the above AHP steps. The weight values were obtained based on the evaluation of the judgement of twenty experts, and a low consistency ratio value of less than 0.1 was obtained in the pairwise comparison that verified consistency with the expert's judgement.

Table 5. 5: Weight of the L, R P C risk parameters in the FRB structure

Risk Parameters (Antecedent attributes)	**Weight**
Likelihood Probability (L)	0.31
Resilience (R)	0.08
Probability of hazard undetected (P)	0.32
Consequence (C)	0.29

Table 5. 6: Weight of the C_T, C_{QV}, C_q risk parameters in the FRB structure

Risk Parameters (Antecedent attributes)		**Weight**
Consequence severity	Time-based C_T	0.27
	Quantity/Volume C_{QV},	0.14
	Quality-Based C_q	0.59

5.3.4. Establishment of Fuzzy Rule Base (FRB) with a Degree of Belief (DoB) structure

In constructing the FRB structure to assess AFTL risk factors using equation (5.1), the six risk assessment parameters L, R, P, and C (C_T C_{QV} C_q) were considered the antecedent attributes (If part) and their Risk status (RS) was represented as the consequent attributes (THEN part). Similarly, the risk status (RS) of the failures can be defined using such linguistic variables (*Sh*, *h* = 1, …, 5) as "Very high" "High" "Medium" " Low" and "Very Low" as defined in table 5.2 (Tah and Carr, 2000). Consequently, FRB with belief structures in the six risk assessment parameters can be established.

A two separate fuzzy IF-THEN rule structure was established using equation (5.1). The first rule structure comprises the L, R P C risk assessment parameters and the second rule structure split the consequence C_T C_{QV} C_q risk assessment parameters. A subjective belief degree (DoB) can be assigned to the linguistic variables based on the knowledge from multiple experts (Yang et al, 2009) and a proportion method can be used to rationalise the distribution of DOB to describe the consequent attribute R of the rule structures (Alymai et al; 2014), taking into the consideration the relative importance (weight) of the risk parameters (Cheng Peng, 2019).

To facilitate data collection and the representation of the judgement of the expert based on the six antecedent attributes and conclusion, five assessment grades (Table 5.2) are allocated to each of the risk parameters in the antecedent (IF part) and the consequent (THEN part).

and taking into account the weight of each parameter for any conclusion attributes, the DoBs belonging to a particular grade in the antecedent can be obtained by adding the normalised weight of the risk parameters with the same grade. Taking rule two in the L, R P, C belief structure as an illustration

Rule 2: If L is "highly unlikely", R is "very low", P is "highly unlikely", and C is "Low" then the risk level (R) is "very low" with a 71% DoB and "Low" with a 29% DoB.

Hence, the cumulative weight of all the risk parameters holding very low grades was 0.71(0.31+0.08+0.32) and the weight of the risk parameters with Low grades was 0.29.

The DoB belonging to very low and low-risk status was 71% and 29% respectively. Similarly in the C_T C_{QV} C_q belief structure

Rule 2: If C_T is very low, C_{QV} is very low, and C_q is low then the risk level is very low with a 41% DoB and Low with a 59% DoB. The total weight of all the risk parameters holding "very low" grades was 0.41(0.27+0.14) and the weight of the risk parameter with a "Low grade" was 0.59 (0.59). The DoB belonging to "very low" and "low risk" status is 41% and 59% respectively. The FRB structure developed to assess AFTL risk factor contains six hundred and twenty-five (625) L, R P C risk assessment parameters rule structure and one hundred and twenty-five (125) C_T, C_{QV}, C_Q, risk parameter FRB structures as partially shown in Table 5.7 to 5.8. details of the FRB rules are presented in Appendix nine and Appendix ten.

Table 5. 7: The established L, R, P, C FRB with a belief structure for the assessment of AFTL risk factors

Rules	Antecedent Attribute (input)				Risk result (Output)				
No	L	R	P	C	Very Low	Low	Medium	High	Very High
1	Highly Unlikely	Very Low	Highly Unlikely	Very Low	1				
2	Highly Unlikely	Very Low	Highly Unlikely	Low	0.71	0.29			
3	Highly Unlikely	Very Low	Highly Unlikely	Medium	0.71		0.29		
4	Highly Unlikely	Very Low	Highly Unlikely	High	0.71			0.29	
5	Highly Unlikely	Very Low	Highly Unlikely	Very High	0.71				0.29
11	….	…	…	…	…	..	..	..	..
621	Definite	Very High	Definite	Very Low	0.29				0.71
622	Definite	Very High	Definite	Low		0.29			0.71
623	Definite	Very High	Definite	Medium			0.29		0.71
624	Definite	Very High	Definite	High				0.29	0.71
625	Definite	Very High	Definite	Very High					1

Table 5. 8: The established CT, CQV, and CQ FRB with a belief structure for the assessment of AFTL risk factors

Rules	Antecedent Attribute (input)			Risk result (output)				
No	CT	CQV	CQ	very low	Low	Medium	High	Very high
1	Very low	Very low	Very low	1				
2	Very low	Very low	Low	0.41	0.59			
3	Very low	Very low	Medium	0.41		0.59		
4	Very low	Very low	High	0.41			0.59	
5	Very low	Very low	Very high	0.41				0.59
…	….	…	…	…	…	…	…	…
122	Very High	Very high	Low		0.59			0.41
123	Very High	Very high	Medium			0.59		0.41
124	Very High	Very high	High				0.59	0.41
125	Very High	Very high	Very high					1

5.3.5. Collection of data to estimate the AFTL risk factors

A survey questionnaire (Appendix three) was developed and distributed among the stakeholders engaging in the AFTL chain to seek their opinion and experience on the investigated risk factors based on the six risk parameters in the antecedents and their corresponding assessment grades. The questions were in a closed-ended format using the Likert scale, to investigate the level of agreement of each risk factor to the assessment parameters and pilot tested by employing five industry experts with experience and knowledge in dealing with the transport and logistics of agro-food products in the global markets prior sending to the correspondent.

The survey questionnaires were sent via email to twenty industry experts to participate in the study and a note to conduct a followed-up face-to-face structured interview. This approach allows the researcher to 1) understand the respondent more and provides immediate clarity on the questions each respondent might misunderstand or otherwise be left unanswered (Martelli and Greener, 2015). A total of seven participating companies representing a 35% response rate responded and agreed to participate in the study. The subjective distribution from the seven expert judgements was initially checked to ensure consistency and then merged using a weighted average approach (Wan et al, 2015) based on the relevant importance of the experts.

5.3.6. Risk Inference using Bayesian network (BN) technique

Once the data collected from the experts were checked for their biases and prepared. The BN techniques are then applied to conduct risk inference. BN help to synthesize the associated DoBs of the different applicable rules. its techniques have been proven to be a useful tool for capturing the non-linear causal relationship and synthesizing the associate DoBs (Garvey et al., 2015; Qazi et al., 2017). To use BN, the FRB developed in section 5.3.4 first needs to represent in the form of conditional probabilities (Garvey et al., 2015). For example, rule 3 in Table 5.8 is expressed using equation (5.1) as follows (yang et al, 2017):

R3: If highly unlikely (L1), Very low (R1), Highly unlikely (P1) and Medium (C_L),

THEN {(Very Low (R1), 0.71), (Low(R2), 0), (Medium (R3) 0.29), (High(R4),0), (Very high(R5),0)}.

This expression can further be expressed in the form of conditional probability using equation (5.7) as follow: (Yang et al., 2008)

Given L1, R1, P1 and C, the probability of

Rh (h=1,2,3,4,5) is (0.71,0,0.29,0,0), or

P(Rh|L1,R1,P1, C) = (0.71,0,0.29,0,0). Eq (5.7)

Where "|" symbolises conditional probability.

Using a BN technique, the FRB structures can be modelled and converted into a converging connection that includes four parents node N_L N_R N_P and N_{CL} with an extended parent node N_{CT} N_{CQV} N_{CQ} (Nodes L, R, P, C CT, CQV, CQ) and one child node (Node Rs). After the FRB has been transferred into a BN, The FRB risk inference of the risk assessment is simplified as the calculation of the marginal probability of node N_{RS}

To marginalise R_s the required conditional probability table (CPT) of $N_{RS,}$ P(R|L, R, P $\sum_c p(c)$, obtained using Eq(5.7). The result is a table containing value P(Rh|L1,R1,P1, CL1) $PRh|\ Li, Rj\ Pk\ CLm$ (h = 1….,5, I = 1…..,5, j = 1…..5, k = 1…..5, l = 1….5,) as partly shown in Table 5.9

Table 5. 9: The conditional Probability table for Node RS,

L	L1																								
R	R1																								
P	P1					P2					P3					P4					P5				
R/C	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
R1	1	0.71	0.71	0.71	0.71	0.68	0.39	0.39	0.39	0.39	0.68	0.39	0.39	0.39	0.39	0.68	0.39	0.39	0.39	0.39	0.68	0.39	0.39	0.39	0.39
R2	0	0.29	0			0.32	0.61	0.32	0.32	0.32	0	0.29	0	0	0	0	0.29	0	0	0	0	0.29	0	0	0
R3	0	0	0.29			0	0	0.29	0	0	0.32	0.32	0.61	0.32	0.32	0	0	0.29	0	0	0	0.32	0.29	0	0
R4	0	0	0	0.29		0	0	0	0.32	0	0	0	0	0.29	0	0.32	0.32	0.32	0.61	0.32	0	0	0	0.29	0
R5	0	0	0		0.29	0	0	0	0	0.29	0	0	0	0	0.29	0	0	0	0	0.29	0.32	0	0.32	0.32	0.61

Hence, the subjective probabilities β_i transformed from the expert's judgement based on the six risk parameters and their assessment grade on the AFTL risk factors can be considered as the prior probabilities of every parent node

Similarly, the prior probabilities of node N_R N_P N_C N_{CT} N_{CQV} N_{CQ} can be computed as $p(R_j) = \beta_j$, $p(P_K) = \beta_K$, $p(C_L) = \beta_L$ $p(CT_{L1}) = \beta_{L1}$, $p(CQV_{L2}) = \beta_{L2}$ $p(CQ_{L3}) = \beta_{L3}$, respectively. On completing the analysis of the prior probabilities of all the nodes, the marginal probability of the node R (N_R) can be calculated using equation (5.8) (Jensen and Nielsen, 2007)

$$P(R_H) = \sum_{i=1}^{5}, \sum_{j=1}^{5}, \sum_{k=1}^{5}, \sum_{L=1}^{5}, P\left(R_H \mid L_i\, R_j\, P_K\, C_L\right)\left(P(L_i)\, P(R_j)\, P(P_K) \sum cP(c)\right)$$

$$\text{Where } \sum cP(c) = \sum P\left(c \mid C_T\, C_{CQV}\, C_{CQ}\right) P(C_T)\, P\left(C_{CQV}\right) P\left(C_{CQ}\right)$$

(h= 1, 2...,5) Eq (5.8)

5.3.7. Prioritisation of AFTL risk factors using appropriate utility functions.

To prioritize the status of each AFTL risk factor, RH (h=1,2,3,4,5) the study assigned a linearly numerical utility value as defined in the study of Yang et al (2014), to describe the preference degree of the five utility expressions. i.e To describe the grading estimates of Rh for the h^{th} variables {$R_H = R_H^1$, " Very Low", R_H^2, " Low", R_H^3, " Medium", R_H^4, " High", R_H^5, " Very High"}, the U_{Rh} value (h= 1……5) can be obtained as

$$U_{Rh}^1 = 10^0 = 1$$

$U_{Rh}^{2} = 10^{1} = 10$

$U_{Rh}^{3} = 10^{2} = 100$

$U_{Rh}^{4} = 10^{3} = 1000$

$U_{Rh}^{5} = 10^{4} = 10000$

Thus, the Risk Ranking Index value (RRI) of the AFTL risk factor can be obtained using equation (5.9)

$$\text{RRI} = \sum_{h=1}^{5}, P(\text{Rh})\ U_{Rh} \qquad \text{Eq (5.9)}$$

Where the larger the RRI valve signifies a higher risk level of the AFTL risk factor

5.3.8. Validation using sensitivity analysis techniques.

When a new model having a subjective element in the methodology process is developed, it is essential to conduct an accuracy check before the methodology can be broadly used in practice (Zaili Yang et al., 2008), although various mechanistic testing tools are available to test the soundness of a newly developed model as explained in the study of Zaili Yang et al., (2008). In this study, sensitivity analysis was applied to test the accuracy of the belief structure based on subjective judgement and on how sensitive the conclusion of the linguistic estimate p(Rh) or the risk index was to a minor change in the judgment of the risk parameters (input).

Hence, if the reliability of the FRB structure is robust and the BN inference reasoning is logical, then the sensitivity analysis must at least follow the below three axioms (Zaili Yang et al., 2008; Alyami et al., 2014).

Axiom 1. “A slight increment/decrement in the subjective probability of each input node should undoubtedly result in the effect of a relative increment/decrement of the posterior probability value of the output node”.

Axiom2. The influence magnitude of the risk index value should be kept consistent with their weight distribution given the same variation of a subjective probability distribution of each risk attribute.

Axiom 3. The total influence magnitudes of the combination of the subjective probability variation from x attributes (evidence) on the RRI values should always be higher than the one from set x-y(y Є x) attributes (sub-evidence).

5.4. A real case study on AFTL chain's risk factors

5.4.1. Case description

To demonstrate the feasibility and applicability of the proposed model, seven leading food exporters (i.e. 5 for rice and 2 for cocoa) that own large logistics departments or professional logistics sub-contractors from the republic of Vietnam in the global market were invited to participate in the study to conduct the AFTL chain risk evaluation. A questionnaire (Appendix 5.4) was designed to collect data from the company's most senior managers, each with more than 15 years of experience in dealing with agro-food export and logistics services in the global markets. The experts' knowledge and experience are described in Table 5.10.

Table 5. 10: Expert knowledge and experience

1	Trading manager	Had worked as a supervisor and line manager in food supply chain industries with more than 20 years of experience
2	General manager	Had more than 20 years of experience with the global transport and logistics of Agri-food products
3	Director	Had more than 20 years of in product handling, storing and transporting food products from Vietnam to the global market.
4	Senior sales executive	Had Worked for more than 15 years for the company, with the responsibility to arrange good transport and logistics to complete the sales contract.
5	Sales Executive	Had more than 15 years of experience in arranging multi-modal transportation for food products in and out of Vietnam
6	Production manager	Had worked in the Agri-food production and logistic unit for more than 20 years
7	Logistic manager	Had more than 20 years of experience in dealing with food transport and logistics.

In the questionnaire, the seven industry experts were asked to evaluate each of the forty-six FTL risk factors concerning the six risk parameters, in terms of their associated linguistic grades and DoBs. Their feedback data were first checked, to ensure practical and non-biased belief function, then combined by computing their average to produce the failure risk input value based on the six risk parameters.

5.4.2. Result of AFTL risk factors with a high likelihood of occurrence

Of all the forty-six significant AFTL risk factors, fluctuation in the currency exchange rate, followed by humidity monitoring control, global sourcing of networks and a payment delay from the shippers are the top four risk factors of the high likelihood of occurrence. Based on the average opinion of the seven industry experts and before combining them for a final risk ranking, fluctuation in currency exchange has a DoB value of 0% highly unlikely, 12.86% unlikely, 22.86% likely, 24.29% highly unlikely and 40% definite likelihood of occurrence. Similarly, the humidity monitoring control has an average risk value of 78.57% highly likely and 21.43% definite likelihood of occurrence in the FTL chain as shown in Table 5.11 and presented in Figure 5.3

Table 5. 11: Factors of the high likelihood

	Fluctuation in the currency exchange rate	Humidity monitoring control	Global sourcing network	Payment delay from the shipper
Highly Unlikely	0.00%	0.00%	7.14%	12.86%
Unlikely	12.86%	0.00%	7.14%	8.57%
Likely	22.86%	0.00%	38.57%	45.71%
Highly likely	24.29%	78.57%	30.00%	17.14%
Definite	40.00%	21.43%	17.14%	15.71%

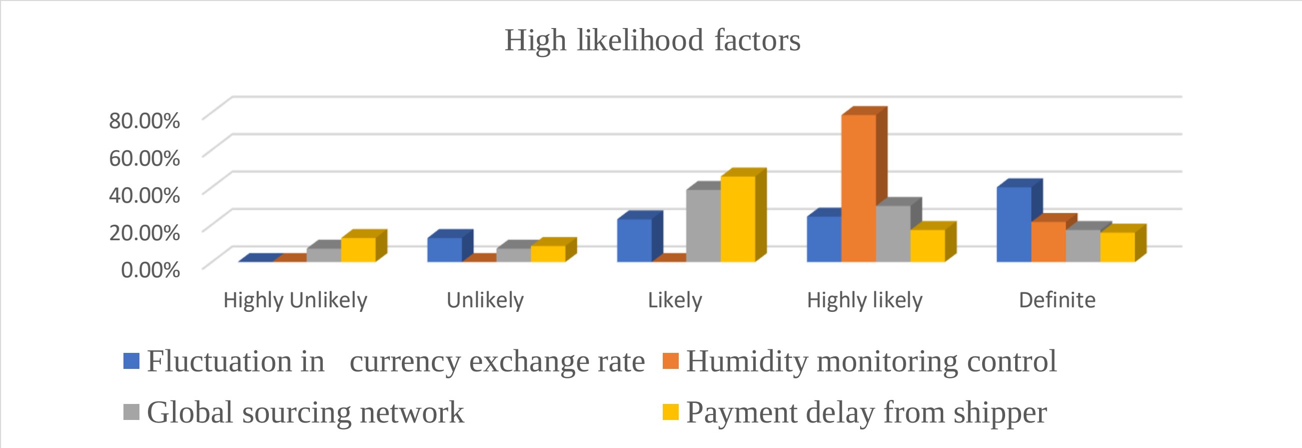


Figure 5. 3: Top AFTL risk factor with a high likelihood

5.4.3. Result of factors of the high probability of risk undetected

The probability of risk detection is the ability of a stakeholder to detect the risk factor before its occurrence. Based on the average expert opinion, service quality deterioration, food safety leadership, adaptation to food standards and storage /warehousing are the four top risk factors with a high detection probability (Table 5.12). Deterioration in service quality is ranked first among the 46 risk factors in the FTL chain with a failure input value of 21.42% likely, 38.57% highly likely and 40% definite probability of detection as presented in Figure 5.4

Table 5. 12: High probability of risk undetected

	Deterioration in service quality	leadership in food safety	Adaptation to food standard	storage and warehousing
Highly Unlikely	0.00%	0.00%	0.00%	38.57%
Unlikely	0.00%	0.00%	0.00%	4.29%
Likely	21.43%	12.86%	12.86%	14.29%
Highly likely	38.57%	64.29%	67.14%	27.14%
Definite	40.00%	22.86%	20.00%	15.71%

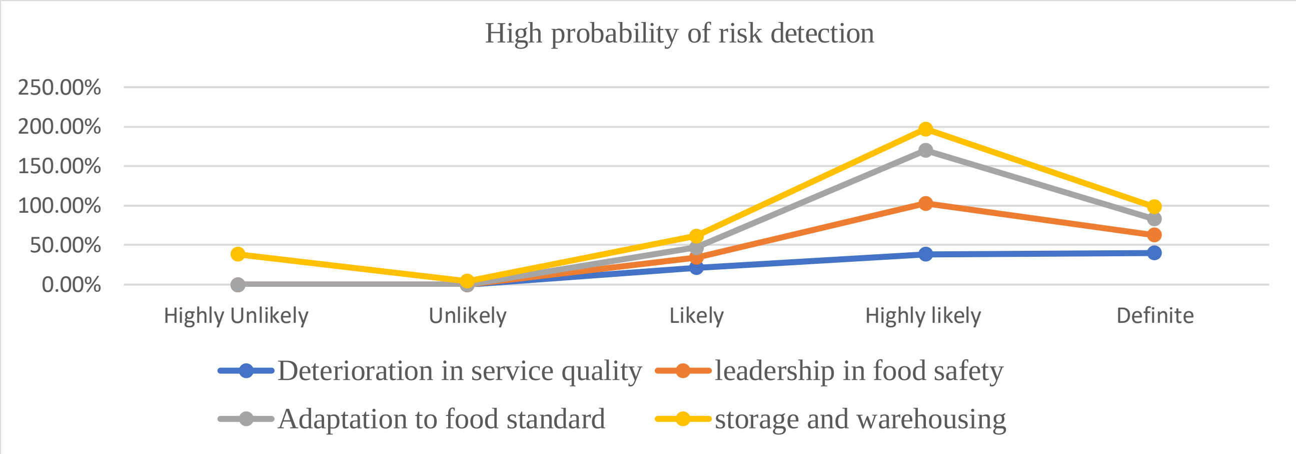


Figure 5. 4: High probability of risk detection AFTL risk factor

5.4.4. Result of factors of the high resilience impact

The resilience impact assesses the ability of a stakeholder in the AFTL chain to recover from the consequence outcome of a risk factor or be in a better state than its initial stage after the risk occurs. Low supplier transparency, leadership in food safety, poor food preservation and communication failure among the partners are the top risk factor with a high resilience impact as shown in Table 5.13 and presented in Figure 5.5

Table 5. 13: Resilience

	Low supplier transparency	Leadership in food safety	Poor food preservation	communication failure among partners
Very Low	0.00%	0.00%	0.00%	0.00%
Low	0.00%	0.00%	8.57%	2.86%
Medium	00.00%	12.86%	8.57%	25.71%
High	32.86%	20.00%	18.57%	12.86%
Very High	67.14%	67.14%	64.29%	58.57%

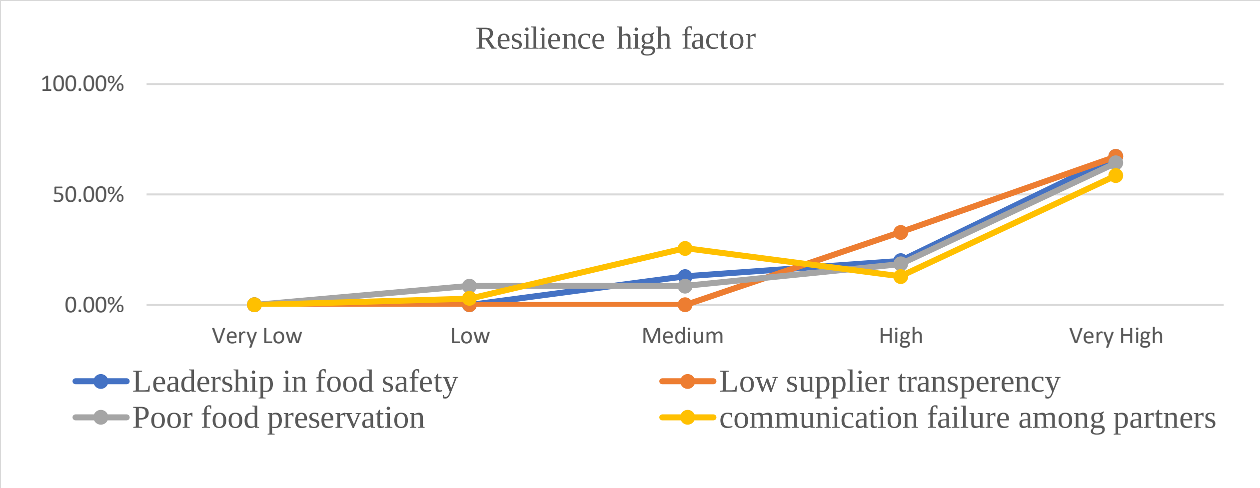


Figure 5. 5: High resilience AFTL risk factor

5.4.5. Result of factors of the high consequence

The consequence assesses the effect of a risk factor on the stakeholder after its occurrence. Based on a risk factor effect on the delay (time), volume or quantity of the product (quantity) and the quality of the product (quality) on the arrival to its destination, its risk consequence is qualified and evaluated. The survey result reveals that adaptation to food standards, followed by leadership in food safety, employee wages and fire accidents are the top risk factors, as illustrated in Figure 5.6 Adaptation to food standards has a failure input value of 78.57% high and 21.43% very high (Table 5.14). The average responses from the experts show that adaptation to food standards has the highest severity consequence on the product delivery time. Similarly, employee wages, followed by humidity monitoring control, leadership in food safety standards and lack of sufficient handling equipment are the top four risk factors with a significant consequence on the quantity of the products, as illustrated in Figure 5.7. The employee wages ranked first with a failure input value of 0% very low, 38.57% low, 4.29% medium, 30.00% high, and 27.14% very high (Table 5.15). The significant risk factors based on the consequence of product quality include low supplier transparency, followed by humidity monitoring control, fire accident and deterioration in service quality (Table 5.16). This result shows that the proposed model can present flexible risk results and simplify the imprecise data information problem, to support a safety-based decision on a real situation in the AFTL chain.

Table 5. 14: Consequence of time-based

	Adaptation to food standard	leadership in food safety	Employee wages	Fire accident
Very Low	0.00%	0.00%	0.00%	0.00%
Low	0.00%	0.00%	0.00%	0.00%
Medium	0.00%	7.14%	38.57%	40.00%
High	78.57%	72.86%	42.86%	44.29%
Very High	21.43%	20.00%	18.57%	15.71%

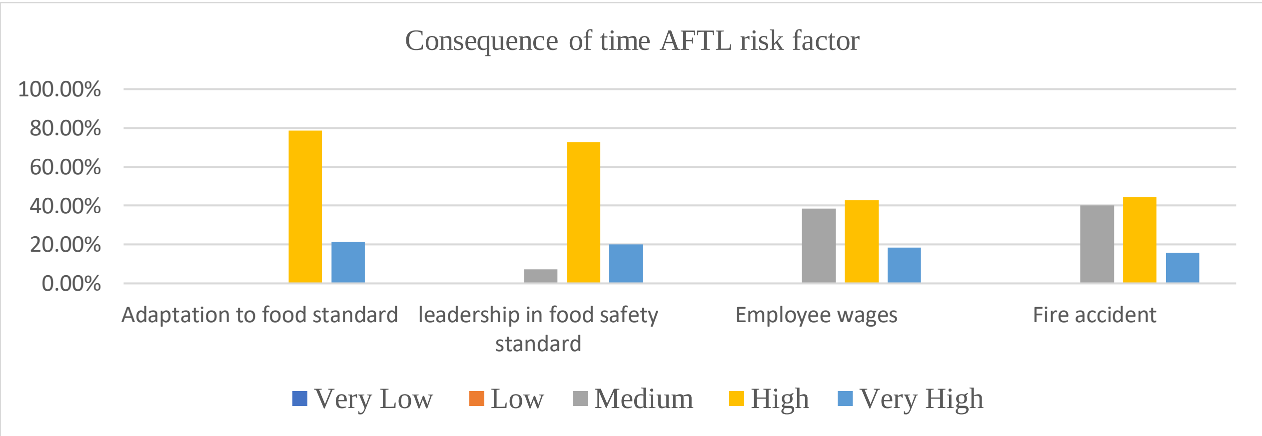


Figure 5. 6: High consequence of time AFTL risk factor

Table 5. 15: Consequence quantity based

	Employee wages	Humidity monitoring control	Leadership in food safety	lack of sufficient handling equipment
Very Low	0.00%	0.00%	0.00%	0.00%
Low	38.57%	0.00%	0.00%	45.71%
Medium	4.29%	0.00%	12.86%	11.43%
High	30.00%	78.57%	67.14%	25.71%
Very High	27.14%	21.43%	20.00%	17.14%

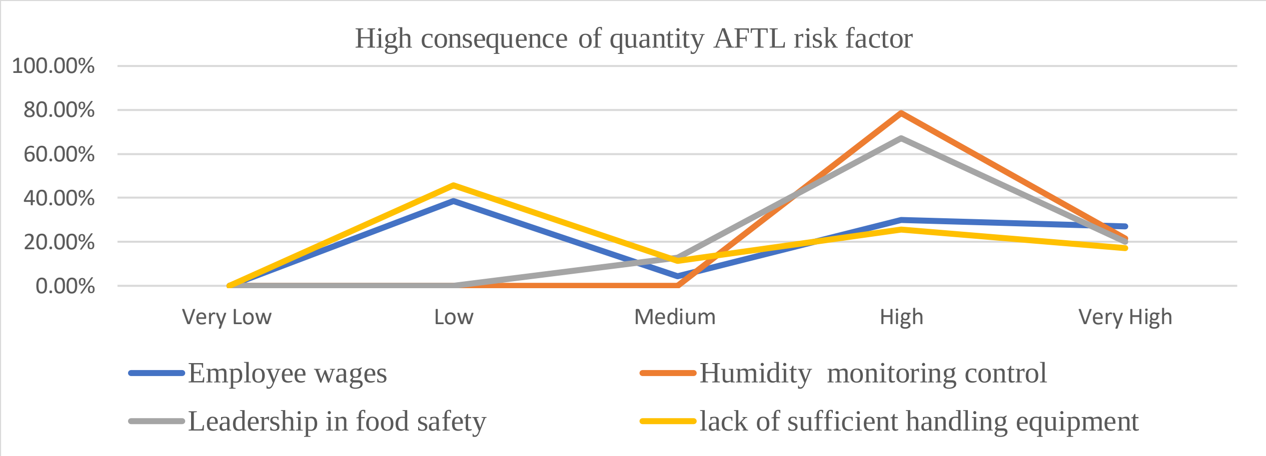


Figure 5. 7: High consequence of quantity AFTL risk factor

Table 5. 16: Consequence quantity based

	low supplier transparency	humidity monitoring control	Fire accident	Deterioration in service quality
Very Low	0.00%	0.00%	25.71%	0.00%
Low	0.00%	0.00%	2.86%	0.00%
Medium	20.00%	0.00%	10.00%	1.43%
High	8.57%	32.86%	22.86%	77.14%
Very High	71.43%	67.14%	38.57%	21.43%

5.4.6. Result of the final priority ranking of risk factor

Estimation of all the risk factors in terms of the combined six risk parameters was obtained and transformed into a form of prior probability using Eq (5.8), and the priority index of each risk factor is obtained using Eq (5.9). Taking the risk factor " Government Transport Policy (R2)," for illustration purposes. Table 5.16 present the seven expert judgements on the " Government Transport Policy (R2)," risk level. The Expert combined DOBs were then transformed into a form of prior probabilities of the six nodes in the BN tools, and the risk level for (R2) "Government transport policy (R2) risk level obtained using Eq (5.8) as follows

P(Rh)= {(22.41% Very low, 16.20% Low, 35.65% medium, 19.28% High, 6.46% Very High)}. The result signifies that the "Government transport policy" risk level is Very low with 22.41% DoB, Low with 16.20% DoB, Medium with 35.65% DoB, High with 19.28% DoB and very high with 6.46% DoB.

To facilitate the BN inference, Hugin Lite software was used to computerise the calculations (Alyami et al., 2014), as shown in Figure 5.8. and the RRI value was obtained using Eq (5.9) as 876.2941 (= 22.41% x 1 + 16.20% x 10 + 35.65% x100 + 19.28% x1000 + 6.46% x10000). Similarly, the ranking index of all 46 AFTL risk factors was obtained as presented in (Table 5.18). Findings show that leadership in food safety management, low supplier transparency, deterioration in service quality and adaptation to changes in food standards are the four top priority risk factors in the AFTL chain. This risk factor requires more attention with respect to AFTL chain risk management.

Table 5. 17: Expert evaluation result for (R2) "Government Transport Policy."

Risk Parameters	Experts							Combined DOB
	1	2	3	4	5	6	7	
Likely probability	0% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	80% Highly Unlikely	90% Highly Unlikely	24.29% Highly Unlikely
	0% Unlikely	0% Unlikely	0% Unlikely	00% Unlikely	10% Unlikely	20% Unlikely	10% Unlikely	5.71% Unlikely
	0% Likely	90% Likely	90% Likely	90% Likely	90% Likely	0% Likely	0% Likely	51.43% Likely
	50% Highly likely	10% Highly likely	10% Highly likely	10% Highly likely	0% Highly likely	0% Highly likely	0% Highly likely	11.43% Highly likely
	50% Definite	0% Definite	0% Definite	0% Definite	0% Definite	0% Definite	0% Definite	7.14% Definite
Resilience impact	0% Very Low	0% Very Low	0% Very Low	0% Very Low	0% Very Low	80% Very Low	90% Very Low	24.29% Very Low
	0% Low	0% Low	0% Low	0% Low	10% Low	20% Low	10% Low	5.71% Low
	0% Medium	0% Medium	90% Medium	0% Medium	90% Medium	0% Medium	0% Medium	25.71% Medium
	90% High	10% High	10% High	10% High	0% High	0% High	0% High	17.14% High
	10% Very High	90% Very High	0% Very High	90% Very High	0% Very High	0% Very High	0% Very High	27.14% Very High
The probability of risk detection	10% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	0% Highly Unlikely	80% Highly Unlikely	10% Highly Unlikely	14.29% Highly Unlikely
	90% Unlikely	10% Unlikely	0% Unlikely	10% Unlikely	0% Unlikely	20% Unlikely	90%Unlikely	31.43% Unlikely
	0% Likely	90% Likely	10% Likely	90% Likely	0% Likely	0% Likely	0% Likely	27.14% Likely
	0% Highly likely	0% Highly likely	90% Highly likely	0% Highly likely	90% Highly likely	0% Highly likely	0% Highly likely	25.71% Highly likely
	0% Definite	0% Definite	0% Definite	0% Definite	10% Definite	0% Definite	0% Definite	1.43%Definite
Consequence Time based	0% Very Low	0% Very Low	0% Very Low	0% Very Low	0% Very Low	80% Very Low	90% Very Low	24.29% very low
	0% Low	10% Low	10% Low	10% Low	0% Low	20% Low	10% Low	8.57% Low
	50% Medium	90% Medium	90% Medium	90% Medium	0% Medium	0% Medium	0% Medium	45.71% Medium
	50% High	0% High	0% High	0% High	90% High	0% High	0% High	20.00% High
	0% Very High	0% Very High	0% Very High	0% Very High	10% Very High	0% Very High	0% Very High	1.43% Very high
Consequence Quantity/Volume based	20% Very Low	0% Very Low	0% Very Low	0% Very Low	0% Very Low	80% Very Low	90% Very Low	27.14% Very Low
	80% Low	10% Low	10% Low	10% Low	0% Low	20% Low	10% Low	20.00% Low
	0% Medium	90% Medium	90% Medium	90% Medium	0% Medium	0% Medium	0% Medium	38.57% Medium
	0% High	0% High	0% High	0% High	90% High	0% High	0% High	12.86% High
	0% Very High	0% Very High	0% Very High	0% Very High	10% Very High	0% Very High	0% Very High	1.43%Very high
Consequence Quality based	20% Very Low	80% Very Low	0% Very Low	80% very low	0% Very Low	0% Very Low	90% Very Low	38.57% Very Low
	80% Low	20% Low	0% Low	20% Low	0% Low	0% Low	10% Low	18.57% Low
	0% Medium	0% Medium	0% Medium	0% Medium	0% Medium	0% Medium	0% Medium	0.00%medim
	0% High	0% High	10% High	0% High	90% High	80% High	0% High	25.71% High
	0% Very High	0% Very High	90% Very High	0% Very High	10% Very High	20% Very High	0% very high	17.14% Very High

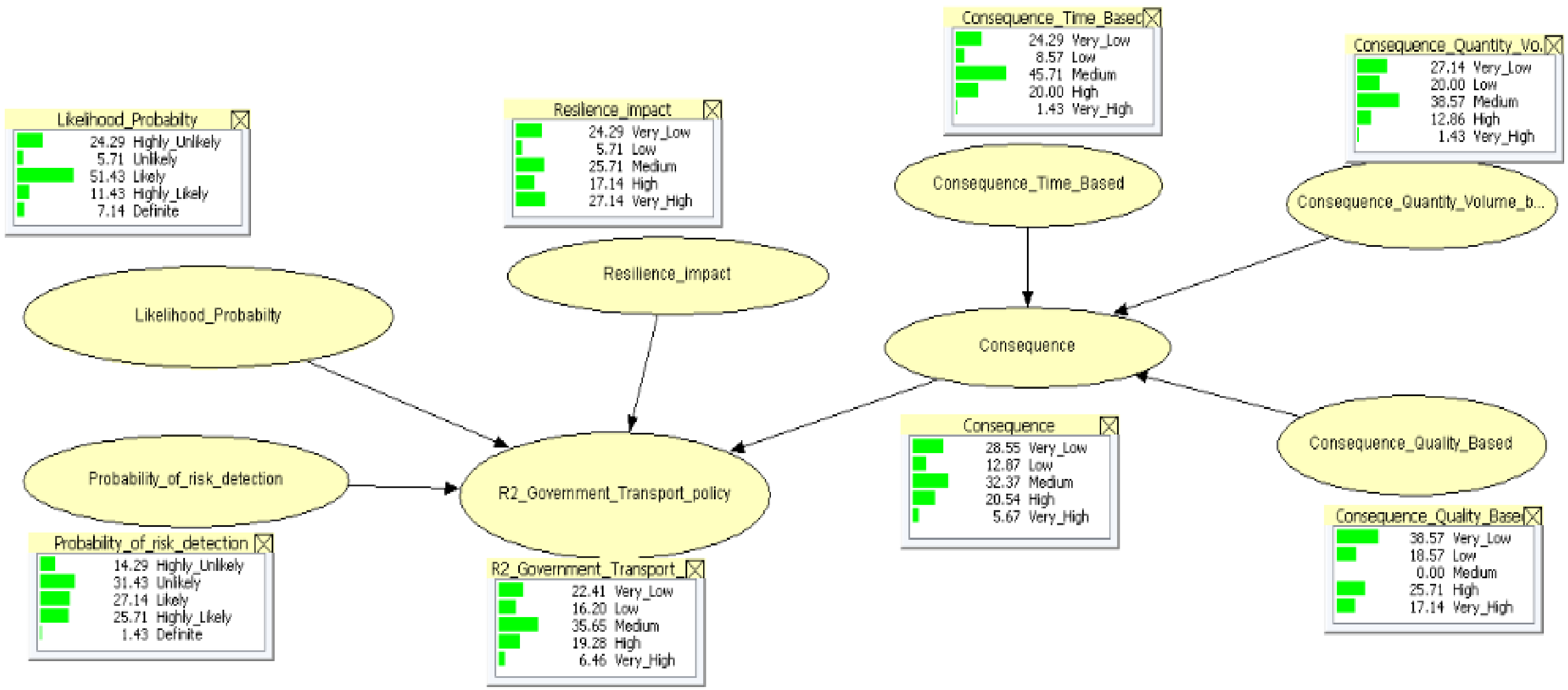


Figure 5. 8: Government Transport Policy (R2) risk evaluation using HUGIN lite software

Table 5. 18: The risk ranking index values of the AFTL risk factors

Risk Factors	RRI Values	Ranking
R1. Flood	724.9807	32nd
R2. Government transport policy/banking seasonal interest rate	876.2941	19th
R3. External legal issues	404.2505	44th
R4. Labour strike	796.8429	27th
R5 Worker Union relation	1147.7583	12th
R6. Pilferage and non-delivering	877.9897	18th
R7. Cyberattack	793.9873	28th
R8. Changes in the currency exchange rate	712.3933	34th
R9. Payment delay from the shipper.	860.3065	21st
R10. Higher Transportation cost	300.6442	46th
R11. Excessive inventory	675.6364	38th
R12. Deterioration in service quality	1961.326	3rd
R13. Poor handling	890.6221	16th
R14. Fire accident	1217.3114	10th
R15. Product damaged in transits	620.2423	39th
R16 Temperature abuse	828.675	24th
R17.Cross-contamination	835.1479	23rd
R18.Insufficient holding space	384.5872	45th
R19.Timely availability of the vehicle	755.9821	30th
R20.Truck accident	822.7009	25th
R21.Human error	691.831	37th
R22.Improper sanitation and backhauling hazardous material	512.4844	43rd
R23. Poor pest control	729.3474	31st
R24.Communication failure among partners	761.1427	29th
R25.Labour skilled personnel	1176.391	11th
R26. Employee wages	1361.1582	8th
R27.Overburden employee	1266.3559	9th
R28. Poor motivation among the workforce	1367.9911	7th
R29. Leadership in food safety management	2140.0569	1st
R30. Adaptation to food standard regulation change	1842.0904	4th
R31. Poor employee hygiene	843.3775	22nd
R32. Obsolete technology	903.637	15th
R33 Storage and warehouse	1389.6505	6th
R34. Lack of sufficient cargo handling equipment	909.5105	14th
R35. Risk of applying sensing technology	814.2535	26th
R36. Humidity monitoring /control	1742.68	5th
R37. Negligently equipment maintenance	698.6486	36th
R38. Power system	595.5345	40th
R39.Poor packaging	522.2701	42nd
R40 poor preservation	874.109	20th
R41.Inaccurate shipment from the supplier	719.4242	33rd
R42.Low supplier transparency	2103.0957	2nd
R43. Low supplier integration	710.4899	35th
R44.The poor performance of sub-contractor	914.7115	13th
R45. Poor logistics contract	889.3488	17th
R46.Global sourcing network	554.4703	41st

5.5. Validation of the finding result.

Consequently, to validate the reliability of the analysed result and the robustness of the developed model, sensitivity analysis was conducted according to the three axioms stated in section 5.3.8. Firstly, the consistent relationship between the six risk parameters in the complex FRB structure and the RI value proved logical. In this study, the software (Hugin) was used to compute a minor variation change in the linguistic grade of risk assessment parameters, The findings reveal that the posterior probability value of their outputs is sensitive to the assessment grade. For instance (R2) "Government transport policy "as shown in Figure 5. 9, a slight 0.2 variation decrease the top-level state "highly unlikely" and 0.2 increase on the bottom level state "Definite" of the node "*probability of risk detection* " the posterior probability value of the output the top-level state "Very Low" decrease from 22.41% to 22.35% and the bottom level state "very high" increase from 6.46% to 6.52%, the RRI value increases rapidly from 876.294 to 882.294. A similarity checks on all the AFTL risk factors verifies the model with AXIOM 1.

Secondly, the study shows that the RI values are sensitive to the influence magnitude that closely follows the weight ratio between the six risk assessment parameters (L, R P, C_T, C_{QV} and, C_Q) used in developing the FRB rule-based structure. The study applied a graphical form of sensitivity analysis, and the result shows subjective probability variation changes between the top and bottom level grades on a varying scale of 1 through 5. The effect of the RI after the changes can be obtained using equation (5.10)

$$EI = RI' - RI = \sum_{h=1}^{5}, P(Rh)' \, U_{RH} - \sum_{h=1}^{5}, P(Rh) \, U_{RH} \qquad \text{Eq (5.10)}$$

Taking (R2) "Government transport policy" (R2) as an illustration, a subjective probability change of 1.0 between the top and bottom level state of the assessment parameters L, R P, C_T, C_{QV} and, C_Q using equation (5.10) created an effect to RI value of 29 (905.3-876.3 for "L"), 8 (884.3-876.3 for "R"), 32 (908.3-876.3 for "P"), 18 (894.3-876.3 for "C_T"), 87.9 (964.2- 876.3 for "C_{QV}"), 8 (884.3-876.3 for C_q), respectively. The influence magnitude of the subjective probability changes of the assessment variables to the RI values of a similar variation follows a similar distribution as illustrated in Figure 5.10. Thus, such findings reveal that the developed FRB structure was consistent with AXIOM 2. Consequently, in line with AXIOM 3, the study verifies that the total influence magnitude of the combination of the probability variation from any of the six assessment parameters is always greater than one attribute. Take for instance, (R2) "Government transport policy "Given a change in the node "Likelihood Probability" to "highly likely" with a 50% DoB and "definitely" with a 50% DoB. The posterior probability value of the risk output and RRI values was found to increase as presented in Figure 5. 11.

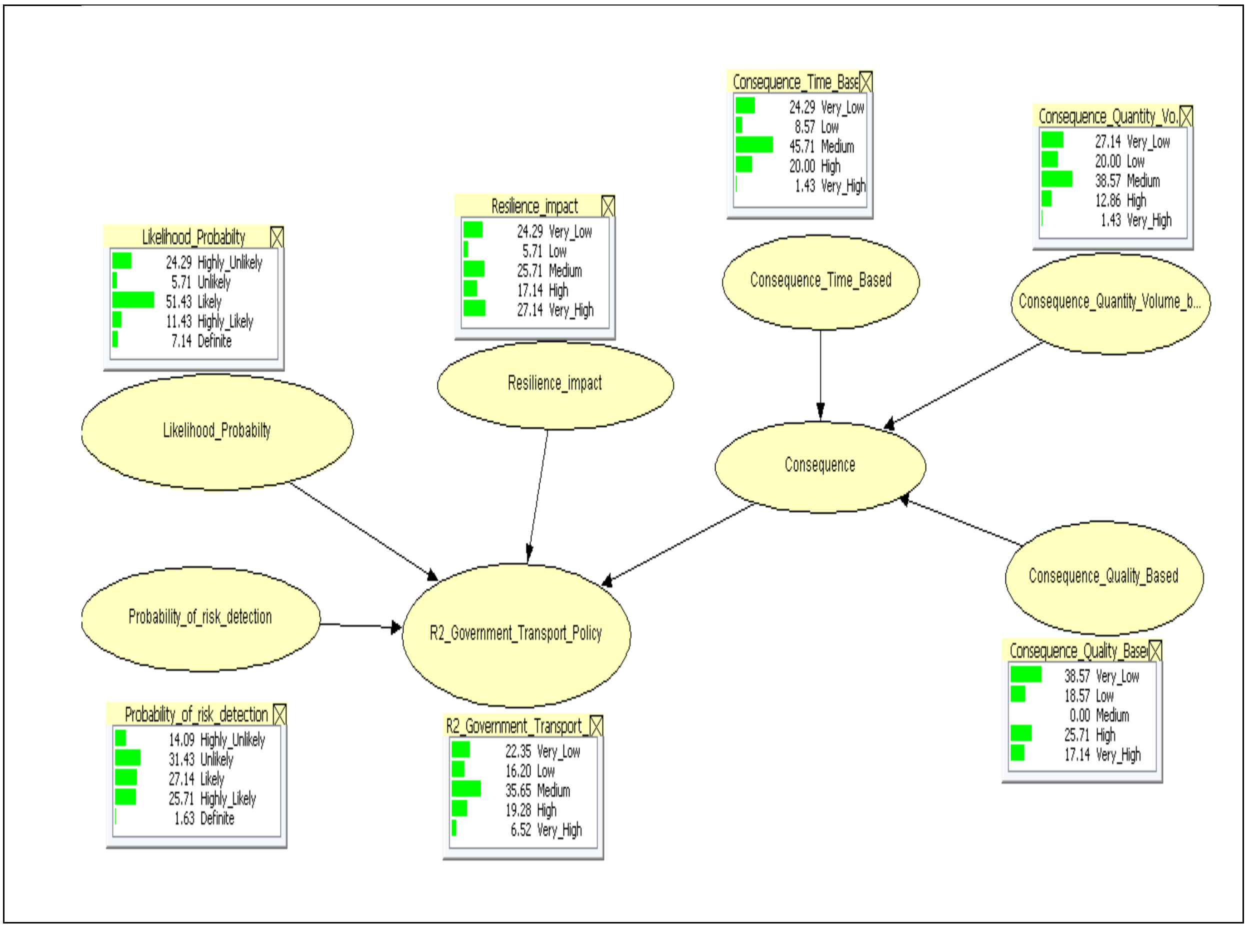


Figure 5. 9: The evaluation of the risk output of "Government Transport Policy (R2)" given evidence of "R=100% High"

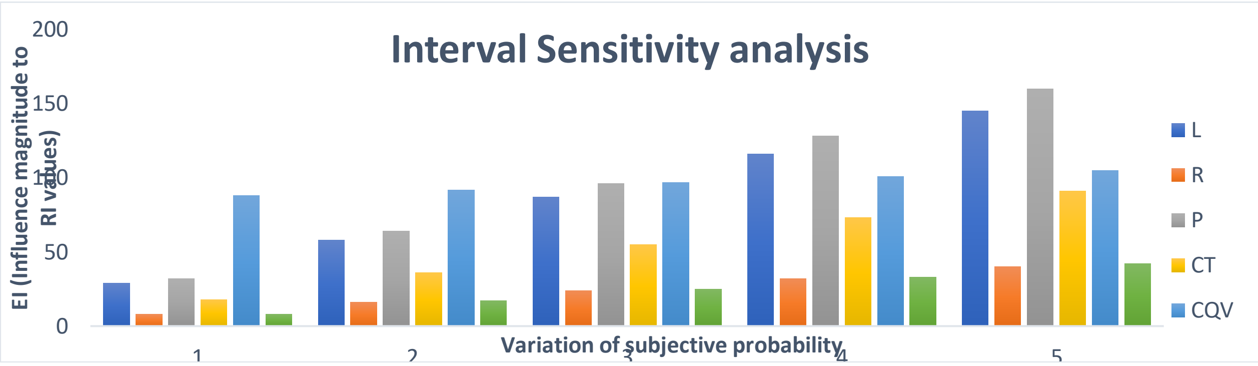


Figure 5. 10: Sensitivity analysis of interval variation of sizes 1 to 5

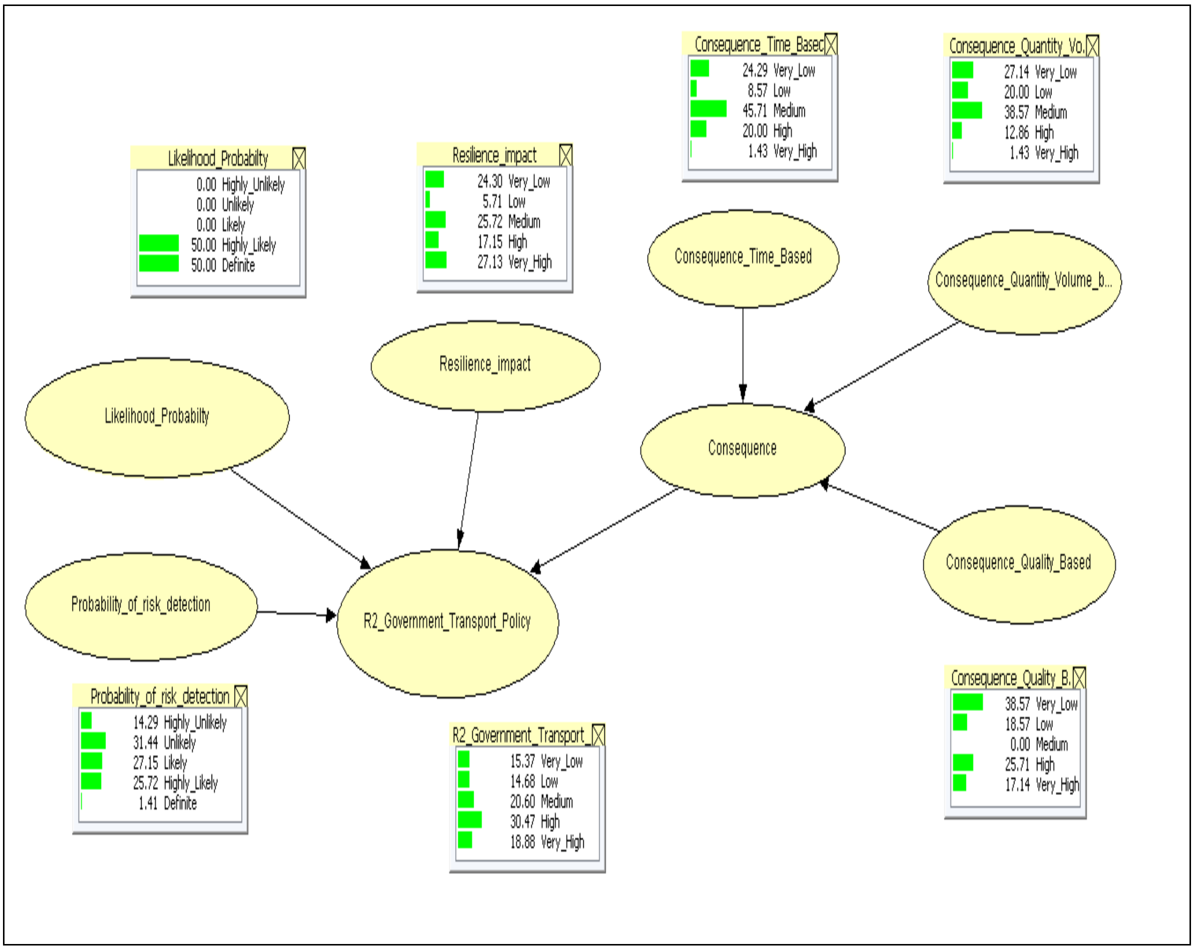


Figure 5. 11: The evaluation of the risk output of "Government Transport Policy (R2)" given slight changes to node "L" parameters

5.6. Conclusion

This paper provides experimental evidence on the successful application of the FRB-BN model to evaluate and prioritise risks in AFTLs using subjective risk data. It also shows that the model can present a sensible and flexible risk result in a real-life situation by employing multiple risk parameters with a set of linguistic grades to simplify the failure information in assessing the concerning risk in the AFTLs chain. The new findings reveal that 1) the risk factors of different characteristics are evaluated on the same plane for effective overall risk control from a supply chain perspective, 2) in terms of practical implication, the high-level risk factors against each risk parameter and their combination (from an overall risk angel) are identified, which can provide useful insights for transport logistic managers, food risk assessors and the internal/external auditors for effective risk control of the selected FTLs, and 3) the generic methodology can be tailored and applied to model risks of other food supply chains from, as its theoretical contribution. Although the proposed framework does not focus on modelling and evaluating the causal risk mitigation strategies. In the next chapter, an advanced model capable of evaluating the relevant root causes influencing the top priority risk and the mitigation strategies will be developed. However, after the consultation of the domain experts, the study was limited to the evaluation of the root causes influencing the hazard with a high probability of un-detection (service quality) and its mitigation strategies

CHAPTER SIX – ASSESSMENT FRAMEWORK FOR THE SERVICE QUALITY RISK HAZARD

6.1. Introduction

This chapter focuses on assessing the causal variables influencing the service quality risk hazards in the AFTL chain using the decision-making trial and evaluation laboratory (DEMATEL) and Evidential reasoning (ER) approaches. The DEMATEL was introduced to analyse the cause-and-effect interdependency relationship between the verified causal variable indicators (CVIs) and the Evidential reasoning algorithm was introduced to aggregate the assessment of the quantitative and qualitative variables with imprecise, incomplete or vague data information. An empirical study was carried out to collate primary data from the top three countries (The republic of Vietnam, China and Thailand), handling and supplying Agro-food products into the global market and the findings of the result facilitate the decision-making process in each of the causal variables and facilitate the process for choosing the appropriate strategies to mitigate causal variables that influence in the deterioration of service quality in the FTL chain

6.2. Overview of the service quality causal variable indicators

6.2.1. Literature review

The study adopted a systematic literature review method to identify, select and analyze the relevant research paper on service quality using the literature reference and "cited by" references for relevance. The search engines the web of science, Google Scholar and Emerald insight were used. The selected keywords were frequently used in the literature to describe the food transport logistic service quality variables. Thus, the selected keywords used for the search (including strings and substrings such as food safety, transport, logistics, quality, and risk models. To ensure that the most relevant literature was evaluated, the study imposed a (stratified) selection by defining the criterion for including or excluding studies. Only the articles published in English were considered and included. Conference proceedings, textbooks, working papers, anonymous papers and other unpublished works were excluded. The selected articles stem from 2000 to December 2019. The start date was set based on a prior review describing the problem relevant to the service quality measurement in logistic activities that was first introduced that year (Franceschini and Rafele, 2000). In total was the selection and evaluation of sixty papers. Eventually, we analyzed each paper for descriptive, methodological, and thematic contents to identify, categorized and classify individual published papers according to the relevant research topic within the study research stream. The process enabled three main research lines to be identified.

Research line 1: Underline the principle of service quality perceptions. This line of research compiles the literature perception of quality. It covers industry-specific service quality measures that define the services provided by the transport logistic firm and the principles governing their service quality measurement.

Research line 2: This line delineates the concept of transport logistic service, group service quality attributes and the "dimensionality" of the service quality construct from the existing framework with the potential for incorporation and synthesis in a new framework for transport logistic service provider

Research line 3: Service quality modelling. This line defines the various service quality measuring models, pinpoints their limitations and modelling transport logistic service quality for the food industry

6.2.1.1. Underline principles of quality perception

The term “Quality” according to the International Standard Organization (ISO) is the totality of features and characteristics of a product or service that bears its ability to satisfy the stated or implied needs (ISO 9000). Similarly, in the academic literature, “Quality” had been defined from two different approaches namely: 1) a subjective approach- proposing quality as an adaptation to service specification pre-defined by the service provider, and 2) an objective approach- proposing quality as perception and evaluation of customer satisfaction when their expectation is meet (Thai, 2013). A lot of academia adopts the subjective definition of quality. For instance, Mellat-Parast, (2013) defines quality as a group of practices that enables a continuous process and improvement among the stakeholders. The author's definition is in line with Siddh et al., (2017) definition of quality, although the authors incorporate improvement of performance and customer satisfaction in their definition. Quality is unquestionable of paramount importance to service delivery, it measures how an organisation's service delivery meets the customer and stakeholder expectations (Pleger Bebko, 2000; Nakhai and Neves, 2009). Similarly, according to, Islam and Zunder (2014) service quality in the supply chain perspective is the ability to distribute a product or material in conformance with the client requirement and standard i.e. the degree to which the performance of an organization meets the stated service criteria. In the academic literature, several authors had argued that the attributes and elements associated with supply chain service quality are more focused on specific service settings. Over the last twenty years, several service quality indicators have been published in the literature.

6.2.1.2. Overview of the service quality indicators

The various set of indicators reviewed in the literature covering the different aspects of service quality was presented in Table 6.1. The indicators reflect the objectives, competencies, and performance. Some of the indicators act as a service descriptor (for example reliability, responsiveness, empathy) while others act as a proxy to evaluate service outcome (Brady and Cronin, 2001). It must also be remarked that some of these indicators represent the customer perceptions of service provided (reliability, tangibles, responsiveness, empathy, assurance, and lead time) while some represent the internal management of service provision (productivity, competence). It is also noted that some indicators are similar with different interpretations. Some are split as a sub-indicator, or as a group based on the quality that influences the delivery of the services to meet the stakeholder need and/or firm objectives (Jari et al., 2010; Emari et al., 2011) for instance, reliability- the ability of a firm to perform the promised service dependably and accurately is measured as a sub-indicator of correctness, completeness and on-time delivery and also used independently as a modelling factor to measure the quality of performance (Franceschini and Rafele, 2000; Thai, 2013). It is also noted in the literature that several authors classify the quality measuring attributes into a different dimensions of a construct, as seen in the study (Jari et al., 2010; Emari et al., 2011 Thai, 2013). Furthermore, based on the general conceptualization of the attributes in the service industries and the interpretative review of its modelling framework in the literature, it was suggested that quality attributes must define the value and services provided in meeting stakeholder and market expectations. It must be comprehensive, casually oriented, and reflect the activities that can define the quality standard of service delivery (Rixer et al., 2001). From the academic literature, it was revealed that there was no standard framework that had been designed to measure the quality performance of a general services industry. All the frameworks are industry-specific with a general focus on the organisation's features and purpose (Rafiq and Jaafar, 2007; Ladhari, 2008; Emari et al., 2011).To name a few, the attributes of service quality for campus career service centres suggested by (Engelland et al., 2000), Historic houses (Frochot and Hughes, 2000), the manufacturing industries (Franceschini and Rafele, 2000), the banking industry (Emari et al., 2011), Health care industry and others as presented in Table 6.2. Hence, no study had attempted to integrate this plethora of studies on service quality for the food transport logistic chain creating a knowledge gap.

Table 6. 1: Summary of service quality indicators in the service industry

Indicators	Date				No of papers	Reference
	2000-2005	2006-2010	2011-2015	2016-2020		
Tangibles	8	2	2	1	13	Engelland et al (2000); Frochot and Hughes (2000); Vaughan and Shiu, (2001); Brady and Cronin, (2001); Sureshchandar et al., (2002); Getty and Getty, (2003); Khan, (2003); Rafele (2004); Akbaba, (2006); Markovic, (2006); Thai (2013), Kilibarda et al., (2016)
Reliability	9	1	4	2	16	Engelland et al (2000); Franceschini and Refele (2000); Vaughan and Shiu, (2001); Getty and Getty (2003), Khan (2003); Wolfinbarger and Gilly, (2003); Yoon and Suh, (2004); Jabnoun and Khalifa, (2005); Karatepe et al., (2005); Markovic (2006), Thai (2013), Islam and Zunder, (2014); Kilibarda et al., (2016).
Responsiveness	6	1	1	3	10	Engelland et al (2000); Frochot and Huges (2000); Vaughan and Shiu (2001); Getty and Getty (2003); Khan (2003); Yoon and Suh (2004); Markovic (2006); Thai (2013); Kilibarda et al., (2016).
Assurance	3	2	1	1	7	Engelland et al (2000), Khan (2003), Yoon and Suh (2004), Akbaba (2006), Markovic (2006), Kilibarda et al., (2016).
Empathy	5	1	1	1	8	Engelland et al (2000), Frochot and Huges (2000,) Khan (2003), Yoon and Suh (2004), Karatepe et al (2005), Markovic (2006), Kilibarda et al., (2016)
Communication	3				3	Frochot and Huges (2000), Vaughan and Shiu (2001), Getty and Getty (2003)
Consumables	1				1	Frochot and Huges (2000)

Lead time	2		2	1	5	Franceschini and refele (2000), Rafele (2004), Thai (2013), Islam and Zunder (2014), Kataike et al, (2019)
Regularity	2		1		3	Franceschini and Refele (2000), Rafele (2004), Thai (2013)
completeness	2		1		3	Franceschini and Refele (2000), Rafele (2004), Thai (2013)
Flexibility	1	2	1	2	6	Franceschini and Refele (2000), Rafele (2004), Rafiq and Jaafar (2007), Thai (2013),
Correctness	2		3	1	6	Franceschini and Refele (2000), Rafele (2004), Thai (2013) Kataike et al., (2019)
Harmfulness	1				1	Franceschini and Refele (2000)
Acess	2				2	Vaughan and Shiu, (2001), Janda et al., (2002)
Humaneness	2		1		3	Vaughan and Shiu (2001), Sureshchandar et al., (2002); Thai (2013)
Security	3		2	1	6	Vaughan and Shiu (2001), Janda et al (2002), Wolfinbarger and Gilly, (2003); Thai (2013),
Enabling	1				1	Vaughan and Shiu (2001)
Empowerment	1				1	Vaughan and Shiu (2001)
Competence	1	1	1		3	Vaughan and Shiu (2001), Rafiq and Jaafar (2007), Thai (2013)
Equity	1				1	Vaughan and Shiu (2001)
Respect and caring	1	1			2	Sower et al., (2001),
Efficiency	2	2	2	1	7	Sower et al (2001) Parasuraman et al (2005) Rafiq and Jaafar (2007), Fernie et al (2010), Thai (2013), Islam and Zunder (2014), Kataike et al, (2019),
Information	2	1		1	4	Sower et al (2001) Janda et al (2002), Rafiq and Jaafar (2007), Infani et al, (2019)
Attitude	1				1	Brady and Cronin (2001)
Behaviour	1				1	Brady and Cronin (2001)
Expertise	1				1	Brady and Cronin (2001)
Waiting time	1				1	Brady and Cronin (2001)
Social responsibility	1		1		1	Suresschchandar et al (2002), Thai (2013)
Confidence	1				1	Getty and Getty (2003)
Fulfilment	2				2	Wolfinbarger and Gilly (2003), Parasuraman et al (2005)
Process	2				2	Yoon and Suh (2004) Gournaris (2005)
Education	1				1	Yoon and Suh (2004)
System availability	1		1		2	Parasuraman et al (2005), Thai (2013)
Privacy	1				1	Parasuraman et al (2005)
productivity	2				2	Franceschini and Refele (2000), Rafele (2004)
Availability	1	1			2	Rafele (2004) Akbaba (2006)
Aggregated service			2		2	Ling and Lang (2011), Thai (2013)
Transit Handling			2		2	Ling and Lang (2011), Thai (2013)
Sustainability			1		1	Islam and Zunder (2014)

Table 6. 2: The industry-specific quality indicators

Service industry	Country	Reference	Dimensions
Campuses career service	USA	Engelland et al (2000)	Tangibles, reliability, empathy assurance, responsiveness
The service quality provided in historic houses	UK	Frochot and Huges (2000)	Responsiveness, tangibles, communication, consumables, and empathy
Manufacturing	Italy	Franceschini and Refele (2000)	Lead time, regularity, reliability, completeness, flexibility, correctness, harmfulness, productivity.
Voluntary sector	Scotland	Vaughan and Shiu (2001)	Access, responsiveness, communication, humaneness, security, competence, enabling/empowerment, reliability, equity, tangibles
Hospital service quality	USA, Australia Moroccan	Sower et al (2001), Wilkins et al (2007), Laghrabli et al., (2016)	Respect and caring, effectiveness and continuity, appropriateness, information, efficiency, effective meal, first impression, staff diversity
Amusement parks, dry cleaning, fast food, and photograph developing	USA	Brady and Cronin, (2001)	Attitude, behaviour, expertise, ambient condition, Design, social factor, waiting time, tangibles,
Banking (UK)	UK, Indian, UAE, Cyprus, Iran	Aldlaigan and Buttle, (2002) Suresschchandar et al (2002), Jabnoun and Khalifa, (2005); Karalee et al., (2005) Emari et al (2011)	Service product, the human element, systematization, tangibles, social responsibility.
Internet retail service quality	USA	Janda et al (2002)	Performance, access, security, sensation, information,
Lodging/hotel industry	USA, Turkey	Getty and Getty (2003), Akbaba (2006)	Tangibility, reliability, responsiveness, confidence, communication
Ecotourism	USA	Khan (2003)	Ecotangibles, assurance, reliability, responsiveness, empathy, tangibles
Online e-tail services	USA	Wolfinbarger and gilly (2003), Feng, Zheng, and Tan (2007)	web site design, fulfilment, /reliability, security/privacy,
Consulting service	Korea	Yoon and Suh (2004)	Assurance, responsiveness, reliability, empathy, process, education
Business to Business service	Greece	Gournaris (2005)	Potential quality, Hard process, soft process, output
Electronic services	not specified	Parasuraman et al (2005)	Efficiency, system availability, fulfilment, privacy
High education service	Croatia	Markovic (2006)	Reliability, empathy, assurance, e-learning, responsiveness, tangibles

Urgent Transport service	Spain	Caro and Garcia (2007)	Personal interaction, design, physical environment, outcome
Third-party logistic companies	UK	Rafiq and Jaafar (2007)	Information quality, ordering procedure, efficiency, the effectiveness of the order placement procedure, simplicity, flexibility of the ordering procedure, tie and effort taken
Ocean freight forwarder industry in	Taiwan, Serbian	Wen- Chen Lin (2011) Kilibarda et al (2015)	Reliability, responsiveness, assurance, empathy, tangibility
General, industrial, and logistic operators in	Europe	Islam and Zunder (2014)	Sustainability, reliability, efficiency and cost, transit time, punctuality

6.2.1.3. Transport logistic service quality indicators

Transport logistic activities facilitate the physical flow of goods from the point of origin to the point of destination (Lai, 2002). They engaged in planning, implementing, and controlling procedures for the different and effective transportation and storage of goods, including services and related information conforming to customer requirements (Huber et al., 2015). The council of logistics management (2000), define a transport logistic service provider as a firm that engaged with the effective flow and storage of goods and related information from the point of origin to the point of consumption to meet customers' requirements (CLM, 2000). The actors in the transport logistic chain evaluate transport logistic service quality based on the way activities are executed and/or services are delivered (Agamez-Arias and Moyano-Fuentes, 2017). From the perspective of activities, Lu (2003), Liang et al., (2006) and Thai, (2013) consider that transport logistic service providers must be able to provide a value-added task of short transit time and reliability, a low tariff of pickup, storage, convenient pickup and delivery, cargo tracing service, emergency handling, intermodal service. From the perspective of service delivery, service quality is defined by transit time, good staffs professional knowledge and service attitude, on-time delivery, safe delivery, accuracy in the date and quantity of delivery, a reliable schedule, reduction in the cycle time, reduction in the frequency of damage, accuracy in documentation, sufficient provision of shipping space, reasonable damage indemnification, reasonable operations fees and reasonable transportation price (Evers and Johnson, 2000; Yang and Lin, 2017). Rixer et al, (2001) define service quality in the food transport and logistic chain as the ability to provide services that meet the food product quality requirements. For instance, in the cold food transport and logistic supply, the freshness of the cold food product is highly sensitive to temperature, humidity, and other environmental factors, the integrity of the cold product must be preserved throughout the transport logistic phase to minimize losses due to a poor operating margin (Srivastava et al., 2015). However, despite the theoretical support of multi- indicators for the service industry, there is currently no framework developed to fit the contextual need to evaluate the service quality in the food transport and logistic chain. Table 6.3 summarises key relevant service quality indicators reviewed from the literature to evaluate the quality of service in the food transport and logistic chain. The review shows that measuring indicators have either a numerical unit of measurement i.e. can be quantified, or a subjective unit of measurement (Qualitative).

Table 6. 3: Transport logistic service quality indicator units of measurement

Quantitative Dimensions		
Key Dimension	**Interpretation**	**Reference**
Equipment efficiency	It reflects the number of orders or unit load delivered per month	Franceschini and Rafele, (2000)
Staff efficiency	It reflects the ability of the staff to contribute to the service control.	
Consistency in storage and warehousing	it reflects the consistency in storage and warehousing	
Responsiveness to customer orders	reflects the ability to respond to customer orders and provide prompt service.	Franceschini and Rafele, (2000)
Timeliness of shipment, pickup, and delivery	reflect the duration of the delivery activities.	Kilibarda et al., (2016) Kataike et al, (2019)
Productivity	Is measured as the number of items /orders /quantities delivered divided by the period considered multiplied by 100	Franceschini and Rafele, (2000)
Regularity	Is measured as the number of orders or quantities delivered divided by the total number of the order delivered multiplied by 100	

Lead time	Duration of the delivery activities. Is measured as the total order cycle time occurring from the arrival of a customer order to receiving of goods	Kataike et al., (2019)
Correctness of order	It reflects the number of a mistake in order	Franceschini and Rafele, (2000)
Safety of service delivery	It reflects the number of accidents occurring during product transportation journeys in a certain period	
Security of service delivery	It reflects the number of recorded threats to the transport logistic activities	
Consistency in order handling	It reflects the consistency in the order of handling	
Completeness of order	It reflects the completeness and accuracy of the order of information	Mesquita and Brush, (2008)
Flexibility	It reflects the degree to which organisations adapt to the changing demands of the users.	Franceschini and Rafele, (2000)
Qualitative Dimensions		
Tangibles	It reflects how visually appealing the equipment and the facilities are associated with the service provided	Akbaba (2006), Markovic (2006), Kilibarda et al (2015), Kilibarda et al., (2016)
Responsiveness	Responsiveness to customers' complaints and providing prompt service.	Yoon and Suh (2004), Markovic (2006) Kilibarda et al., (2016), Kataike et al, (2019)
knowledge and understanding of customer needs and requirements	It reflects the ability to understand customer needs and requirement	Thai, (2013)
Assurance	knowledge and courtesy of employees and their ability to convey trust and confidence).	Engelland et al (2000), Khan (2003), Yoon and suh (2004), Akbaba (2006), Markovic (2006), Kilibarda et al (2015), Kilibarda et al., (2016),
Empathy	The organisation's knowledge and courtesy of employees and their ability to inspire trust and confidence in their client	
Openness in information exchange	It reflects the degree of openness in the information exchange between all parties in the transport logistic system regarding the 'Plan' 'Source' and 'delivering 'process	Sower et al (2001) Janda et al (2002), Rafiq and Jaafar (2007)
Collaboration with external partners	It reflects the degree to which the firm collaborates with its partners	Ling and Lang (2011)
Company ethical image	It reflects how the ethical culture is perceived by the customer	Akbaba (2006), Thai (2013)
Condition and availability of equipment and facilities	It reflects the customer expectation of the equipment and facilities of the firm	Handgraaf et al (2008), Thai (2013)
Application of IT and electronic data	it reflects the degree to which IT and electronic data interface is used	

interface in customer service		
Shipment tracing capacity	The availability of information about the shipment	
Product tracing and tracking capacity	The availability of information about the product during transit	
Reliability of order information	How the firm perform the promised service dependably and accurately	
Reliability of available service		
Reliability of documentation		
Speed of service performance	it reflects the Speed of service performance	
Order placement convenience	it reflects the convenience of order placement	
Availability of order information	it reflects the availability of order information	
Consistency of order handling	it reflects the Consistency of order handling	
Social responsibilities and concern for human safety	It reflects the perception the customer has of the service delivered as requiring a social responsibility norm	
Competitive price of service	It reflects the position of the company relative to its competitors on service delivery cost efficiency.	
Aggregated services	This includes the speed of issuing a bill of lading, multimodal transport services, the convenience of pickup and delivery	Ling and Lang (2011)
Transit Handling	Transit time	
Efficiency	This measures how the firm resources are economically utilised when providing a service to the customer	Sower et al (2001) Parasuraman et al., (2005) Rafiq and Jaafar (2007), Islam and Zunder (2014), Kataike et al, (2019),
Delivery frequency	Total number of deliveries that took place in a certain period	
Vehicle capacity used	Total used capacity per journey or vehicle divided by total available loading capacity	
Distance travel per day	Total number of miles travelled during a certain period over some days	
Berth utilisation	The used berth capacity in a certain period	
Port utilisation	The used port infrastructure capacity in a certain period	
Labour utilisation	The used labour in a certain period	
Order to delivery cycle time	Average time from the moment order is ready to be delivered to the customer	
Vessel round trip duration	Average turnaround of the vessel from loading to discharging	
inventory level	The frequency of excessive stock	

6.2.1.4. Service quality indicators assessment models

In the literature, previous authors had adopted various models to evaluate the service quality of a firm starting from the Nordic model (Grönroos, 2004), the SERVQUAL model (Neo et al., 2004, Brady and Cronin, 2001), Parasuraman -Zeithami-Berry (PZB) model (Franceschini and Rafele, 2000), Structural equation model (SEM) (Williams et al., 2009), The SERVPERF model (Juga et al, 2010), Fuzzy Zone of Tolerance (FZOT) model (Lin and Liang, 2011), Kano model (Meng et al. 2011, Sobhan et al, 2018) and a multi-criteria decision models (So et al, 2006). The Nordic model was the first modelling instrument developed to measure service quality, based on a three-dimensional framework of function, technical, and environment quality (Grönroos, 2004), then later advances to the SERVQUAL model with a five-dimensional framework namely; reliability, empathy, responsiveness, assurance and tangibles to measure organizational functional quality. The SERVQUAL model was proposed to serve as a generic instrument extensively used in the literature to measure various organization service quality. For instance, Neo et al. (2004) apply the SERVQUAL model in practice when measuring the quality of the logistics services of the 3PL company that deals with the distribution of consumer goods. Chen et al. (2009) use the SERVQUAL instrument for measuring the quality of services in sea transport, where they investigate two new gaps referring to different business users (freight forwarders and transporters) and the different positions of employees. Ho et al. (2012) use a modified SERVQUAL model for determining the influence of the logistics service quality (LSQ) dimensions on customer satisfaction in the courier services industry in Malaysia, In addition to the five dimensions of the SERVQUAL model, the authors also investigate the customers' perception criteria: professionalism and ability, attitudes and behaviours, accessibility and flexibility, reliability and truthfulness, gaining customers, company fame, and credibility. Kilibarda et al., (2016) used the SERVQUAL model to measure the quality of logistic service of freight forwarding companies in the Serbian markets, measuring service quality from the marketing viewpoint and client perspective. Despite the wide application of the SERVQUAL instrument, there has been criticism that (1) it only reflects on the service delivery process rather than the outcome of service encounters and (2) The validity of the items and dimensions underlying the SERVQUAL instruments has been questioned with an argument that its dimension is too few for the specific context of research. (Brady and Cronin, 2001). Other critics of the SERVQUAL model can be found in the study of Ladhari (2008). The Kano model categorizes the qualitative characteristics of service dimensions into three main categories of requirements for evaluation namely: (1) attributes whose presence is accepted without creating satisfaction (B), 2) attributes whose presence gives satisfaction and absence gives dissatisfaction (O), 3) attribute whose presence gives satisfaction but whose absence is accepted without causing dissatisfaction (Meng et al. 2011, Sobhan et al, 2018). The model is criticized in that attribute having a neutral transition from E toward O are not measured (Yan et al., (2018). Similarly, modelling frameworks capable of handling multi-layer service quality dimensions are currently adopted in the literature. So et al., (2006) adopt the Analytic hierarchy process (AHP) model to evaluate the service quality of Third-party logistic service providers using the five generic dimensions of SERVQUAL. The AHP is a multi-criteria decision-making tool in which a complex problem is broken down into multiple hierarchy levels representing multiple sub-problems. Each level consists of various attributes and criteria relative to each sub-problem. AHP is limited in its inability to capture the interdependent relationship between the dimensions. Ding, (2009) proposed a Quality Function Deployment (QFD) model to identify solutions for service delivery systems using multi-level criteria. The QFD model translates stakeholders' wants, needs, and requirements into product specifications and customer quality/satisfaction. It is limited in situations when information is incomplete or imprecise or views are subjective or endowed with linguistic characteristics thus creating an uncertain decision-making environment. Xu Jian and Cao Zhenpeng (2008), proposed a Gray correlation model to analyse logistic service quality using a six-layer dimension of personnel's quality; information quality; order of the course; the intact intensity of the goods, dealing with error and timeliness. The Gray model can be used to handle the ambiguity in the decision-making problems with discrete data and can generate satisfactory results using a relatively small amount of data, though, the application of the model is not widely recognised and verified (Talib et al., (2013) proposed a Fuzzy AHP approach to support the generic logistic performance dimension benchmarking process. The FAHP approach extends the AHP method by combining it with the fuzzy set theory for specific situations when the dimension is not completely defined, or where there are no exact and reliable data on the realization of a certain problem. The fuzzy modelling requires a robust membership function in its application, which is difficult to find through the experience of the expert. Tadic et al., (2014) adopt the Decision-Making Trial and Evaluation Laboratory Model (DEMATEL) and Analytical network process (ANP) to evaluate the quality dimensions criteria of city logistic activities, integration of DEMATEL and ANP model has been proven to be a successful tool to evaluate interdependencies among variables. Although, the DEMATEL model has its drawbacks with the inability to handle the human bias and uncertainty in the data, however, it allows a better understanding of the influences by the analysis of factors in cause and effect relationships, capable of knowing the strength of the relationship between and among the variables (Tadić et al. 2014). It is also worth noting that some of the models usually measure or evaluate service quality dimensions using either a quantitative approach or a subjective judgement which are usually inadequate in addressing the problems. However, in the literature, the multiple attribute decision analysis (MADA) model based on the evidential reasoning (ER) approach is proven to be a powerful method to analyse multiple attributes under the challenge of data uncertainty

(Yang et al., 2001, Tang et al., 2004, Huynh et al., 2006). Hence, it is necessary to develop a generic and robust model to deal with the vagueness, uncertainty and inadequacy of data associated with the causal variable indicators influencing the AFTL service quality risk hazards. The study adopts a subjective approach based on applying the DEMATEL techniques and evidential reasoning algorithm to close the drawbacks with the assessment models.

6.3. The application of the DEMATEL model to assess the CVIs influencing the AFTL service quality risk hazards

The review of the literature reveals that the causal variable indicators influencing the service quality risk hazard in the AFTL chain are interrelated and to evaluate their relationship, the DEMATEL model was adopted in the study to assess the interdependent strength of influence among the different indicators.

6.3.1 Methodology for the assessment of the CVI's using the DEMATEL model

Following the review of service quality indicators as discussed in section 6.2.1, a brainstorming exercise was conducted with seven domain experts (five academics and two industry members), each with more than fifteen years of working experience in the food transport and logistics industry. The experts were asked to select among the reviewed causal variables that are applicable in the measurement of service quality in the AFTL chain. The exercise lasted for a month between April and June 2020. During the process, some of the indicators were removed and modified, until a consensus was reached. The CVIs applicable to measure the service quality indicators in the AFTL chain were grouped under four main dimensions as illustrated in Figure 6.1. The management CVIs group - includes the indicators that define the management activities, such as responsiveness to customer needs, knowledge and understanding of customer requirements, staff efficiency, tangibles, company social responsibilities and concern for human safety, company ethical image, openness to information sharing and collaboration with external partners. The operation CVIs group - includes the indicators that define the attitude and behaviour of the organisation in meeting the customer needs, such as flexibility and completeness of order, the correctness of order and consistency in order handling. The resources CVIs group includes the indicator that defines the resources available for service delivery, such as the condition and availability of equipment and facilities, application of IT and electronic data interface in customer services, consistency in storage and warehousing, shipment tracing capacity, product tracing and tracking capacity. The relation CVIs group includes the attributes that define the speed, security and reliability of the services provided, i.e., reliability of order information, the safety of service delivery, reliability of available service, reliability of documentation, the security of service delivery, order placement convenience, availability of order information, consistency of order handling, timeliness of shipment, pick-up and delivery, and competitive price of service. Table 6.5 present the interpretation and unit measurement of the multilayer causal variable indicators.

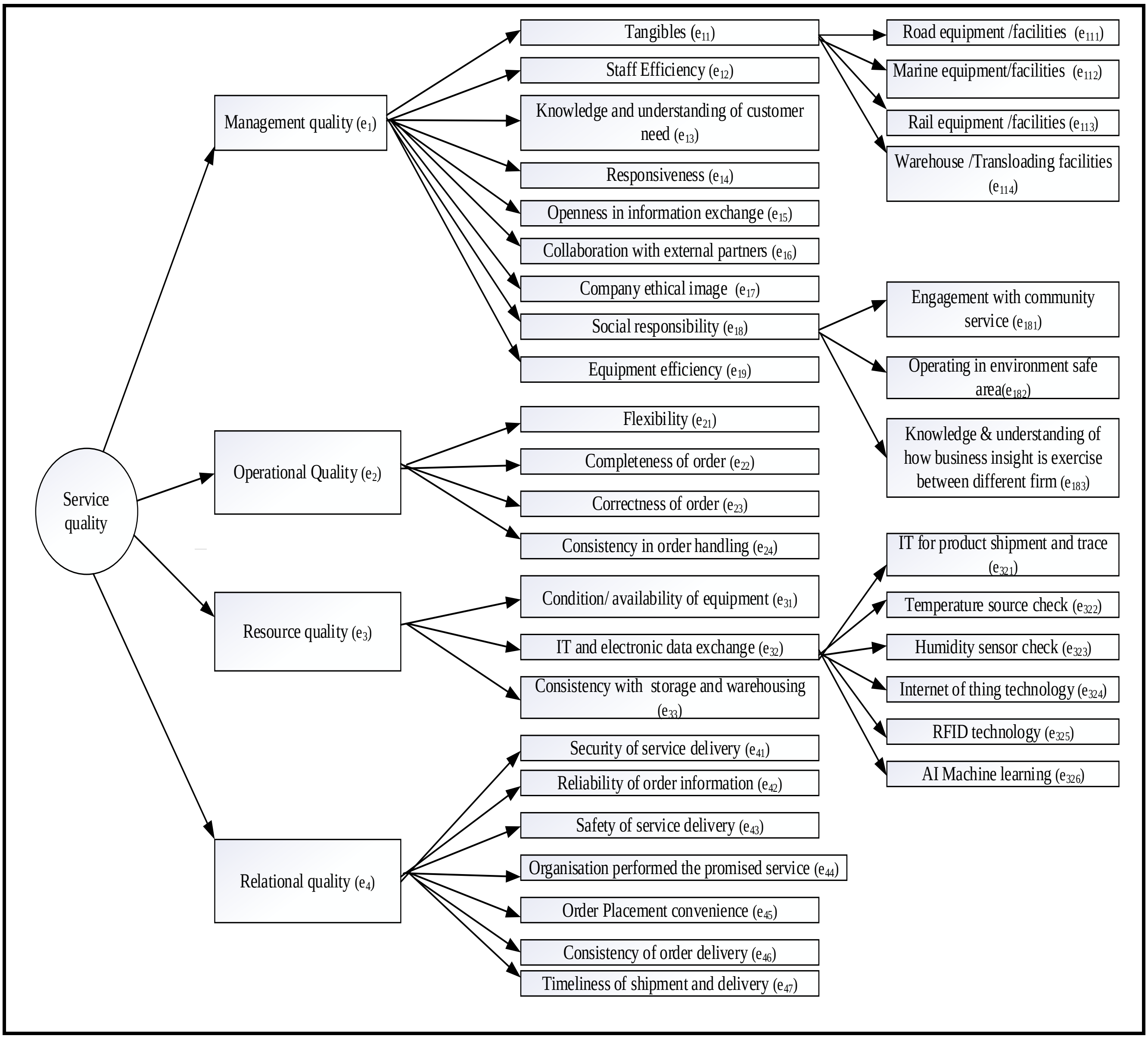


Figure 6.1: Hierarchy of the verified CVI's to measure the service quality in the FTL chain

Table 6. 4: AFTL service quality variable indicators

Dimension	Principal - CVI	CVIs interpretation	Reference
Management-attribute (A)	Staff efficiency	It reflects the ability of the staff to contribute to service delivery.	Franceschini and Rafele, (2000)
	Responsiveness	It reflects the ability to respond to customer orders and provide prompt service.	Markovic (2006), Kilibarda et al., (2016), Kataike et al, (2019)
	Equipment efficiency	It reflects the ability of the equipment to contribute to service delivery	Franceschini and Rafele, (2000)
	Tangibles	It reflects how visually appealing the company facility equipment, personnel, and communication materials are associated with the service provided	Akbaba(2006), Kilibarda et al (2015), Kilibarda et al., (2016)
	knowledge and understanding of customer needs and requirements	It reflects the ability to understand customer needs and requirements with major competitors	Thai, (2013)
	Openness in information exchange	It reflects the degree of openness in the information exchange between all parties in the transport logistic system regarding the 'Plan' 'Source' and 'delivering ' process	Sower et al (2001) Janda et al (2002), Rafiq and Jaafar (2007)
	Collaboration with external partners	It reflects the degree to which the firm collaborates with its partners with major competitors	Ling and Lang (2011)
	Company ethical image	It reflects how the organisation's ethical culture is perceived by the customer with major competitors	Akbaba(2006), Thai (2013)
	Social responsibilities and concern for human safety	It reflects the perception the customer has on the service delivered as requiring a social responsibility norm with major competitors	Handgraaf et al (2008), Thai (2013)
Operation attribute	Flexibility	It reflects the degree to which organisations adapt to the changing demands of the users.	Franceschini and Rafele, (2000)
	Completeness of order	It reflects the completeness and accuracy of the order information.	Mesquita et al, (2008)
	The correctness of the order	It reflects the number of mistake orders.	Franceschini and Rafele, (2000)
	Consistency in order handling	It reflects consistency in order handling.	Franceschini and Rafele, (2000)
Resource attribute	Consistency in storage and warehousing	It reflects the consistency in storage and warehousing.	Franceschini and Rafele, (2000)
	Condition and availability of equipment and facilities	It reflects the customer expectation of the equipment and facilities of the firm	Handgraaf et al (2008), Thai (2013)
	Application of IT and electronic data interface in customer service	It reflects the degree to which the IT and electronic data interface is used	
	Shipment tracing capacity	The availability of information about the shipment	

	Product tracing and tracking capacity	The availability of information about the product during transit	
Relation attribute	Security of service delivery	It reflects the number of recorded threats to transport logistic activities.	Franceschini and Rafele, (2000)
	Safety of service delivery	It reflects the number of accidents occurring during product transportation journeys in a certain period.	Franceschini and Rafele, (2000)
	Timeliness of shipment, pickup and delivery	It reflects the duration of the delivery activities.	Kilibarda et al., (2016), Kataike et al, (2019)
	Reliability of order information	How the firm perform the promised service dependably and accurately	Handgraaf et al (2008), Thai (2013)
	Reliability of available service		
	Order placement convenience	How convenient to place an order	
	Consistency of order delivery	Consistency in the delivery of the order	

6.4. DEMATEL application

During the AFTL measuring attributes selection process, it became apparent that the verified indicators are related directly or indirectly and it will be difficult for the stakeholders to evaluate the effects of a single attribute while avoiding interference with the others (Liou et al., 2007). To address such a problem, the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva 1972 introduced the DEMATEL technique to solve a complicated problem involving multi-interactive attributes (Shieh et al., 2010). The DEMATEL technique is unique in its ability to measure the direct and indirect relationship and influence between multi-attribute and map their interdependency relationship via a causal digraph (Ha and Yang, 2017). It has a wide application in the literature such as in higher education support systems (Chen and Chen, 2010), Airline safety measurement (Liou et al., 2007), and port performance assessment (Ha and Yang, 2017). Compared to other traditional multi-criteria decision-making (MCDM) tools, DEMATEL allows a better understanding of the cause-and-effect relationships between multiple criteria, uses a causal digraph to represent such a relationship and enables stakeholders to predict their management behaviour by taking into account the interdependent strength of influence among the multi-criteria. The assessment of CVIs using the proposed DEMATEL techniques was carried out following the below steps based on Shieh et al., (2010) and Ha and Yang, (2017).

Step 1 Compute an initial direct-relation matrix.

In this stage, the experts define the relations between the attributes using a pair-wise comparison scale ranging from 0 to 4, where 0 represents “(no influence)”, 1 “(Low influence)”, 2 “(medium influence)”, 3 “(high influence)” and 4 “(very high influence)”. Suppose there are *n* basic CVIs in a group X = $\{X_1\ X_2 \ldots\ldots\ldots X_1 \ldots\ldots\ldots X_{n-1}, X_n\ \}$ The notation of

X_{IJ} indicates the degree to which the experts believe the *i*th CVI influence the *j*th CVI. For *i*=*j*, the diagonal elements are set to zero. For each expert, a nXn positive matrix is established as Xk = $[x_{ij}^{k}]$. Where k is the number of experts, with 1≤ k ≤ m. Thus, $X^1\ X^2\ X^3 \ldots\ldots X^m$ is the matrices from *m* experts. To aggregate all the *m* experts' opinions, the average matrix A [a_{ij}] can be constructed using Eq (6.1)

$$A\,[\,a_{ij}\,] = \frac{1}{m}\sum_{k=1}^{m} X_{ij}^{k} \qquad i.j = 1, 2, \ldots, n. \qquad \textbf{(6.1)}$$

Step 2 Obtain the normalised direct-relation matrix D.

The normalised relation matrix D = $[d_{ij}]$nxn can be obtained using Eq (6.2) where the maximum value of the sum of each row and column is used to obtain the coefficient of S. All elements in matrix D are complying with $0 \leq d_{ij} \leq 1$.

$$\mathbf{D = A.S}$$

Where $$S = \min\left[\frac{1}{\max_{1\leq i\leq n}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max_{1\leq i\leq n}\sum_{i=1}^{n} a_{ij}}\right] \; i, j\ 1, 2, \ldots n. \qquad (6.2)$$

Step 3 Compute the total relation matrix T and the sum of rows and columns

The total relation matrix T is obtained using Eq (6.3), where *I* represent the identity matrix. Let *r* and *c* represent the sum of rows and the sum of columns of the total relation matrix T. if r_i is the sum of the *i*th row in the matrix T and c_j is the sum of the *j*th column in the matrix T, then the value of r_i indicates the effects given by indicator *I* to the other indicators (Eq. 6.4) and c_j shows effects received by indicator *j* from the other indicators (Eq. 6.5), both directly and indirectly. When *j*=*i*, the total effect given and received by attribute *i* is calculated by the sum ($r_i + c_j$), which presents the degree of importance of attribute *i* on the system (ri − cj) and represents the net contributing effect of attribute *i* to the system. If the $(ri - cj)$ value is positive, the attribute *i* is a net cause and if the $(ri - cj)$ value is negative the attribute is a net receiver (Ha and Yang, 2017).

$$T = [t_{ij}]\, nxn = lim\, (D + D + \ldots + D_M)$$

$$= \mathbf{\Sigma Di \infty m} = \mathbf{D\,(I - D)^{-1}} \qquad \textbf{(6.3)}$$

$$\mathbf{T} = [t_{ij}], \mathbf{I}, \mathbf{j} = \mathbf{1}, \mathbf{2}, \ldots \ldots \mathbf{n}$$

$$\mathbf{R} = [\mathbf{r}_i]_{nx1} = (\sum_{j=1}^{n} \mathbf{t}_{ij}\, \mathbf{tij})_{nx1} \qquad (\mathbf{6.4})$$

$$\mathbf{C} = [\mathbf{cj}]\mathbf{1xn} = (\sum_{i=1}^{n} \mathbf{tij})\mathbf{1xn} \qquad \textbf{(6.5)}$$

Step 4 Obtain a threshold value (α) *and construct the influential relation map (IRM))*

The Matrix T provides details on the effect each attribute has on the other. To filter out those attributes with a negligible effect in the matrix, a threshold value (α) is set. Only the attributes whose value are higher than the set threshold is considered and shown in the digraph. The threshold value is set by either using the subjective judgement of an expert or by using a mathematical equation (Shieh et al., 2010). In this study, the threshold value is obtained by computing the average of the element in the matrix T and the digraph is obtained by mapping the dataset of $(R + C,\ R - C)$

6.4.1. Case description

To demonstrate the feasibility and applicability of the DEMATEL model, a questionnaire (Appendix four) was designed to collect subjective judgement from the domain expert on the degree of influence of the CVIs in the AFTL chain. The DEMATEL questionnaire was pilot tested with five academia (with more than 10 years of valuable experience from working in the food transportation and logistics firm) to ensure the validity of the questionnaire. The validated questionnaire was then translated into Chinese, Vietnamese and Thailand languages and ethical approval was obtained to validate the questionnaire contents and participant consent before being sent via email to the participants in China, Thailand, and the Republic of Vietnam. The questionnaire consists of two-part; part A gathers the respondents' demographic and company information, and Part B contain questions on the direct level of influence relationship between the CVIs. A total of 300 questionnaires were sent out to random food transportation and logistics companies in the three countries. Three weeks later, a reminder email was sent to the companies and by the cut-off period, a total of 50 questionnaires were returned, representing a 16.7% response rate, which corresponded to the number of samples adequately used in the literature with the application of DEMATEL techniques (Liou et al., 2007; Chen and Chen, 2010; Ha and Yang, 2017).

6.4.1.1 Analysis of survey results

Geographical distribution of the respondent

Figure 6.2 presents the analyzed geographical distribution of the respondents. 44% of the respondents are from China, 32% from Thailand and 24% from the Republic of Vietnam. The respondents were asked to indicate their position in the company, the majority of the respondent are senior management officials. 26% occupied a senior executive position and above, 34% of the respondents are department managers, 20% of the respondents are operation managers and 12% of the respondents are supervisors, 2% of the respondents are area/country managers and 6% of the respondents are assistance managers and team leaders as presented in Figure 6.3. The high calibre of the respondent that participated in the survey supports the trust and reliability of the study data. Furthermore, the respondents were asked about their years of experience in the AFTL chain to assess the confidence level of data received, 68.0% of the respondents have more than five years of working experience in the food transport logistic chain which indicates that the participants have in-depth knowledge about the study. The participants were also asked questions concerning the kind of Agro products they handled, 12% of the respondents work in firms handling vegetable products, 19% work in firms handling grain, beans and cashew nut products, 9% work in firms handling meat and poultry product, 27% work in firms handling fish and seafood product, 10% work in a firm handling dairy food products and 22% work in a firm handling consumable products as shown in Figure 6.4. Furthermore, 37.93% of the respondents are from companies providing their services using maritime transport, 25.86% of the respondent are from companies providing their services using road transport, 5.17% of the respondent are from companies providing their services using rail transport and 29.31% of the respondent are from companies providing their using multimodal transport. Concerning the direction of logistic activities, 22% of the respondents deal only with exported food products, 36% of the respondents deals with both exported and imported food products, 31% of the respondents deal with domestic food products and 11% of the respondents work in hand with an international firm dealing with food products respectively

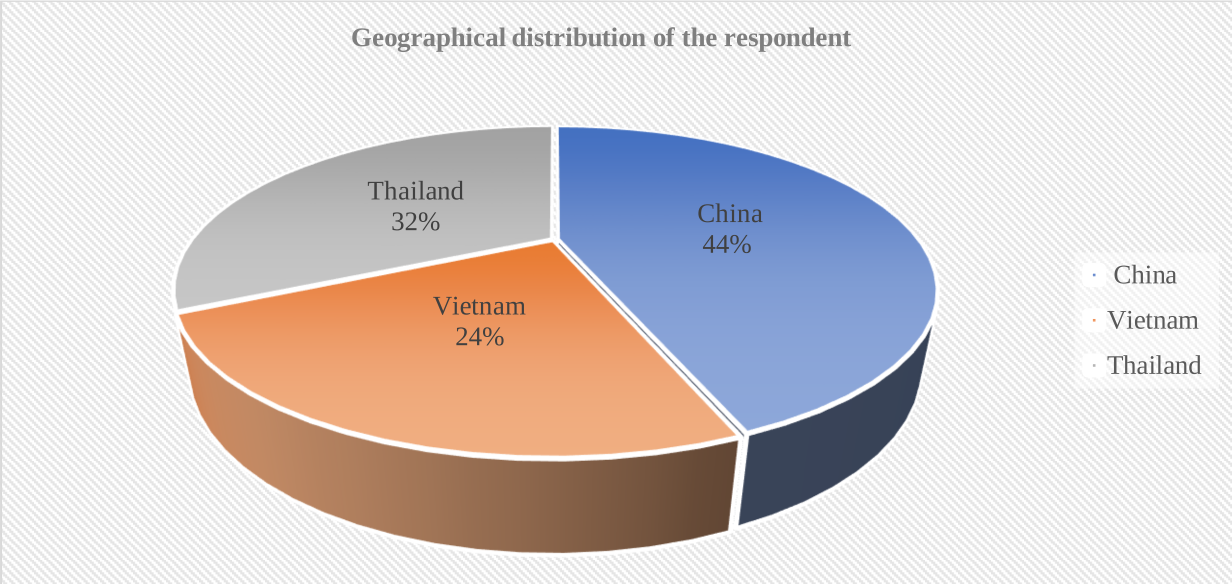


Figure 6. 1: Geographical distribution of the respondent

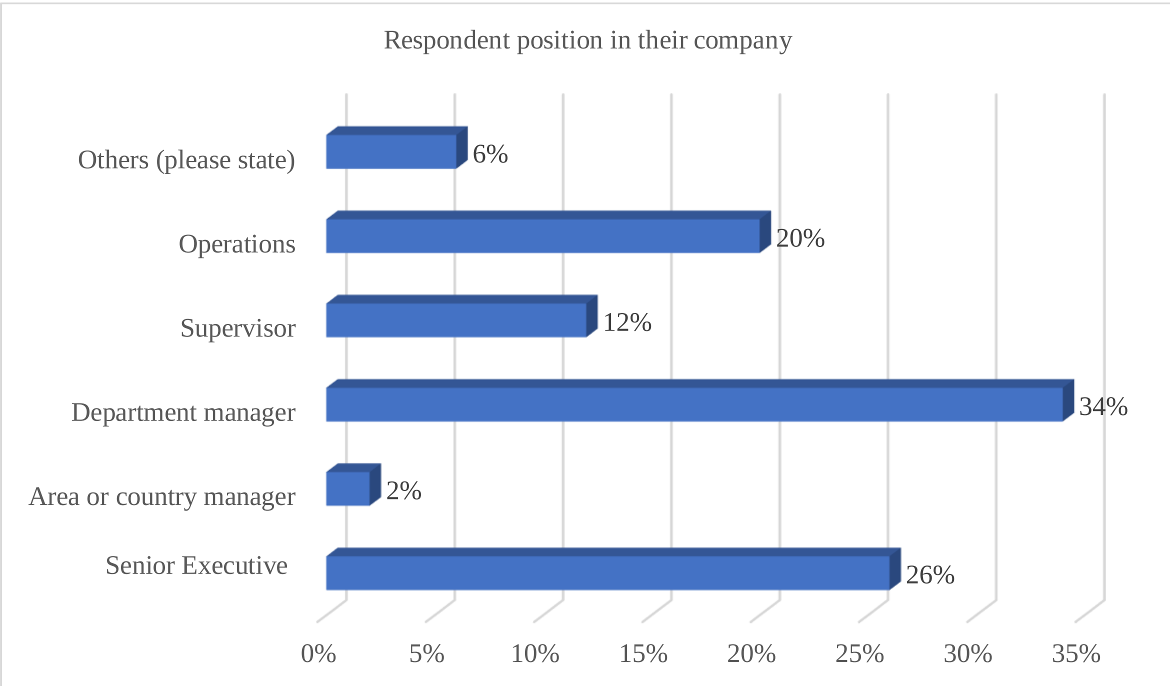


Figure 6. 2: Respondent position in their company

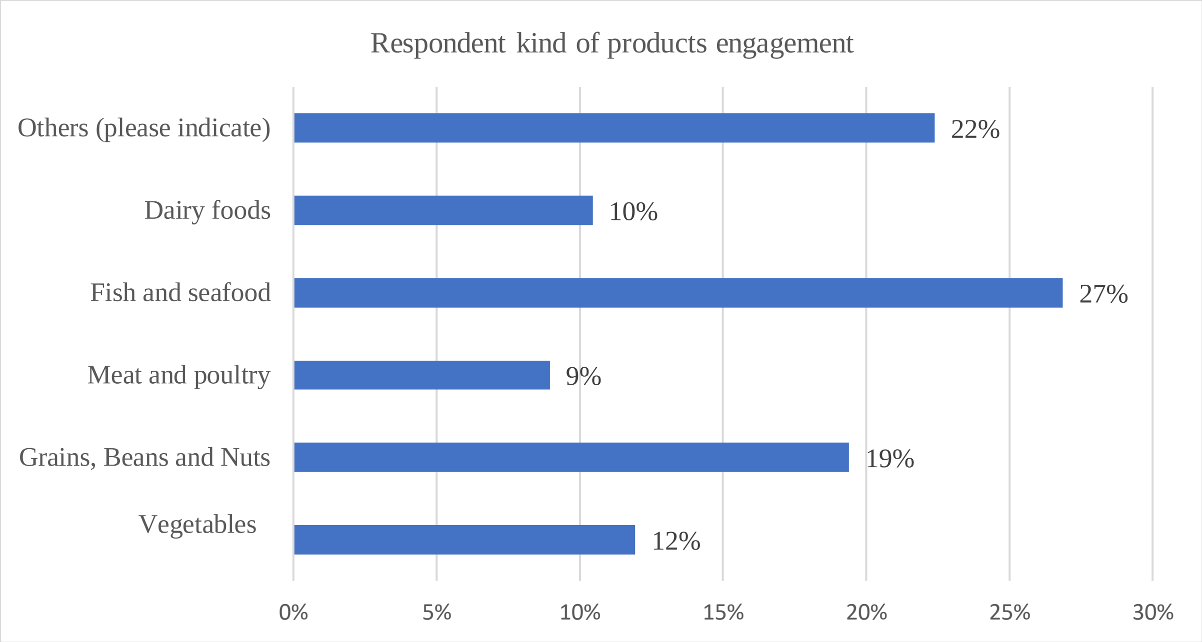


Figure 6. 3: Respondent type of products engagement

6.4.2. The computation of the DEMATEL method

In this section, the computation of the expert's opinion on the degree of influence and interdependency relationship among different attributes and indicators was analysed. The analysis result facilitated the understanding of (1) The interdependency relationship among all the CVIs 2) The indicators that have a positive influence on the other indicators (net cause) and (3) The criteria that are influenced by the other criteria (net receiver). Following the DEMATEL procedural steps.For the main dimension, a $[4\ x\ 4]$ direct relation matrix A was computed based on the average opinion of the experts. The average relation matrix A for the main quality group is shown in Table 6.5

Table 6. 5: The initial direct relation 4x4 matrix of the main dimension

Attributes group	A	B	C	D
Management attributes (A)	0	3.27	2.91	2.85
Operational attributes (B)	3.07	0	2.87	2.77
Resource attributes (C)	3.07	3.06	0	2.88
Relational attributes (D)	2.85	2.95	2.88	0

Step 2 is to compute the normalized initial direct relation -matrix D. The initial direct-relation matrix for the main quality group is shown in Table 6.6

Table 6. 6: Normalised direct relation Matrix of the main dimension

	A	B	C	D
Management attributes (A)	0.0000	0.3621	0.3223	0.3156
Operational attributes (B)	0.3400	0.0000	0.3178	0.3068
Resource attributes (C)	0.3400	0.3389	0.0000	0.3189
Relational attributes (D)	0.3156	0.3267	0.3189	0.0000

Step 3 is to compute matrix T. Table 6.7 present the Matrix T of the main quality group

Table 6. 7: Total relation matrix T of the main dimension

	A	B	C	D
A	12.9783	13.5572	12.8546	12.6703
B	12.8904	12.9414	12.5201	12.3381
C	13.2149	13.5267	12.5942	12.6559
D	12.8377	13.1475	12.4830	12.0661

Step 4. To depict the direct effect of the attributes and set a threshold value to obtain a digraph. The direct and indirect effect of the main group is presented in Table 6.8 and a threshold value of 12.8298 is computed based on the average element of matrix T. The digraph of the main group is presented in Figure 6.5.

Table 6. 8: The sum of the influence of the main dimensions

	$(R_i + C_i)$	$(R_i - C_i)$	IDENTITY
A	103.9817	0.139094	Cause
B	103.8629	-2.48269	Effect
C	102.4437	1.539882	Cause
D	100.2648	0.80375	Cause

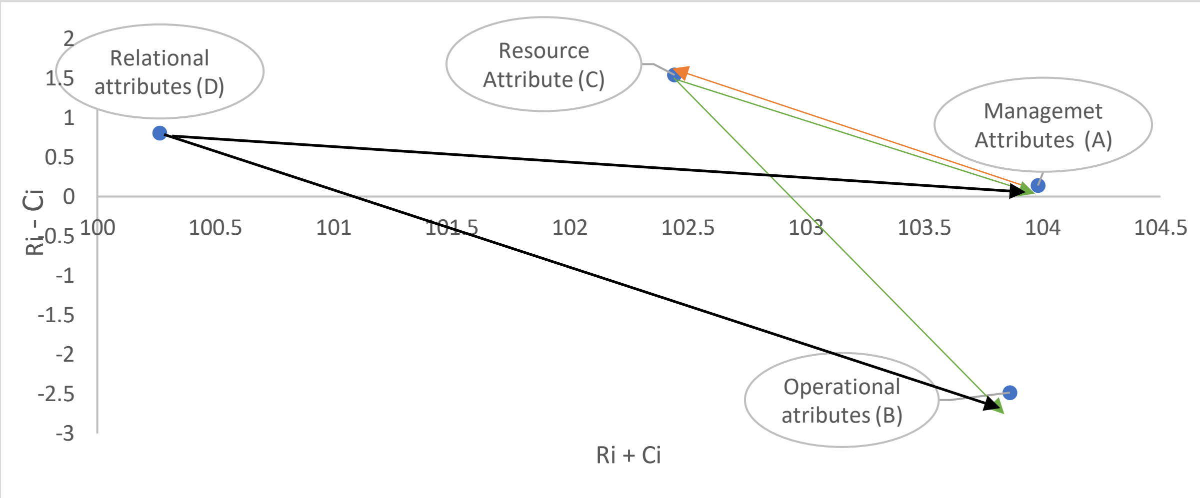


Figure 6. 4 The IRM for the causal relationships among the four main group

As shown in Table 6.8, the $(R_i + C_i)$ values represent the relative importance of each element. The management group have the highest $(R_i + C_i)$value of 103.9817 and is ranked first followed by operation group (B) with $(R_i + C_i)$value of 103.8629, resource group (C) with $(R_i + C_i)$value of 102.4437 and the relation group with $(R_i + C_i)$ value of 100.2648. This indicates that the "Management group" has the highest degree of importance amount all the attributes. In contrast to the importance, the $(R_i - C_i)$ values signify the cause-effect relationship. Attributes with negative $(R_i - C_i)$ values depict a net receiver (effect) and an element with a positive $(R_i - C_i)$ depicts a net cause. The management group (A), resource group (C) and relational group (D) all have positive $(R_i - C_i)$ values, meaning they have a positive influence (net cause) on the other group. The operational group has negative $(R_i - C_i)$ values, meaning is being influenced (effect) by the other group.

6.4.2.1. The *sub-group multiple attributes analysis*

The same DEMATEL process was followed to analyse the cause-and-effect relationship among the sub-attributes in each of the main groups. For the computed analysis of the attributes in the "management group" as shown in Table 6.9. Ranking the attributes in terms of their relative significance $(R_i + C_i)$ values, the staff efficiency is ranked as the most important with a $(R_i + C_i)$ value of 41.85 followed by the knowledge and understanding of the customer needs, with a $(R_i + C_i)$ value of 40.19, social responsibilities were ranked the least with a $(R_i + C_i)$ value of 35.98. Furthermore, responsiveness, openness in information exchange, company ethical image, social responsiveness, and equipment efficiency are the net cause attributes in the management group with positive $(R_i - C_i)$ values which indicate that they all have positive influences on the other attributes within the group. Whereas tangibles, staff efficiency, knowledge and understanding of customer needs and requirements and collaboration with external partners are the net receiver attributes, they all have negative $(R_i - C_i)$ values. Thus, these attributes are influenced by the other attributes in the group. Similarly, based on the computed average of the attributes in the management group matrix T a threshold value of 2.145448 is obtained and used to depict the digraph of the attributes in the management group as presented in Figure 6.6

Table 6. 9: The sum of the influence of management sub-criteria

	$(R_i + C_i)$	$(R_i - C_i)$	**Identity**
Tangibles	39.61747	-2.24293	Effect
Staff efficiency	41.85464	-1.42256	Effect
Knowledge and understanding of customer needs and requirements	40.19239	-0.34481	Effect
Responsiveness	38.74701	1.022013	Cause
Openness in information exchange	37.9065	0.224496	Cause
Collaboration with an external partner	38.33638	-0.23682	Effect
Company ethical image	37.42286	1.191458	Cause
Social responsibilities	35.98031	1.691511	Cause
Equipment efficiency	37.50506	0.117661	Cause

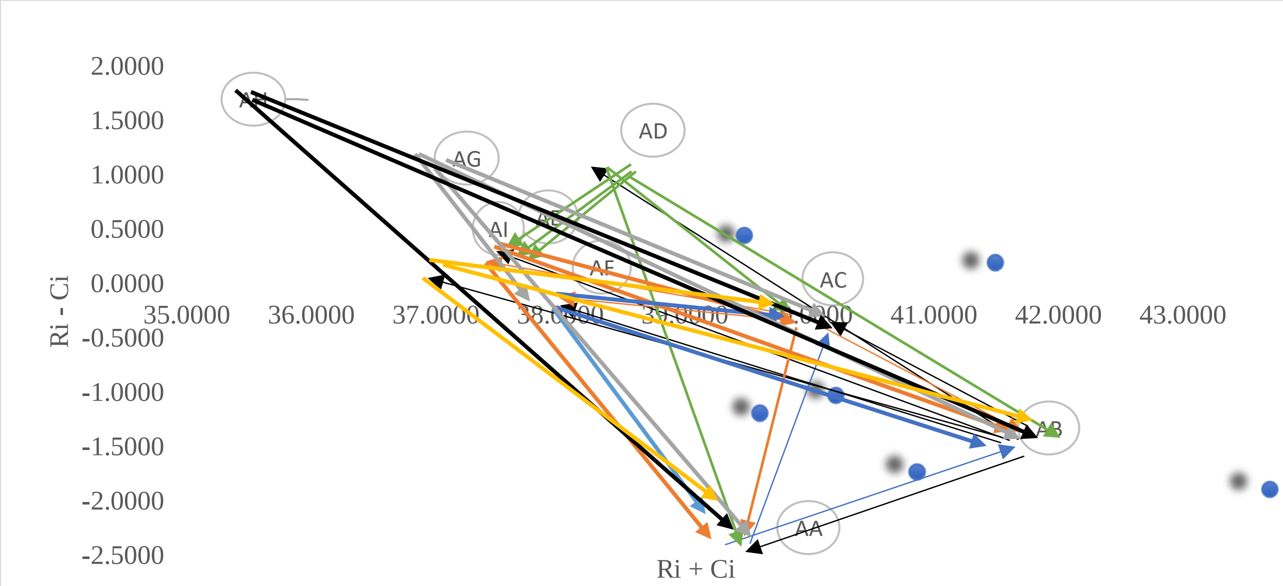


Figure 6. 5: The IRM of causal relationships among the attributes in the management group

The computed analysis of the attributes in the "operation group" is shown in Table 6.10. The attributes are ranked based on the $(R_i + C_i)$ value. Completeness of order is the highest-ranked attribute with a value of 54.22, followed by the correctness of order with a value of 53.92, consistency in order handling with a value of 52.97 and flexibility with a value of 51.69. Among the attributes in the operation group, the correctness of order is the only attribute with a positive $(R_i - C_i)$ value, i.e it has a positive influence (net cause) on the other attributes. The other attributes have a negative $(R_i - C_i)$ value i.e they are being influenced by other attributes. Based on the computed average of the attributes in the operation group matrix T, a threshold value of 6.65036 is obtained and used to depict the digraph of the attributes in the operation group as presented in Figure 6.7.

Table 6. 10: The sum of the influence of the attribute in the operation group

	$(R_i + C_i)$	$(R_i - C_i)$	Identity
Flexibility	51.6999	-0.1399	effect
Completeness of order	54.2245	-0.2245	effect
The correctness of the order	53.918	0.81	cause
Consistency in order handling	52.97	-0.446	effect

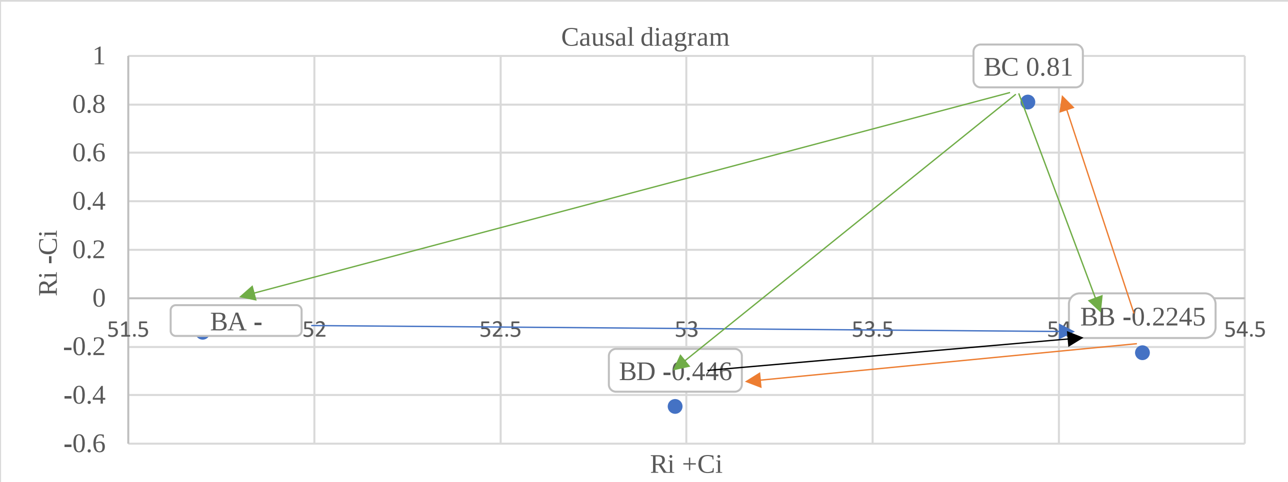


Figure 6. 6: The IRM of causal relationships among the attributes in the operation group

For the computed analysis of the attributes in the "resource group" as shown in table 6.11, ranking these attributes in terms of their relative significance $(R_i + C_i)$values, application of IT and electronic data interface in customer services is ranked first with a $(R_i + C_i)$ value of 40.99, followed by condition and availability of equipment and facilities with a $(R_i + C_i)$ value of 40.17, product tracing and tracking capacity are the least ranked attributes with a $(R_i + C_i)$ value of 39.17. Among the attributes in the "resource group ", the capacity to track a shipment, the capacity to track and trace products and the application of IT and electronic data interface in customer services are net causes attributes, with positive $(R_i - C_i)$ values, these attributes have a positive influence on the other attributes within the group, in contrast, condition and availability of equipment and facilities, consistency in storage and warehousing are the attributes with a negative $(R_i - C_i)$ values i.e they are net receiver's attributes and are influenced by other attributes within the group. Similarly, based on the computed average of the attributes in the resource group matrix T a threshold value of 3.9916 is obtained and used to depict the digraph of the attributes in the resource group as presented in Figure 6.8.

Table 6. 11: The sum of the influence of resource sub-criteria

	$(R_i + C_i)$	$(R_i - C_i)$	Identity
Condition and availability of equipment and facilities	40.16926	-0.31674	Effect
Application of IT and electronic data interface in customer service	40.98979	0.529791	Cause
Consistency in storage and warehousing	39.29132	-0.76868	Effect
Shipment tracking capacity	39.95701	0.237008	Cause
Product tracing and tracking capacity	39.17431	0.31631	Cause

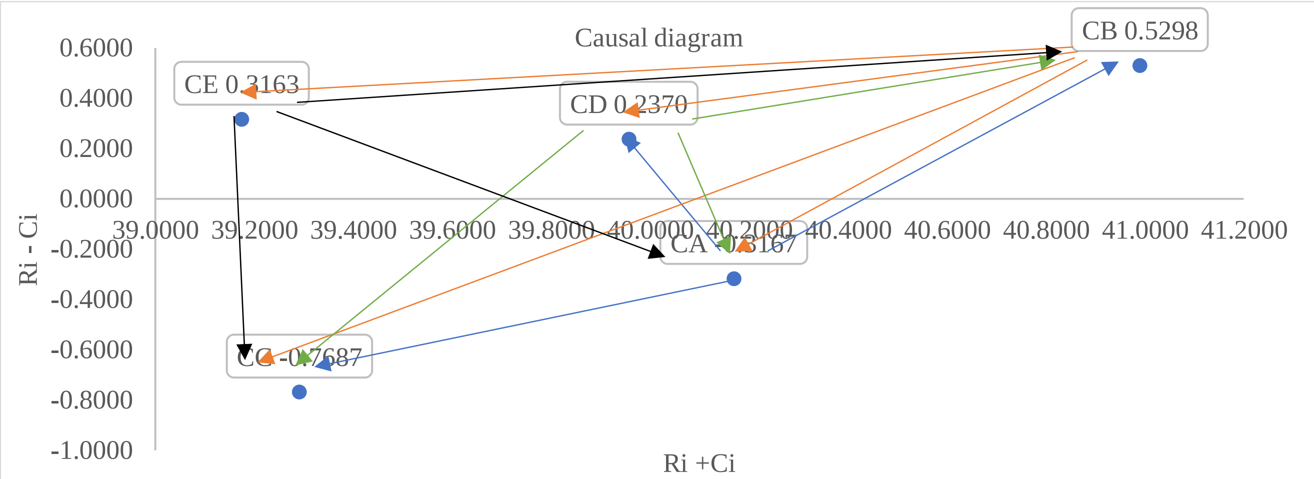


Figure 6. 7: The IRM of causal relationships among the attributes in the resource group

For the computed analysis of the attributes in the "relation group" as shown in table 6.12. The reliability of order information is the most significant attribute with a $(R_i + C_i)$ value of 91.34, competitive price of service is the least ranked attribute with a $(R_i + C_i)$ value of 42.80 respectively. Although convenience in placing the order is ranked the seventh-ranked attribute in terms of significance, it is the only attribute in the relation group with a positive $(R_i - C_i)$ value, this attribute can influence the other attributes within the group

Table 6. 12: The sum of the influence of relational sub-criteria

	$(R_i + C_i)$	$(R_i - C_i)$	Identity
Safety of service delivery	91.02996	-2.48914	Effect
Reliability of order information	91.34676	-1.97424	Effect
Reliability of available service	91.33355	-1.14885	Effect
Reliability of documentation	90.96999	-1.98531	Effect
Security of service delivery	91.3124	-1.6488	Effect
Speed of service performance	**73.89707**	**-1.78193**	**Effect**
Order placement convenience	**89.54812**	**15.45082**	**Cause**
Consistency of order delivery	**90.81339**	**-0.79221**	**Effect**
Timeliness of shipment and delivery (DI)	**88.71488**	**-2.23422**	**Effect**

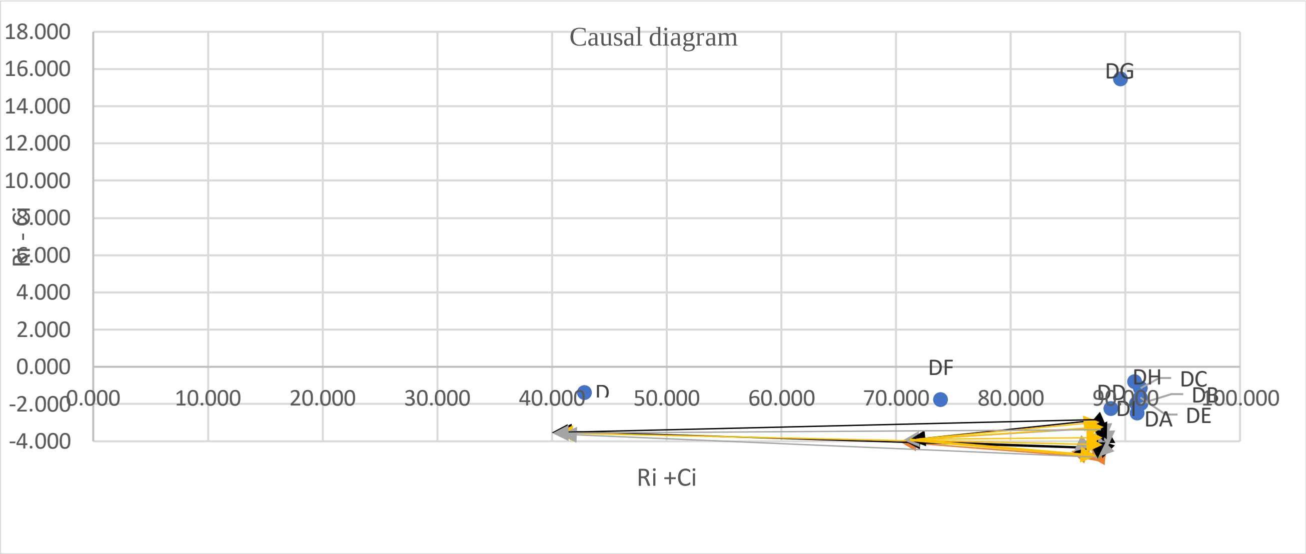


Figure 6. 8: The IRM of causal relationships among the attributes in the relation group

6.4.2.2 Estimating the weight of the CVIs

The influencer relationship of the CVIs based on the opinions of the 50 experts was used to guide the weight of the CVIs (Tadić et al. 2014). The normalised weight of the variables was calculated by weighted arithmetic mean value of their level of importance $(R_i + C_i)$ .The domain experts were considered to have reasonable and equivalent knowledge and their relative weights are equally assigned while computing their judgements. The normalised weighted value of the attributes is presented in Table 6.13. the finding indicates that the attributes in the management and operation group have the highest weighting, with the same weighted value of 0.253, followed by the attributes in the resources group and the relational group. In the management group, staff efficiency is the most important attribute with a local weighted value of 0.120, while in the operation group, completeness of order is the most important attribute with a local weighted value of 0.255. The normalized weighted value of all the attributes plays an important role in the integrated risk assessment model

Table 6. 13: Normalised weighted value of the attributes

Upper-level attributes	Bottom level attributes		local weight	Global weight
Management attribute e_1 0.253	e_{11}	e_{111}	0.0285	0.007
		e_{112}	0.0285	0.007
		e_{113}	0.0285	0.007
		e_{114}	0.0285	0.007
	e_{12}		0.120	0.031
	e_{13}		0.116	0.029
	e_{14}		0.111	0.028
	e_{15}		0.109	0.028
	e_{16}		0.110	0.028
	e_{17}		0.108	0.027
	e_{18}	e_{181}	0.035	0.009
		e_{182}	0.035	0.009
		e_{183}	0.035	0.009
	e_{19}		0.108	0.027
Operation attribute e_2 0.253	e_{21}		0.243	0.061
	e_{22}		0.255	0.064
	e_{23}		0.253	0.064
	e_{24}		0.249	0.063
	e_{31}		0.197	0.050
Resource attribute e_3 0.250	e_{32}	e_{321}	0.205	0.051
		e_{322}	0.196	0.049
		e_{323}	0.200	0.050
		e_{324}	0.067	0.017
		e_{325}	0.067	0.017
		e_{326}	0.067	0.017
Relation attribute e_4 0.244	e_{41}		0.148	0.036
	e_{42}		0.148	0.036
	e_{43}		0.148	0.036
	e_{44}		0.120	0.029
	e_{45}		0.145	0.035
	e_{46}		0.147	0.036
	e_{47}		0.144	0.035

6.4.2.3. Implication of the findings

This research bridges the gaps within the literature by defining the AFTL service quality measuring indicators and analyzing their interdependency relationships. The application of DAMTEL to model AFTL service quality criteria is a contribution to the literature, the result provides important information that stakeholders and managers in the food supply chain can use to make strategic and commercial decisions. The findings have managerial implications. Firstly, the study identified the attributes (cause group) that can influence other attributes. AFTL chain managers can focus more on those attributes that will impact the effect group attribute. Taking for instance the attribute in the operation group, particular attention should be given to the correctness of order, this attribute has a positive influence (net cause) on the other attributes and its impact could lead to the deterioration of food quality, food waste, generation of carbon footprint and social environments. Managers should ensure accuracy in the customer orders and improve the customer service need because this will reflect on the ethical culture and company standard practices. Similarly, managers should invest in technology that will facilitate an electronic data interface between customer services, enabling shipment and product track and trace during service delivery. Secondly, based on the identified and verified quality measuring attributes AFTL stakeholders can develop a feedback form and carry out a periodic survey to improve the customer service need. Finally, the aggregated assessment of the identified quality attributes can be used to set up a benchmarking quality performance tool, that will compare the service quality performance with another service provider, in other to enhance firm competitiveness and exceed the customer expectation.

6.5 The application of ER algorithm to assess the CVIs influencing the AFTL service quality risk hazards

Figure 6.10 presents a framework flow chart for the assessment of the CVI's influencing service quality hazards using ER algorithm.

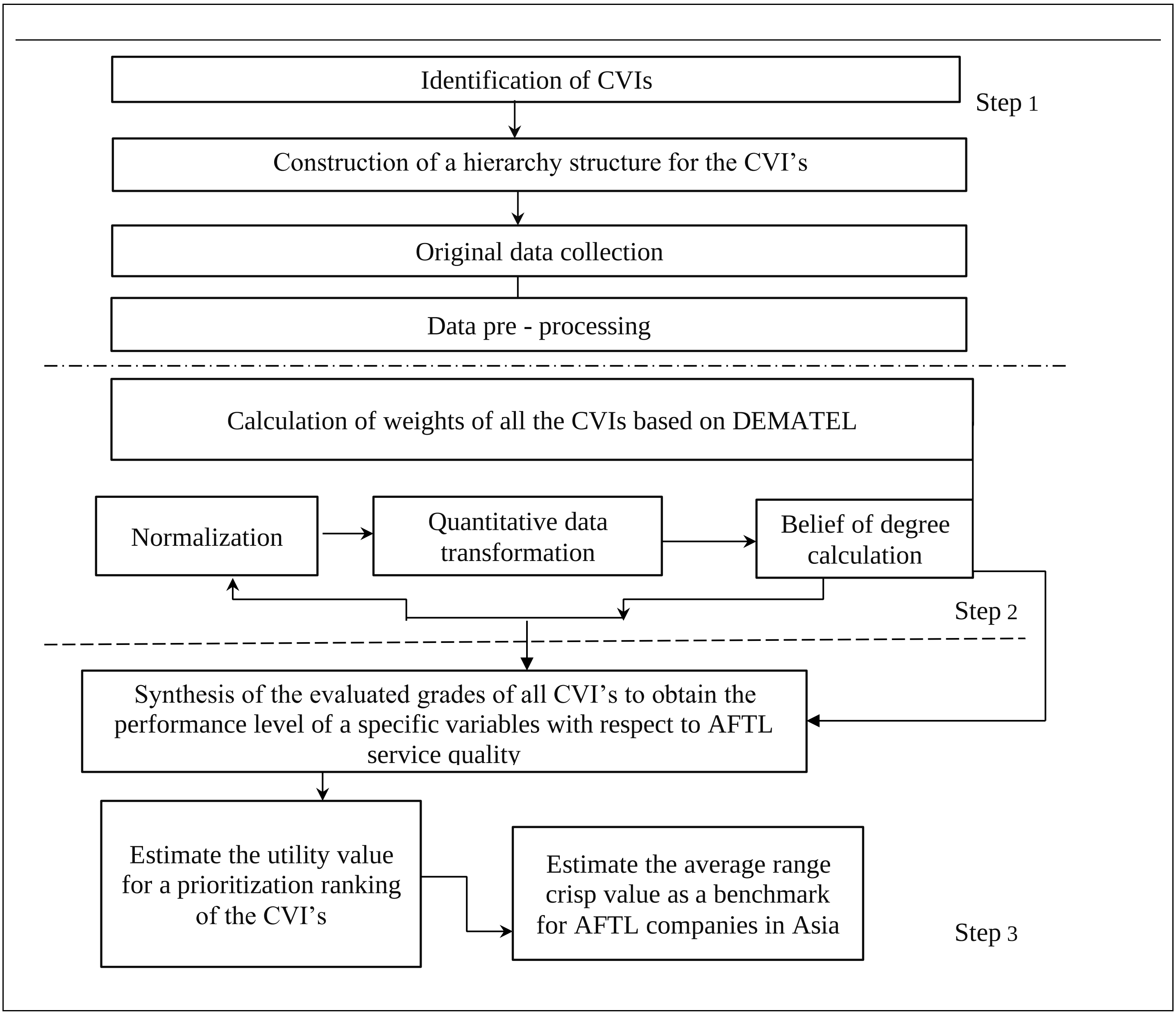


Figure 6. 9: Flow chart for a framework for the assessment of the service quality CVI.

6.5.1 Identification of CVI's and construction of hierarchy structure

The multi-criteria causal variable indicators that impact the service quality of AFTL companies were reviewed from the literature and verified by domain experts. A pairwise comparison survey was conducted with fifty (50) domain experts with more than ten years of working experience in the food supply chain to assess the weighted degree to which individual causal attribute influences the quality-of-service delivery. All the survey experts were considered to have reasonable and equivalent knowledge in comparing the attributes. Thus, the relative weight of the experts was equally assigned while computing their judgement. The DEMATEL techniques discussed in section 6.4 was used to compute the normalized weight of the causal variables as illustrated in the hierarchy structure in Figure 6.11

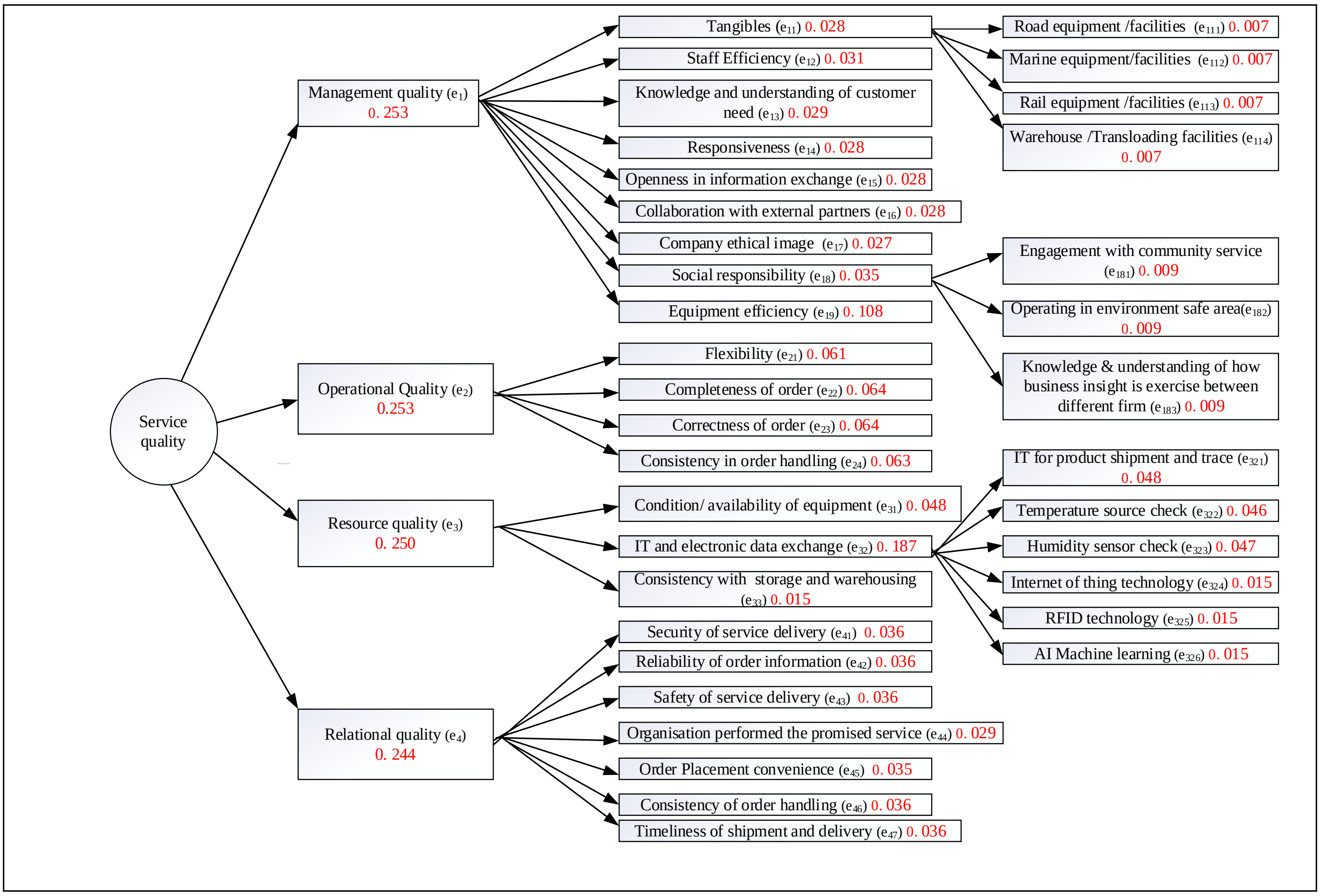


Figure 6. 10: Hierarchy of the identified CVI's with their corresponding weight

6.5.2 Data collection and pre-processing

The multi-criteria CVIs have either numerical data (quantitative unit of measurement) or qualitative (subjective judgements) data attributes as shown in Table (6.4). The data were normalized using a uniform evaluation grade. All the grades were defined such that one point is given to the maximum value that was physically realizable and zero points to the minimum value.

6.5.3. Normalisation of data for the qualitative CVI'S

The qualitative CVI's initial evaluation information was extracted from the case companies using the linguistic term with a degree of belief structure illustrated below. The uniform set of linguistic grades based on five grading scales reviewed in the literature and verified by the domain experts i.e {Poor, Worst, Average, Good, Excellent} or {Very low, Low, Medium, High, Very high} or { Strongly disagree, Disagree, Indifferent, Agree, Strongly Agree} were defined as presented in Table 6.14. The grading scales were represented respectively using equation (6.1)

$$H_n = \{ H_1, H_{2,} H_3\ H_4\ H_5 \} \quad (6.1)$$

Where H_n $(n = 1,2, \dots N)$ presents the evaluation grades and is the standard grade for assessing each indicator.

The experts evaluate the risk assessment level of the qualitative CVIs which can be presented using equation (6.2).

$$S(e_i) = \{(H_1 \beta_{n,i}),\ n = 1,2 \dots\dots N;\ i = 1,\ 2 \dots,\ L\} \quad \textbf{(6.2)}$$

Where $\beta_{n,i}$ represent the variable corresponding degree of belief for the indicator e_i and $\sum_{i=1}^{L}, \beta_{n,i} \leq 1$; *n*=1, 2,…. N represent the number of the linguistic terms, which is equal to 5 in this study, *i*=1,2,….L represents the number of the indicators in the lower level.

6.5.3.1. Degree of Belief (DOB) calculation

The degree of belief of the attributes for the qualitative CVIs was calculated using equation (6.3)

$$\beta_{n,i} = \frac{q_{n,i}}{Q_i}, \quad \text{n=1,2 …. N, i = 1,2,……,} \dot{L} \quad \textbf{(6.3)}$$

where $q_{n,i}$ represent the DOB given by q experts concerning attribute e_i rated as H_n and Q_i represent the total number of experts participating in the evaluation attribute e_i. $\dot{L}$ represent the number of evaluation attributes.

Table 6. 14: Grading for qualitative index

Qualitative Dimensions	Definition of Scale				
	A. Worst	**B poor**	**C. Average**	**D. Good**	**E Excellent**
Tangibles	The company equipment and facilities are not appealing to the quality of service provided	The company equipment and facilities are Partially not appealing to the quality of service provided	The company equipment and facilities are Partially appealing to the quality of service provided	The company equipment and facilities are appealing to the quality of service provided	The company equipment and facilities are very appealing to the quality of service provided
knowledge and understanding of customer needs and requirements	Staff do not have knowledge and understanding of the customer need and requirement	Staff have poor knowledge and understanding of the customer need and requirement	Staff have partial knowledge and understanding of the customer need and requirement	Staff have good knowledge and understanding of the customer need and requirement	Staff have a very good knowledge and understanding of the customer need and requirement
Openness in information exchange	Lack of openness to information exchange	Openness to information exchange	Average openness to information exchange	Good openness to information exchange	Excellent openness to information exchange
Collaboration with external partners	completely lacking collaborating qualities.	A poor collaborator	A partial good collaborator	A good collaborator	An excellent collaborator
Company ethical image	an uncommitted ethical culture	a drifter's ethical culture	an average ethical culture	A good ethical culture	an excellent ethical culture
Social responsibilities and concern for human safety	Service delivered have poor social responsibility values	Service delivered have a drifter social responsibility value	Service delivered has an improved social responsibility value	Service delivered have good social responsibility values	Service delivered have a world-class social responsibility value
Condition and availability of equipment and facilities	Equipment and facilities are not adequate	Equipment and facilities are sometimes adequate.	Equipment and facilities are well adequate	Equipment and facilities are adequately good	Equipment and facilities are adequate.
	A. Very low	**B. Low**	**C. Medium**	**D. High**	**E. Very High**
Application of IT, tracing, tracking and electronic data interface on customer products and in customer service	IT and electronic data interfaces are not adequate	IT and electronic data interfaces are sometimes adequate	IT and electronic data interface are partially adequate	IT and electronic data interface are adequately good	IT and Electronic data interfaces are adequate
Shipment tracing capacity	Shipment information is always not available	Shipment information is sometimes not available	Shipment information is partially available	Availability of shipment information is good	The availability of shipment information is excellent
Product tracing and tracking capacity	Delivering product information is always not available	Delivering product information is sometimes not available	Delivering product information is partially available	Availability of delivery of products information is good	Availability of delivery of products information is excellent
	A strongly disagree	**B disagree**	**C indifferent**	**D Agree**	**E strongly agree**
Reliability of order information	Order information is always not reliable	Order information is sometimes not reliable	Order information is partially reliable	The reliability of order information is good	The reliability of order information is excellent

Reliability of available service	Service availability is always not reliable	Service availability is sometimes not reliable	Service availability is partially reliable	Reliability of service availability is good	Reliability of service availability is excellent
Reliability of documentation	Documentation is not reliable	Documentation is sometimes not reliable	Documentation is partially reliable	Documentation reliability is good	Documentation reliability is excellent
Speed of service performance	Overall speed on service performance is poor	Overall speed on service performance is improving	Overall speed on service performance is average	Overall speed on service performance is good	Overall speed on service performance is excellent
Order placement convenience	Placing of order is not convenient	placing an order is the east convenient	convenience in placing an order is average	convenience in placing an order is good	convenience in placing an order is excellent
Consistency of order handling	Customer orders are not handled correctly	Customer orders are least handled	Customer orders are partially handled	Good handling of customer order	world-class handling of customer order
Timeliness of shipment and delivery	Shipment and delivery of customer products are always delayed	Shipment and delivery of customer products are sometimes delayed	Average timing in the shipment and delivery of customer products.	Good timing in the shipment and delivery of customer products	Excellent timing in the shipment and delivery of customer products

Source:(Handgraaf et al., 2008 ; Thai, 2013 ; Yang et al., 2001)

6.5.3.2. Data normalisation for the quantitative CVI'S

For the CVIs with a quantitative attribute, the data received from the experts were represented by a numerical value. Thus, the data were transformed into a qualitative grade using a rule-based technique as stated in equation (6.4) (Yang et al., 2001).

Assuming the data value H_n for a quantitative attribute e_i is judged to be similar to a grade H_n i.e

$$H_{n,i} \Rightarrow H_n \quad (n= 1, 2, \ldots N) \qquad \textbf{(6.4)}$$

The value of $H_{n,i}$ for each quantitative CVI's were determined from two range values, $H_{min,i}$ and $H_{max,i}$ which were obtained from historical data (Shen et al., 2001). It is worth mentioning that the maximum and minimum grading values for the quantitative attributes were based on the transformation of the historical data received from the industry, due to the lack of historical data from the literature. This decision was agreed upon after an in-depth discussion held with the domain experts. A consensus was agreed upon among the experts that "the maximum and minimum values that are physically realizable from an industrial perspective on each of the quantitative attributes could be used as their maximum and minimum values for the grading purpose.

Taking quantitative criteria "Staff efficiency" for illustration, the attribute was measured as the *ratio of the total order received by the company to the number of employees handling the order*. The highest value (Excellent grade) obtained from the participating company was "5 units of order per person" and the lowest value (worst grade) obtained from the participating company was "340 units of order per person, the mid-point value (Average grade) was calculated as 172.5 unit of order per person, the favourably value better than average (Good grade) was calculated as 88.8 unit of order per person and the unfavourably value worse than average (Poor grade) was calculated as 253.3 unit of order per person. A similar approach was applied to obtain the grading value index of the other quantitative attributes as shown in Table 6.15.

Table 6. 15: Grading for quantitative index.

Quantitative criteria	Worst	Poor	Average	Good	Best
Staff efficiency (order/persons)	340.0	256.3	172.5	88.8	5.0
Responsiveness (%)	75.0	81.3	87.5	93.8	100.0
Equipment efficiency (equipment/order)	0.0	20.83	41.67	62.50	83.33
Flexibility (%)	5.0	28.8	52.5	76.3	100.0
Completeness of order (%)	15.0	36.3	57.5	78.8	100.0
The correctness of order (%)	50.0	62.5	75.0	87.5	100.0
Consistency in order handling (%)	75.0	81.3	87.5	93.8	100.0
Consistency in storage and warehousing (%)	0.0	25.0	50.0	75.0	100.0
Security of service delivery (Threat/month)	26.7	20.0	13.3	6.7	0.0
Safety of service delivery (%)	50.0	62.5	75.0	87.5	100.0
Timeliness of shipment, pickup and delivery (%)	10.0	32.5	55.0	77.5	100.0

Hence, the value $H_{n,i}$ for each of the attributes was calculated using equation (6.5) where N is the number of linguistic grades

$$H_{n,i} = H_{min,i} + \frac{H_{max,i} - H_{min,i}}{N-1} \, x \, (n-1) \qquad \textbf{(6.5)}$$

Suppose the data value for the attribute e_i obtained from the expert was higher i.e $H_n \leq h \leq H_{n+i}$. $\beta_{n,i}$ represent the degree of belief that the attribute e_i is rated for a level H_n.

$$\beta_{n,i} = \frac{H_{n+i} - h}{H_{n+1,i} - H_{n,i}}, \quad \beta_{n+i,i} = 1 - \beta_{n,i} \qquad \textbf{(6.6)}$$

$$\beta_{k,i} = 0, \; K = 1,2,\cdots,N, \; K \neq n, n+1 \qquad \textbf{(6.7)}$$

Supposing the data value for the attribute e_i obtained from the expert was lower i.e $H_{n+i} \leq h \leq H_n$ lower

$$\beta_{n,i} = \frac{h - H_{n+i}}{H_{n,i} - H_{n+1,i}} \quad \beta_{n+i,i} = 1 - \beta_{n,i}$$

6.5.3.3. Synthesis of the risk evaluation of each CVI's index based on ER algorithm

To synthesize the risk evaluation of CVI's index, the ER algorithm was adopted to aggregate the assessment of the attributes from the base level to the top level in the hierarchical structure using their relevant degree of belief and the corresponding weights. The degree of beliefs of all the CVI's was initially transformed into probability masses associated with each grade of the attributes using the following equation (6.8) ~ (6.12)

$$M_{n,i} = \omega_i \beta_{n,i} \text{ , n = 1,2,...N , i = 1,2,....L} \qquad \textbf{(6.8)}$$

Where $M_{n,i}$ is the probability mass representing the degree to which the ith basic attributes e_i support the belief that a criterion is assessed to the nth grade H_n .

The remaining probability mass that is unassigned to any individual grade $M_{H,i}$is calculated using equation (6.9)

$$M_{H,i} = 1 - \sum_{i=1}^{n}, \omega_i \beta_{n,i} = 1 - \sum_{n=1}^{N}, M_{n,i} \qquad \textbf{(6.9)}$$

However, $M_{H,i}$ can be split into two-part $\underline{M_{H,i}}$ and $\widetilde{M_{H,i}}$. Firstly, since the individual unassigned QVI's e_i is the assessed relative importance of their weight $\underline{(M_{H,i}}$) and due to the incompleteness of the belief degree assessment ($\widetilde{M_{H,i}}$). $\underline{(M_{H,i}}$) and ($\widetilde{M_{H,i}}$) can be calculated using equation (6.10-6.11)

$$\underline{M_{H,i}} = 1 - \omega_i \text{ , i= 1,2,...L} \qquad \textbf{(6.10)}$$

$$\widetilde{M_{H,i}} = \omega_i (1 - \sum_{i=1}^{n} \beta_{n,i}) \text{ , i= 1,2......L} \qquad \textbf{(6.11)}$$

Hence, to generate the combined degree of belief of each basic attributes $E_{I(i)}$ was calculated by first defining it as a subset of the first (i)basic criteria as follows,

$$E_{I(i)} = \{ e_{1,} e_{2,} \dots \dots . . e_{i,} \} \qquad \textbf{(6.12)}$$

The coefficient of $M_{n,i}$, $\underline{M_{H,i}}$ and $\widetilde{M_{H,i}}$ can be constructed for i= 1,2,...L-1 to support the hypothesis that E is assessed to the grade H_n.Given the above, the aggregate assessment of the CVIs was calculated using equation (6.13) – (6.19).

$$\text{If} \quad M_{n,I\,(i)} = M_{n,I} \text{ , } M_{H,(I)} = M_{H,I} \qquad \textbf{(6.13)}$$

$$K_{I\,(i+1)} = \left[1 - \sum_{=1}^{N}, \sum_{J=1}^{N}, m_t I_{(i)}\, m_{j,i+1}\right]\dot{-}1 \quad \textbf{(6.14)}$$

Where $K_{I\,(i+1)} =$ is a normalising factor

$$M_{n,I\,(i+1)} = K_{I\,(i+1)}\,[M_{n,I(i)}\,M_{n,i+1} + M_{H,I(i)}\,M_{n,i+1} + M_{n,I(i)}\,M_{H,I(i)}\,] \quad \textbf{(6.15)}$$

$$\underline{M_{H,I\,(i+1)}} = K_{H,I(i+1)}\,\underline{M_{H,I\,(i)}}\,\,\underline{M_{H,i+1}} \quad \textbf{(6.16)}$$

$$M_{H,I\,(i)} = M_{H,I\,(i)} + \underline{M_{H,i}} \quad \textbf{(6.17)}$$

$$\beta_{n,} = \frac{M_{n,I\,(L)}}{1 - \underline{M_{n,i}}(L)} \quad \textbf{(6.18)}$$

$$\beta_{H,} = \frac{\underline{M_{H,I\,(L)}}}{1 - \underline{M_{H,I\,(L)}}} \quad \textbf{(6.19)}$$

To rank the CVIs based on their distributed assessment, it might be difficult to differentiate the assessment of different attributes using their degree of belief linguistic grades. The study adopts the utility value calculation method to convert the belief of degree into a single utility numerical value to reflect the ranking of the CVIs in the same hierarchy (Yang and Xu, 2002).

Hence, suppose $U(H_n)$ is the utility of the grade H_n such that $U(H_{n+1})$ is greater than $U(H_n)$. If u $U(H_{n+1})$ is preferred to H_n then $U(H_n)$ is calculated using a linear distribution(Yang et al., 2018) as shown in equation (6.20), where N denote the number of the linguistic term

$$U(H_n) = \frac{n-1}{N-1}, \quad n\ 1,2\ \ldots\ldots N \quad \textbf{(6.20)}$$

When the information of evaluation is complete and precise, $\beta_{H,}(y) = 0$. The expected utility of the attribute y is used to rank the alternatives using equation (6.21)

$$U(E) = \sum_{n=1}^{N}, \beta_n\ U(H_n) \quad \textbf{(6.21)}$$

When the information of evaluation is incomplete, $\beta_{H,}(y) \neq 0$, the optimal utility value $U_{max}(E)$ and the worst utility value $U_{min}(E)$ corresponding to the value was calculated and converted using equation (6.22) – (6.24).

$$U_{max}(E) = \sum_{n=1}^{N}, \beta_n \quad U(H_n) + \beta_H \quad U(H_n) \tag{6.22}$$

$$U_{min}(E) = \sum_{n=1}^{N}, \beta_n \quad U(H_n) + \beta_H \quad U(H_1) \tag{6.23}$$

$$U(E) = \frac{U_{max}(E) + U_{min}(E)}{2} \tag{6.24}$$

Hence a crisp value was calculated based on the distribution assessment generated via the ER techniques to compare all the CVI's. Similarly, a benchmark value based on the average range of the CVI's utility values can be estimated to benchmark the quality performance of AFTL companies in a future study (Yang et al., 2001)

6.5.4 Questionnaire survey for primary data collection.

The survey questionnaire was designed to investigate and collect raw data from the respondent regarding the index value of the various CVIs. The initial questionnaire was designed based on the attribute unit of measure and pilot tested with three academia, the experts were asked to provide comments concerning the rationality, structure and reliability of the questionnaire design, and few changes were suggested (Appendix five). After the implementation of the academic changes, the validated questionnaires were translated into Chinese, Vietnamese and Thailand languages and ethical approval was obtained before the questionnaires were sent to the company in China, Thailand, and the Republic of Vietnam via email to collect the subjective and objective data of experts based on their experience with the CVI's which come from their working on the frontline in the field of AFTL chain. The questionnaire consists of two-part. Part A asked about the demographic information of the respondent and part B was concerned about the index value of the CVIs. A total of 150 questionnaires were sent to AFTL companies to participate in the study, three weeks later, a reminder email was sent to the companies and by the end of the cut-off period of two months, a total of 26 valid questionnaires were returned from the case companies representing a 17.3% response rate which is corresponded to the number of samples adequately used in the literature with the application of ER techniques (Wan et al., 2018b; Shen et al., 2019).

Table 6. 16: Respondent profile

Company food product	Position	Location
General Fruit	Purchasing manager	China
Grain Beans and nut	General manager	China
Grain Beans and nut	Deputy Manager	China
fish and Seafood	Logistic manager	China
Grain Beans and nut	Area Manager	China
Meat and poultry	Area Manager	Thailand
General Consumer food	Supply chain manager	Thailand
General consumer food	Supply chain manager	Thailand
General Consumer food	Shipping export manager	Thailand
Dried food product	Logistic manager	Thailand
fish and seafood	Customer experience manager	Thailand
Dried food product	Supply chain manager	Thailand
Grain beans and nut	Marketing Manager	Thailand
Grain Beans and nut	Quality assurance manager	Thailand
Grain Beans and nut	Assistance Managing Director	Thailand
Dried food product	Supply chain manager	Thailand
Fish and seafood	Director	Vietnam
Fish and seafood	Vice president	Vietnam
Grain beans and nut	supply chain manager	Vietnam
Vegetable Products	Area manager	Vietnam
Grain Beans and nut	Director	Vietnam
Vegetable products	Assistance Managing Director	Vietnam
Vegetable Products	Area manager	Vietnam
Grain beans and nut	Supply chain manager	Vietnam
Grain beans and nut	Supply chain manager	Vietnam
Grain beans and nut	Supply chain manager	Vietnam

Table 6. 17: Company size

Company size	The companies based on region		
No of Staff	China	Republic of Vietnam	Thailand
1 to 9	3		3
10 to 59	1		2
50 to 249	1	4	4
250 to 499		4	1
> 500		3	

As presented in Table 6.17 a total of twenty-six (26) global AFTL companies participated in the survey, 40 % of the respondent were from Thailand, 38% of the respondent were from the Republic of Vietnam and 19 % of the respondent were from China. Of the ten case companies in Thailand, one company had an employee size ranging from 250 to 499, four had an employee size ranging from 50 to 249, two had an employee size ranging from 10 to 49, and the remaining three case companies had an employee size ranging from 1 to 9. Of the five case companies in China, two companies had an employee size ranging from 50 to 249 and 10 to 49, three companies had an employee size ranging from 1 to 9. Of the eleven case companies in the Republic of Vietnam, three case companies had an employee size of more than 500, four case companies had an employee size ranging from 250- to 499 and four case companies had an employee size ranging from 50 to 249. The experts were asked to indicate the kind of agro-food product they handled in their companies, 42% handled the transportation and logistics of grain, beans, and nut products, 19% handled the transportation and logistics of fish and seafood, 12% handled the transportation and logistics of vegetables and 4% handled the transportation and logistics of fruits products as illustrated in Figure 6.12. The survey questionnaire was limited to the participants that occupy a manager's position or higher due to the sensitivity of data needed for the study, as shown in Figure 6.13, 30% of the domain experts were supply chain managers, 15% were area managers, followed by others senior company leaders in the position of assistant directors, directors, general and deputy managers, shipping export managers, quality assurance manager and vice president. Thus, the high calibre of domain experts that participated in the study supports the validity and reliability of the study data.

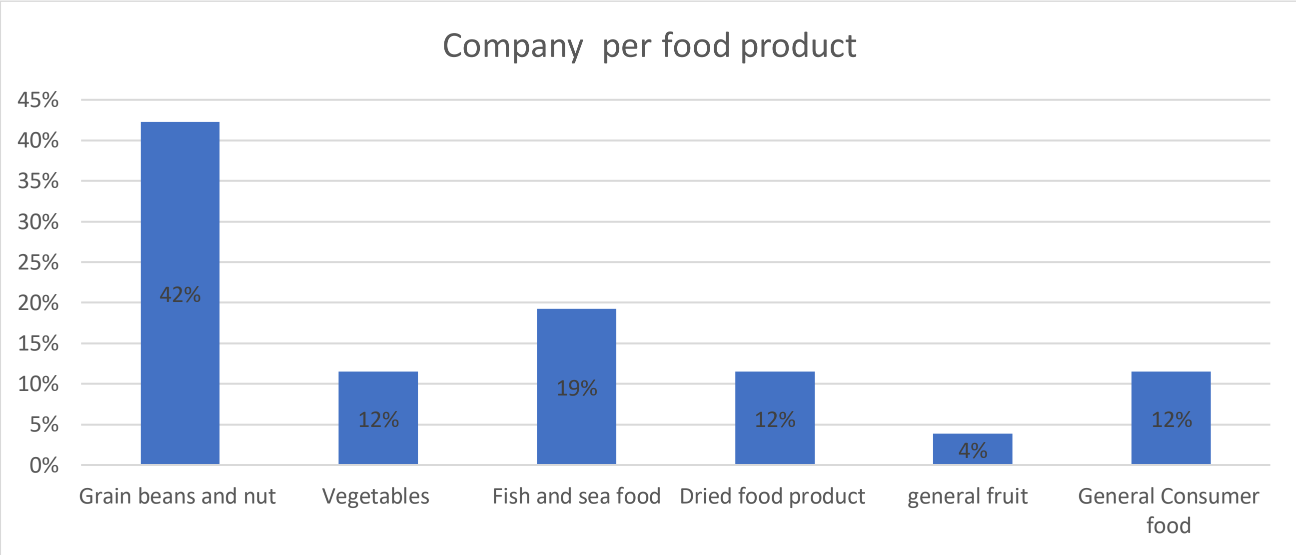


Figure 6. 11: Respondent company per food products

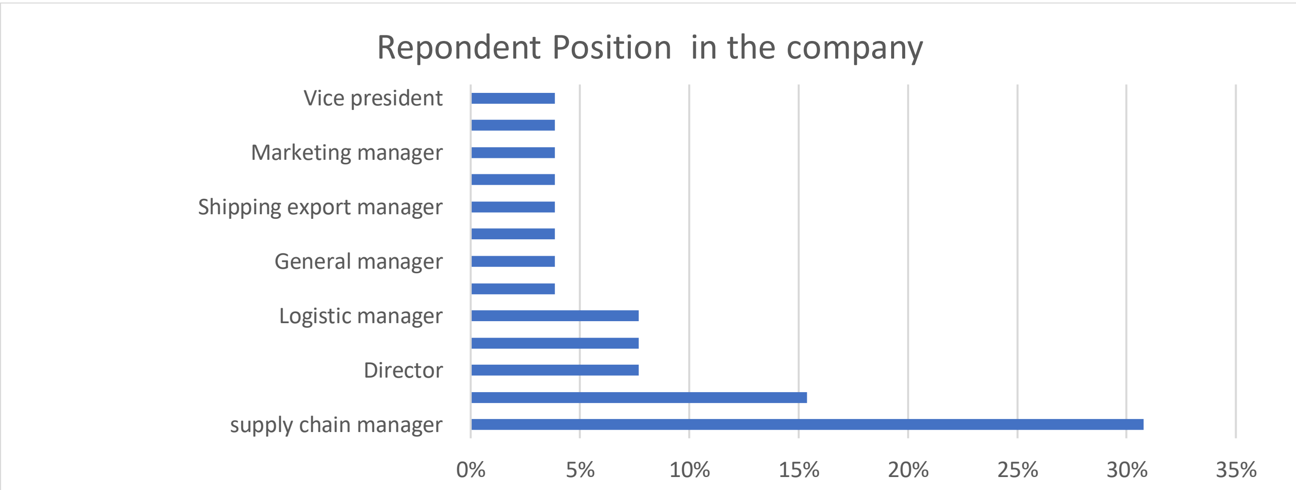


Figure 6. 12: Respondent position in the company

6.5.5 Collection and pre-processing of CVI's data (China – Thailand - Republic of Vietnam)

In this section, the index value of the CVIs was collected and pre-processed. The data were filtered and analyzed based on the CVI's impact on the quality of service of 1) All the AFTL case companies, 2) AFTL companies handing vegetable products, 3) AFT companies handling grain, beans, and cashew nut products and 4) AFTL companies handling seafood product,

6.5.5.1 Overview of all the AFTL case companies' quantitative CVI data transformation

The rule-based technique was used to convert the data value index of the quantitative CVI's received during the survey. The data were described with the pre-defined assessment grade generated using equation (6.5). The corresponding value range of the quantitative CVI's is presented in Table 6.18

Table 6. 18: Grading for quantitative index.

Quantitative criteria	H_1	H_2	H_3	H_4	H_5
Staff efficiency (order/persons) e_{12}	340.0	256.3	172.5	88.8	5.0
Responsiveness (%) e_{14}	75.0	81.3	87.5	93.8	100.0
Equipment efficiency (equipment/order) e_{19}	0.0	20.83	41.67	62.50	83.33
Flexibility (%) e_{21}	5.0	28.8	52.5	76.3	100.0
Completeness of order (%) e_{22}	15.0	36.3	57.5	78.8	100.0
The correctness of order (%) e_{23}	50.0	62.5	75.0	87.5	100.0
Consistency in order handling (%) e_{24}	75.0	81.3	87.5	93.8	100.0
Consistency in storage and warehousing (%) e_{33}	0.0	25.0	50.0	75.0	100.0
Security of service delivery (Threat/month) e_{41}	26.7	20.0	13.3	6.7	0.0
Safety of service delivery (%)e_{43}	50.0	62.5	75.0	87.5	100.0
Timeliness of shipment, pickup and delivery (%) e_{47}	10.0	32.5	55.0	77.5	100.0

Taking a quantitative criterion "staff efficiency (e_{12})" as a demonstrated example, its data value index was calculated based on the ratio of the maximum unit order of a company to the number of employees handling the order in a given period. The quantitative criteria "staff efficiency (e_{12})" value ranges are from 5 units of order per person (Maximum) to 340 units of order per person (minimum). The corresponding quantitative evaluation criteria h_n are calculated using equation (6.5)

$$h_1((e_{12}) = 340,\ h_2((e_{12}) = 256.25\ ,\ h_3((e_{12}) = 172.5,\ h_4\ (e_{12}) = 88.75\ ,\ h_5\ (e_{12}) = 5$$

For a company's quantitative criteria (e_{12}) with a data index value h = 15 units of order per person, the belief degrees are calculated using equation (6.6) as

$$\beta_{4,12} = \frac{5 - 15}{5 - 88.75} = 0.06, \quad \beta_{5,12} = 1 - \beta_{4,12} = 1 - 0.06 = 0.94$$

$$s(e_{12}) = \{ (H_1\ 0),\ (H_2\ 0), (H_3\ 0)\ (H_4\ 0.06), (H_5\ 0.94)\}$$

Similarly, quantitative criteria "equipment efficiency (e_{19})" whose value ranges are from zero (minimum) to 83.33 equipment/order (maximum). The corresponding quantitative evaluation criteria h_n are calculated as

h_1 (e_{19}) = 0, h_2((e_{19}) = 20.83, h_3((e_{19}) = 41.67, h_4 (e_{19}) = 62.50, h_5 (e_{19}) = 83.33.

For a company's quantitative criterion (e_{19}) with a data index value h = 3.3 equipment/order, the belief degrees are calculated as

$$\beta_{1,19} = \frac{20.83 - 3.33}{20.83 - 0} = 0.98, \quad \beta_{2,19} = 1 - \beta_{2,19} = 1 - 0.98 = 0.02$$

$$s(e_{19}) = \{ (H_1\ 0.98),\ (H_2\ 0.02), (H_3\ 0)\ (H_4\ 0), (H_5\ 0)\}$$

Tables (6.19) and (6.20) present the calculated data input (h value) of the quantitative CVIs from the case companies and their corresponding belief of degree.

Table 6. 19: Quantitative CVI's calculated data (h) values from all the AFTL case companies

Case company	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
Case_Company 1	5	80	6.67	100	100	93	80	100	0	100	80
Case_Company 2	10	100	0	50	90	89	100	80	8	100	90
Case_Company 3	300	83	0.03	63	100	100	83	30	0	100	83
Case_Company 4	20	80	0	75	75	73	80	100	26.67	100	60
Case_Company 5	15	90	3.33	40	100	100	90	70	0	100	90
Case_Company 6	100	95	0.04	10	100	99.95	95	100	0	99.75	95
Case_Company 7	340	99.55	0	5	98.68	98.03	99.55	80	0	99.98	98.24
Case_Company 8	272.3	99.83	0.02	8	99.5	100	99.83	33	0	98.8	99.33
Case_Company 9	25	95	2	100	100	100	95	0	0	100	95
Case_Company 10	12.5	95	3	66.67	100	96	95	0	0	100	95
Case_Company 11	90	85.71	0	80	77.78	92.86	95	0	0	100	66.67
Case_Company 12	100	77.78	0	60	90	100	100	0	0	75	70
Case_Company 13	29.23	98.95	0.32	75	100	100	100	85	0	100	98.95
Case_Company 14	25.71	98.89	0.33	83.33	100	100	95	85	0	100	98.89
Case_Company 15	10	100	0	0	100	100	95	100	0	100	100
Case_Company 16	200	83.3	5	100	15	100	86	80	0	100	12.5
Case_Company 17	15	83.3	83	40	80	50	95	100	0.0	0	67
Case_Company 18	22.5	88	63	50	89	50	88	100	0.2	0	78
Case_Company 19	66.66667	75	3	60	100	50	75	90	0.0	0	75
Case_Company 20	30	83	13	50	100	100	83	60	0.0	0	83
Case_Company 21	285.71	100	0	88	95	100	100	98	0.0	100	95
Case_Company 22	200	92	0	40	100	100	92	80	0.3	0	92
Case_Company 23	100	78	0	100	30	94	97	80	0.0	100	29
Case_Company 24	160	99	0	88	88	100	99	90	0.8	99	86
Case_Company 25	16.66667	75	2	67	80	100	75	25	1.3	50	60
Case_Company 26	150	98	0	83	93	100	98	100	0.2	60	92

Table 6.20: Belief degree of the quantitative CVIs from all the AFTL case companies.

	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}
EX 1	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.20),(H_2 0.80),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0.68),(H_2 0.32),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$
EX 2	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.6),(H_5 0.94)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.1$ $(H_3 0.89)$ $(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.47),(H_5 0.53)\}$
EX 3	$\{(H_1 0.52),(H_2 0.48),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.7$ $(H_3 0.28)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.56)(H_4 0.44),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$
EX 4	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.18),(H_5 0.82)\}$	$\{(H_1 0.20),(H_2 0.80),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.05)(H_4 0.95),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0.18)(H_4 0.82),(H_5 0$
EX 5	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.12),(H_5 0.88)\}$	$\{(H_1 0),(H_2 0),(H_3 0.60)(H_4 0.40),(H_5 0)$	$\{(H_1 0.84),(H_2 0.16),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.5$ $(H_3 0.47)$ $(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$
EX 6	$\{(H_1 0),(H_2 0),(H_3 0.13)(H_4 0.87),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0.79),(H_2 0.21),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$
EX 7	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.07),(H_5 0.93)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.06),(H_5 0.94)\}$
EX 8	$\{(H_1 0.19),(H_2 0.81),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.03),(H_5 0.97)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0.87),(H_2 0.13),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.02),(H_5 0.98)\}$
EX 9	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.24),(H_5 0.76)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 0.90),(H_2 0.10),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$
EX 10	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.09),(H_5 0.91)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 0.86),(H_2 0.14),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.40)(H_4 0.60),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$
EX 11	$\{(H_1 0),(H_2 0),(H_3 0.01)(H_4 0.99),(H_5 0)\}$	$\{(H_1 0),(H_2 0.3$ $(H_3 0.67)$ $(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.84),(H_5 0.16)\}$	$\{(H_1 0),(H_2 0)(H_3 0.05)(H_4 0.95),(H_5 0$
EX 12	$\{(H_1 0),(H_2 0),(H_3 0.13)(H_4 0.87),(H_5 0)\}$	$\{(H_1 0.56),(H_2 0.44),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.68)(H_4 0.32),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.47),(H_5 0.53)\}$
EX 13	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.29),(H_5 0.71)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.17),(H_5 0.83)\}$	$\{(H_1 0.98),(H_2 0.02),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.05)(H_4 0.95),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$

	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
EX 1	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.56),(H_5 0.44)\}$	$\{(H_1 0.20),(H_2 0.80),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.89),(H_5 0.11)\}$
EX 2	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.88),(H_5 0.12)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 0),(H_2 0)(H_3 0.20)(H_4 0.80),(H_5 0$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.44),(H_5 0.56)\}$
EX 3	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0.72$ $(H_3 0.28)(H_4 0)$ $(H_5 0)\}$	$\{(H_1 0),(H_2 0.80$ $(H_3 0.20)(H_4 0)$ $(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.76),(H_5 0.24)\}$
EX 4	$\{(H_1 0),(H_2 0.16$ $(H_3 0.84)(H_4 0)$ $(H_5 0)\}$	$\{(H_1 0.20),(H_2 0.80),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0.78)(H_4 0.22),(H_5 0)\}$
EX 5	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0.60)(H_4 0.40),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.20)(H_4 0.80),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.44),(H_5 0.56)\}$
EX 6	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0.02)$ $(H_5 0.98)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.22),(H_5 0.78)\}$
EX 7	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.16),(H_5 0.84)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.07),(H_5 0.93)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.08),(H_5 0.92)\}$
EX 8	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.03),(H_5 0.97)\}$	$\{(H_1 0),(H_2 0.68$ $(H_3 0.32)(H_4 0)$ $(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0.10)$ $(H_5 0.90)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.03),(H_5 0.92)\}$
EX 9	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.22),(H_5 0.78)\}$
EX 10	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.32),(H_5 0.68)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.22),(H_5 0.78)\}$
EX 11	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.57),(H_5 0.43)\}$	$\{(H_1 0),(H_2 0.29$ $(H_3 0.71)(H_4 0)$ $(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0.48)(H_4 0.52),(H_5 0)\}$
EX 12	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.56),(H_2 0.44),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 1)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.33)(H_4 0.67),(H_5 0)\}$
EX 13	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.17),(H_5 0.83)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.60),(H_5 0.40)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0$ $(H_3 0)(H_4 0),(H_5 1)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.05),(H_5 0.95)\}\}$

EX 14	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.25),(H_5 0.75)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.18),(H_5 0.82)\}$	$\{(H_1 0.98),(H_2 0.02),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.70),(H_5 0.30)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.18),(H_5 0.82)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.60),(H_5 0.40)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0 (H_3 0)(H_4 0),(H_5 1)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.05),(H_5 0.95)\}\}$
EX 15	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.06),(H_5 0.94)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0 (H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$
EX 16	$\{(H_1 0),(H_2 0.33),(H_3 0.67)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.6 (H_3 0.33)(H_4 0),(H_5 0)\}$	$\{(H_1 0.76),(H_2 0.24),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0.67 (H_3 0.33)(H_4 0)(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.68),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0 (H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.89),(H_2 0.11),(H_3 0)(H_4 0),(H_5 0)\}$
EX 17	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.12),(H_5 0.88)\}$	$\{(H_1 0),(H_2 0.6 (H_3 0.33)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.02),(H_5 0.98)\}$	$\{(H_1 0),(H_2 0.53 (H_3 0.47)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.94),(H_5 0.06)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.47)(H_4 0.53),(H_5 0)\}$
EX 18	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.21),(H_5 0.79)\}$	$\{(H_1 0),(H_2 0),(H_3 0.92)(H_4 0.08),(H_5 0)$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.98),(H_5 0.02)\}$	$\{(H_1 0),(H_2 0.11 (H_3 0.89)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.52),(H_5 0.48)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.92)(H_4 0.08),(H_5 0)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.03),(H_5 0.97)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.98),(H_5 0.02)\}\}$
EX 19	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.74),(H_5 0.26)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.86),(H_2 0.14),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.68)(H_4 0.32),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.40),(H_5 0.60)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.11)(H_4 0.89),(H_5 0)\}$
EX 20	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.30),(H_5 0.70)\}$	$\{(H_1 0),(H_2 0.7 (H_3 0.28)(H_4 0),(H_5 0)\}$	$\{(H_1 0.38),(H_2 0.62),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.11 (H_3 0.89)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0.72 (H_3 0.28)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.60)(H_4 0.40),(H_5 0)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.76),(H_5 0.24)\}\}$
EX 21	$\{(H_1 0.35),(H_2 0.65),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.51),(H_5 0.49)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.24),(H_5 0.76)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.08),(H_5 0.92)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0 (H_3 0)(H_4 0),(H_5 1)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.22),(H_5 0.78\}\}$
EX 22	$\{(H_1 0),(H_2 0.33),(H_3 0.67)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.28)(H_4 0.72),(H_5 0)$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0.53 (H_3 0.47)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0.28)(H_4 0.72),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.04),(H_5 0.96)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.36),(H_5 0.64\}\}$
EX 23	$\{(H_1 0),(H_2 0),(H_3 0.13)(H_4 0.87),(H_5 0)\}$	$\{(H_1 0.52),(H_2 0.48),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.29),(H_2 0.71),(H_3 0 (H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.48),(H_5 0.52)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.48),(H_5 0.52)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.80),(H_5 0.20)\}$	$\{(H_1 1),(H_2 0)(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0 (H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.16),(H_2 0.84),(H_3 0)(H_4 0),(H_5 0)\}$
EX 24	$\{(H_1 0),(H_2 0),(H_3 0.85)(H_4 0.18)(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.16),(H_5 0.84)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.51),(H_5 0.49)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.56),(H_5 0.44)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.16),(H_5 0.84)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.40),(H_5 0.60)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.12),(H_5 0.88)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.08)(H_5 0.92)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.62),(H_5 0.38\}\}$
EX 25	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.14),(H_5 0.86)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0.90),(H_2 0.10),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.39)(H_4 0.61),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.94),(H_5 0.06)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$(H_1 0),(H_2 1),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.19),(H_5 0.81)\}$	$\{(H_1 1),(H_2 0 (H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0.78)(H_4 0.22),(H_5 0)\}$
EX 26	$\{(H_1 0),(H_2 0),(H_3 0.73)(H_4 0.27),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.32),(H_5 0.68)\}$	$\{(H_1 1),(H_2 0),(H_3 0)(H_4 0),(H_5 0)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.72),(H_5 0.28)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.33),(H_5 0.67)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.32),(H_5 0.68)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1 0),(H_2 0)(H_3 0)(H_4 0.03),(H_5 0.97)\}$	$\{(H_1 0.20),(H_2 0.80),(H_3 (H_4 0),(H_5 0)\}$	$(H_1 0),(H_2 0),(H_3 0)(H_4 0.36),(H_5 0.64\}\}$

6.5.5.1.1 Overview of all the AFTL case company's qualitative CVI data transformation

The total number of AFTL case companies that participated in the qualitative CVI index evaluation was 26. Hence, the total evaluation number of each indicator Q_i was equal to 26, the number of case-company experts $Q_{n,i}$ who's qualitative CVI's were rated as H_n as defined in equation (6.1). Taking, as an illustration, qualitative taking indicator, "Social responsibility and concern for human safety e_{18}"

$$e_{18} = \{ e_{181}, e_{182}, e_{183} \}$$

The belief degree of the indicator $e_{181}, e_{182}, e_{183}$ were calculated using equation (6.8) as follows

$\beta_{1,181} = \frac{q_{1,181}}{Q} = \frac{0}{26} = 0;$ $\beta_{2,181;} = \frac{q_{2,181}}{Q} = \frac{2}{26} = 0.08;$ $\beta_{3,181} = \frac{q_{3,181}}{Q} = \frac{10}{26} = 0.38;$

$\beta_{4,181} = \frac{q_{4,181}}{Q} = \frac{10}{26} = 0.38;$ $\beta_{5,181} = \frac{q_{5,181}}{Q} = \frac{4}{26} = 0.15$

$$S(e_{181}) = \{ (H_1, 0), (H_2, 0.08), (H_3, 0.38), (H_4, 0.38), (H_5, 0) \}$$

$\beta_{1,182} = \frac{q_{1,182}}{Q} = \frac{0}{26} = 0;$ $\beta_{2,182;} = \frac{q_{2,182}}{Q} = \frac{0}{26} = 0;$ $\beta_{3,182} = \frac{q_{3,182}}{Q} = \frac{12}{26} = 0.46;$

$\beta_{4,182} = \frac{q_{4,182}}{Q} = \frac{10}{26} = 0.38;$ $\beta_{5,182} = \frac{q_{5,182}}{Q} = \frac{4}{26} = 0.15$

$$S(e_{182}) = \{ (H_1, 0), (H_2, 0), (H_3, 0.46), (H_4, 0.38), (H_5, 0.15) \}$$

$\beta_{1,183} = \frac{q_{1,183}}{Q} = \frac{0}{26} = 0;$ $\beta_{2,183;} = \frac{q_{2,183}}{Q} = \frac{1}{26} = 0.04;$ $\beta_{3,183} = \frac{q_{3,183}}{Q} = \frac{6}{26} = 0.23;$

$\beta_{4,183} = \frac{q_{4,183}}{Q} = \frac{14}{26} = 0.54;$ $\beta_{5,183} = \frac{q_{5,183}}{Q} = \frac{5}{26} = 0.19$

$$S(e_{183}) = \{ (H_1, 0), (H_2, 0.04), (H_3, 0.23), (H_4, 0.54), (H_5, 0.19) \}$$

Similarly, the belief degrees of all qualitative CVI's were calculated and presented in Table 6.21

Table 6. 21: Belief degree of the AFTL case company's qualitative CVI's

Qualitative CVI's		Belief of degree
$S(e_1)$	$S(e_{111})$	{ $(H_1, 0.04)$, $(H_2, 0)$, $(H_3, 0.31)$, $(H_4, 0.50)$, $(H_5, 0.15)$}
	$S(e_{112})$	{ $(H_1, 0.15)$, $(H_2, 0.12)$, $(H_3, 0.23)$, $(H_4, 0.42)$, $(H_5, 0.08)$}
	$S(e_{113})$	{ $(H_1, 0.35)$, $(H_2, 0.12)$, $(H_3, 0.19)$, $(H_4, 0.27)$, $(H_5, 0.08)$}
	$S(e_{114})$	{ $(H_1, 0.12)$, $(H_2, 0.04)$, $(H_3, 0.15)$, $(H_4, 0.38)$, $(H_5, 0.31)$}
$S(e_{13})$		{ $(H_1, 0)$, $(H_2, 0.08)$, $(H_3, 0.15)$, $(H_4, 0.50)$, $(H_5, 0.27)$}
$S(e_{15})$		{ $(H_1, 0.04)$, $(H_2, 0.04)$, $(H_3, 0.27)$, $(H_4, 0.35)$, $(H_5, 0.31)$}
$S(e_{16})$		{ $(H_1, 0.04)$, $(H_2, 0)$, $(H_3, 0.31)$, $(H_4, 0.42)$, $(H_5, 0.23)$}
$S(e_{17})$		{ $(H_1, 0)$, $(H_2, 0.04)$, $(H_3, 0.46)$, $(H_4, 0.27)$, $(H_5, 0.23)$}
$S(e_{18})$	$S(e_{181})$	{ $(H_1, 0)$, $(H_2, 0.08)$, $(H_3, 0.38)$, $(H_4, 0.38)$, $(H_5, 0.15)$}
	$S(e_{182})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.46)$, $(H_4, 0.38)$, $(H_5, 0.15)$}
	$S(e_{183})$	{ $(H_1, 0)$, $(H_2, 0.04)$, $(H_3, 0.23)$, $(H_4, 0.54)$, $(H_5, 0.19)$}
$S(e_{31})$		{ $(H_1, 0)$, $(H_2, 0.23)$, $(H_3, 0.42)$, $(H_4, 0.23)$, $(H_5, 0.12)$}
$S(e_{32})$	$S(e_{321})$	{ $(H_1, 0.15)$, $(H_2, 0.04)$, $(H_3, 0.35)$, $(H_4, 0.27)$, $(H_5, 0.19)$}
	$S(e_{322})$	{ $(H_1, 0.38)$, $(H_2, 0.12)$, $(H_3, 0.23)$, $(H_4, 0.23)$, $(H_5, 0.04)$}
	$S(e_{323})$	{ $(H_1, 0.42)$, $(H_2, 0.15)$, $(H_3, 0.19)$, $(H_4, 0.15)$, $(H_5, 0.08)$}
	$S(e_{324})$	{ $(H_1, 0.38)$, $(H_2, 0.15)$, $(H_3, 0.12)$, $(H_4, 0.23)$, $(H_5, 0.12)$}
	$S(e_{325})$	{ $(H_1, 0.50)$, $(H_2, 0.12)$, $(H_3, 0.12)$, $(H_4, 0.19)$, $(H_5, 0.08)$}
$S(e_{42})$		{ $(H_1, 0.54)$, $(H_2, 0.15)$, $(H_3, 0.12)$, $(H_4, 0.15)$, $(H_5, 0.04)$}
$S(e_{44})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.15)$, $(H_4, 0.62)$, $(H_5, 0.23)$}
$S(e_{45})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.31)$, $(H_4, 0.38)$, $(H_5, 0.31)$}
$S(e_{46})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.27)$, $(H_4, 0.50)$, $(H_5, 0.23)$}

Thus the overall assessment of all the CVIs was aggregated using equations (6.19). However, to minimize the lengthy and tedious calculation involved with the ER algorithm, a window-based intelligent decision system, (IDS) software (Yang and xu, 2002) developed to implement the ER algorithm was used to compute all the CVI's of the case companies and their utility value calculated using equation (6.22)- (6.24) was employed for the synthesis of the criteria in the hierarchical structure. All the inputs in the weight of the lowest level CVI's are combined to determine the risk estimation of each higher level CVI. The distributed risk assessment result of all the AFTL case companies in Asian ratings was obtained as presented in Table 6.22

Table 6. 22: Synthesis result for AFTL case companies in Asian

Companies	Worst	Poor	Average	Good	Best	Utility value	Ranking
Vietnamese company 1	5.33%	6.04%	30.82%	29.39%	28.41%	0.6738	10
Vietnamese company 2	1.27%	15.69%	23.97%	38.27%	20.80%	0.6541	13
Vietnamese company 3	24.30%	1.33%	3.97%	8.13%	62.28%	0.7069	8
Vietnamese company 4	18.42%	7.68%	18.12%	9.12%	48.66%	0.6448	15
Vietnamese company 5	2.37%	1.21%	22.07%	3.61%	70.73%	0.8478	2
Vietnamese company 6	28.82%	3.59%	14.42%	16.74%	36.43%	0.5709	22
Vietnamese company 7	10.85%	8.19%	9.59%	48.24%	23.13%	0.6615	12
Vietnamese company 8	17.05%	1.32%	27.68%	24.90%	29.06%	0.619	17
Vietnamese company 9	20.12%	1.41%	18.75%	43.27%	16.45%	0.5863	19
Vietnamese company 10	23.63%	6.95%	29.48%	14.08%	25.86%	0.5289	24
Thailand company 1	5.33%	6.04%	30.82%	29.39%	28.41%	0.6738	10
Thailand company 2	11.44%	10.60%	19.52%	24.53%	33.91%	0.6472	14
Thailand company 3	7.77%	6.17%	15.11%	21.04%	49.92%	0.7479	6
Thailand company 4	3.08%	15.71%	6.42%	35.75%	39.04%	0.7299	7
Thailand company 5	3.15%	4.48%	31.69%	36.37%	24.31%	0.6855	9
Thailand company 6	20.29%	4.07%	8.35%	41.83%	25.46%	0.6203	16
Thailand company 7	31.63%	8.97%	18.51%	28.17%	12.73%	0.4538	26
Thailand company 8	1.65%	1.89%	3.08%	68.13%	25.25%	0.7836	4
Thailand company 9	1.76%	0.03%	0%	43.20%	55.01%	0.8742	1
Thailand company 10	33.34%	1.10%	25.33%	2.44%	35.27%	0.5004	25
Thailand company 11	20.55%	11.81%	16.87%	30.61%	20.16%	0.5451	23
China company 1	2.88%	6.38%	11.92%	31.99%	46.83%	0.7838	3
China company 2	15.43%	0.52%	43.95%	19.09%	21.01%	0.5743	21
China company 3	3.20%	7.36%	5.52%	48.12%	35.81%	0.7649	5
China company 4	29.71%	6.84%	8.47%	11.86%	43.11%	0.5795	20
China company 5	19.36%	3.00%	25.14%	16.02%	36.47%	0.6181	18

Hence, the overall results were obtained by synthesizing all the CVI's by ER algorithm as illustrated in Figure 6.14.

For instance, the overall distributed assessment result of case company one was assessed as 5.33% worst, 6.04% poor, 30.82% average, 29.39% good and 28.41% best $S(E)$={($Worst$, 0),($Poor$, 6.04%),($Average$, 30.82%)($Good$, 29.39%),($Best$, 28.41%)}

The result indicates that the highest belief of degree in the assessment of case company one is "average" with a confidence of 30.82%. Thus, the service quality performance rating of company A is rated "average".

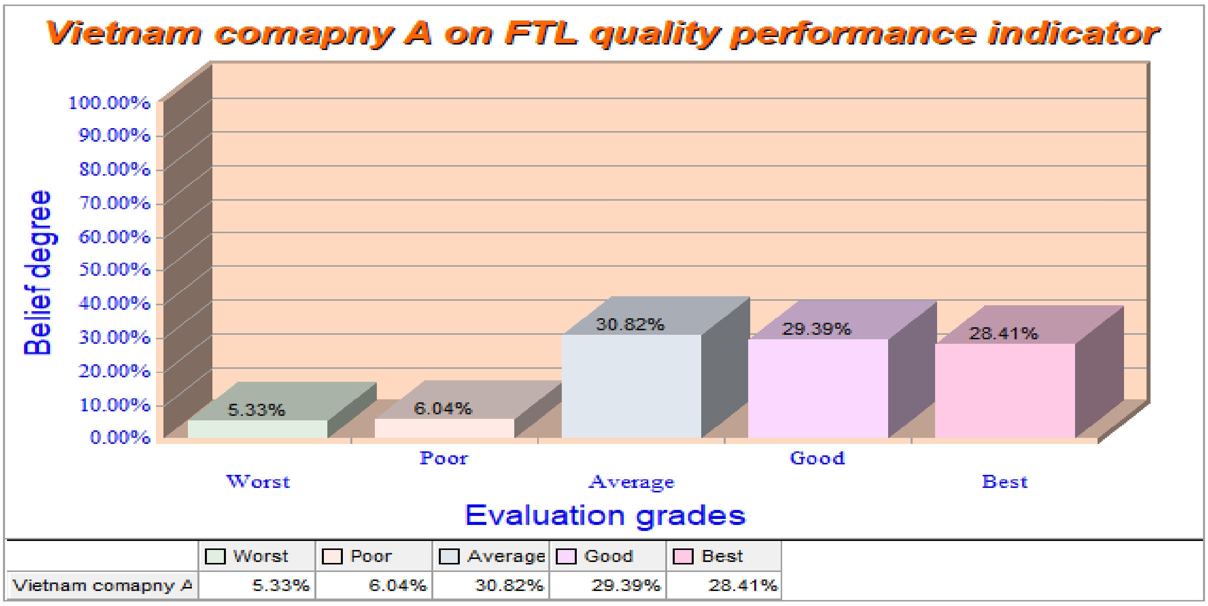


Figure 6. 13: IDS graphic display of the distributed assessment of the quality performance of Company A

To rank, the risk impact for each level of the risk index of companies in the AFTL chain, their utility values using equation (6.27)- (6.29) were used to calculate the utility values of each level of the criterion. The calculated utility values of the companies are presented in figure 6.15. The highest obtained company index value was 0.8742 (87.42%) and the lowest obtained company index value was 0.4538 (45.38%). An average index value of 0.664 (66.4%) was obtained as a benchmarked value to measure the service quality performance of AFTL companies in a future study (Yang et al., 2001)

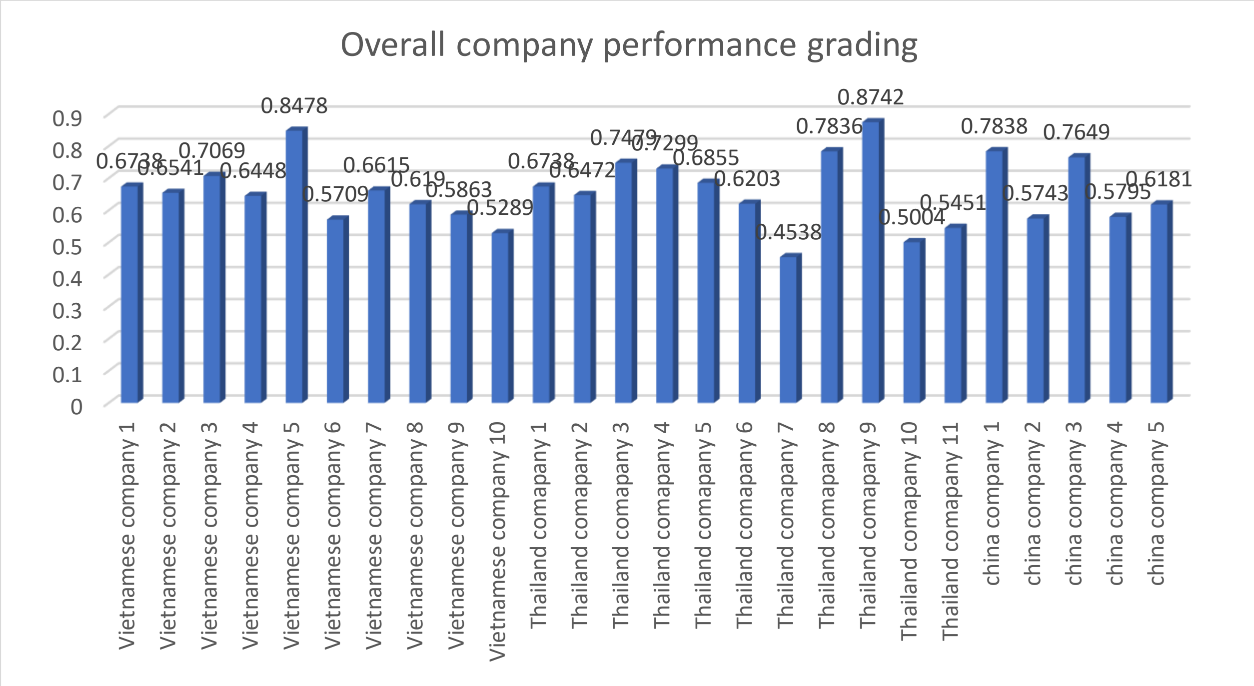


Figure 6. 14: Case companies' utility values.

6.5.5.1.2 Service quality CVI's performance assessment as per case companies

6.5.5.1.2.1. The criteria for group assessment

Figure 6.16 illustrate the performance assessment of the case companies. The result shows that majority of the case companies have a higher quality service performance risk level with the operation and relation CVI's. For the causal variables in the operation group, the least performing case company's risk index level on service quality was 54%. For the causal variables in the relation group level, the least company performance risk index level was 57%. For the attribute in the resource group, more than 53.8% of the case companies had their service performance risk index level below 50%. Thus, the CVI's in the resource group level (i.e. Consistency in storage and warehousing, condition and availability of equipment and facilities, application of IT, electronic data interface in customer services, shipment and product tracing and tracking capacity) are significant to the quality of service in the AFTL chain. Thus, AFTL companies must have a mitigation strategy to cushion their impacts.

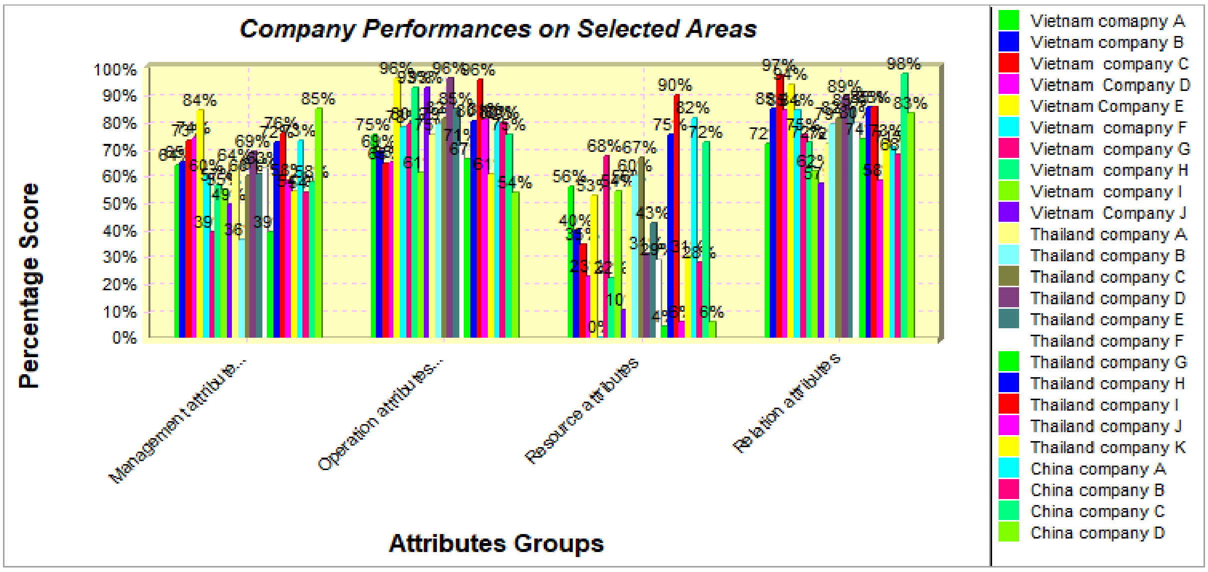


Figure 6. 15: Overall attributes group assessment

6.5.5.1.2.2. Lower-level criterion assessment

Figure 6.17 shows the performance risk index level of the lower-level criteria in the management group. The equipment efficiency, responsiveness to customer order and the tangibles of equipment and infrastructure are ranked the least attributes, with the majority of the participating companies having a performance risk index level below 50%. Thus, the accessibility and efficiency of the types of equipment used in the AFTL firm need to be of a good quality standard. Figure 6.18 shows the performance risk index level of the lower-level criteria in the operation group. The consistency in order handling, adapting to the changing demand of the customer, and the completion and accuracy of order information were the least attributes with 30.7% of the participating company having a performance risk level below average. Thus, a thorough operational check on the daily activities of the AFTL companies is paramount to their quality service delivery. Figure 6.19 shows the performance risk level of the lower criteria in the "resource group". The consistency in storage and warehousing, the lack of electronic data interface, temperature and humidity sensor to track and trace the food product during transit, lack of artificial intelligence and RFID technology application in service were the attributes with more than 50% of the case company having a lower performance risk score. Figure 6.20 show the performance risk score assessment of the lower-level criterion in the “relation group”. The consistent procedure in handling orders and the availability of order information are the least causal attributes that will influence the quality of service performed by the AFTL companies. In summary, the assessment shows that causal variables in the operation and relational group i.e flexibility, completeness of order, the correctness of order, the safety of service delivery, the security of service delivery, and timeliness of shipment are the critical variables that influence the quality of service in the AFTL industry. Organizations must ensure that proper strategies are kept in place to manage and mitigate their performance risk level according to standard business practices.

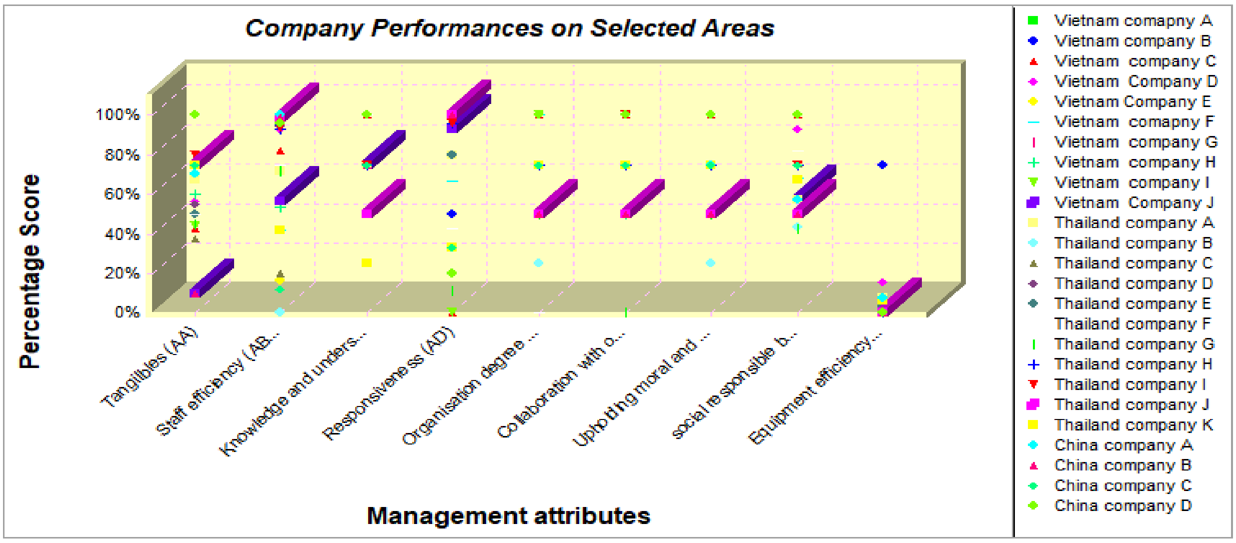


Figure 6. 16: Management attributes assessment

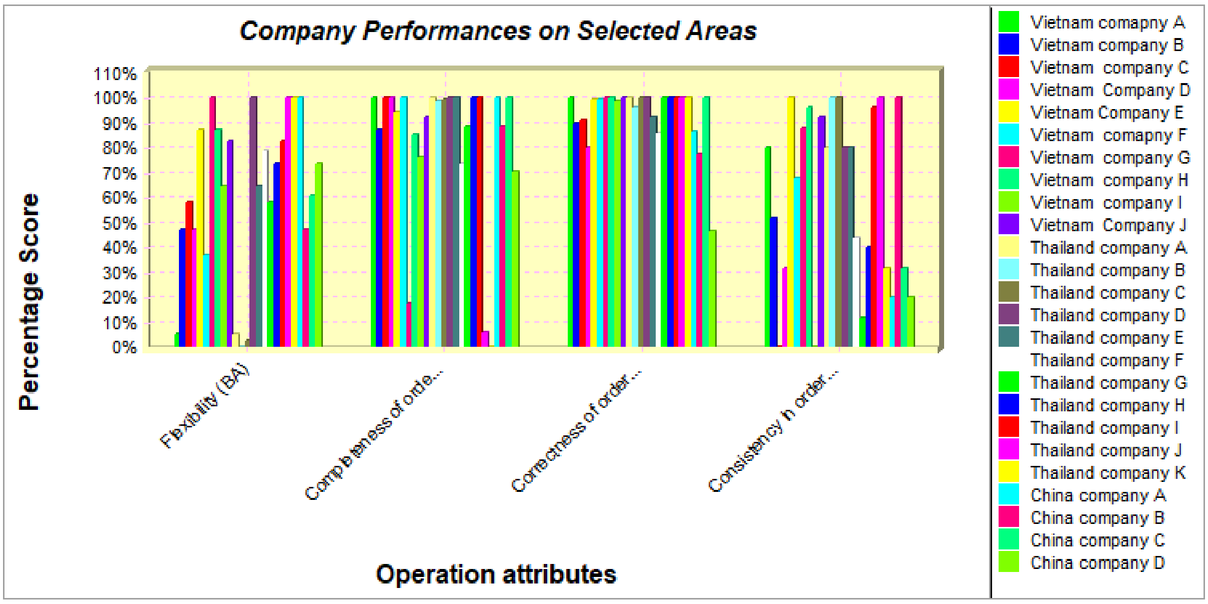
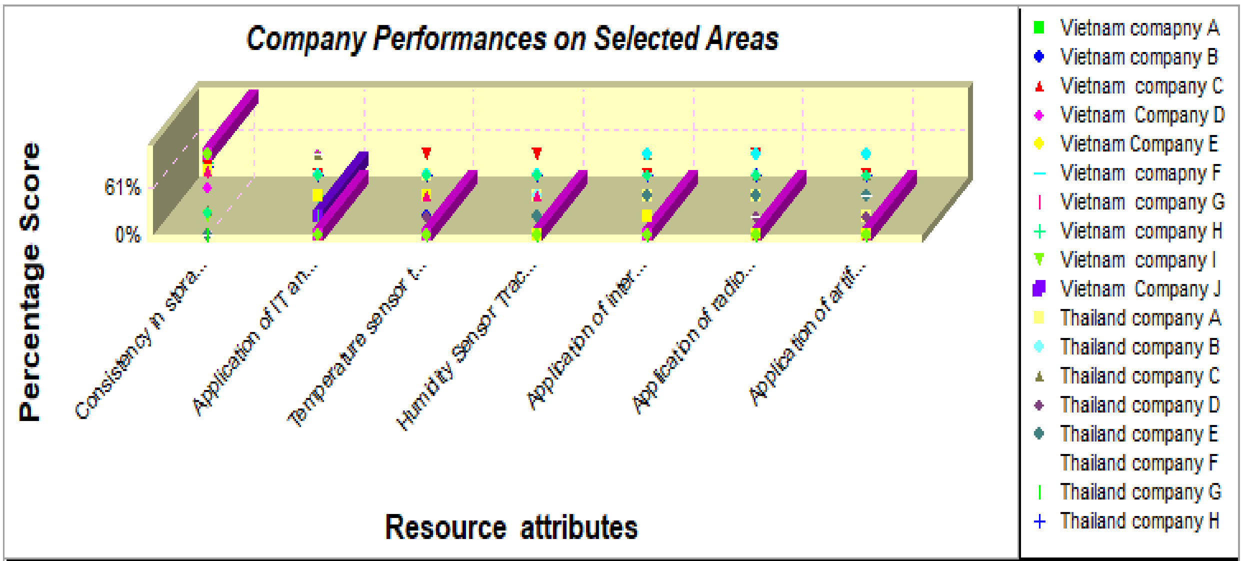


Figure 6. 17: Operation attributes assessment



	Temperature sensor t...	Humidity Sensor Trac...	Application of inter...	Application of radio...	Application of artif...
Thailand company E	50%	25%	50%	50%	50%
Thailand company F	0%	0%	75%	25%	50%
Thailand company G	0%	0%	0%	0%	0%
Thailand company H	75%	75%	75%	75%	75%

Figure 6. 18. Resource attributes assessment

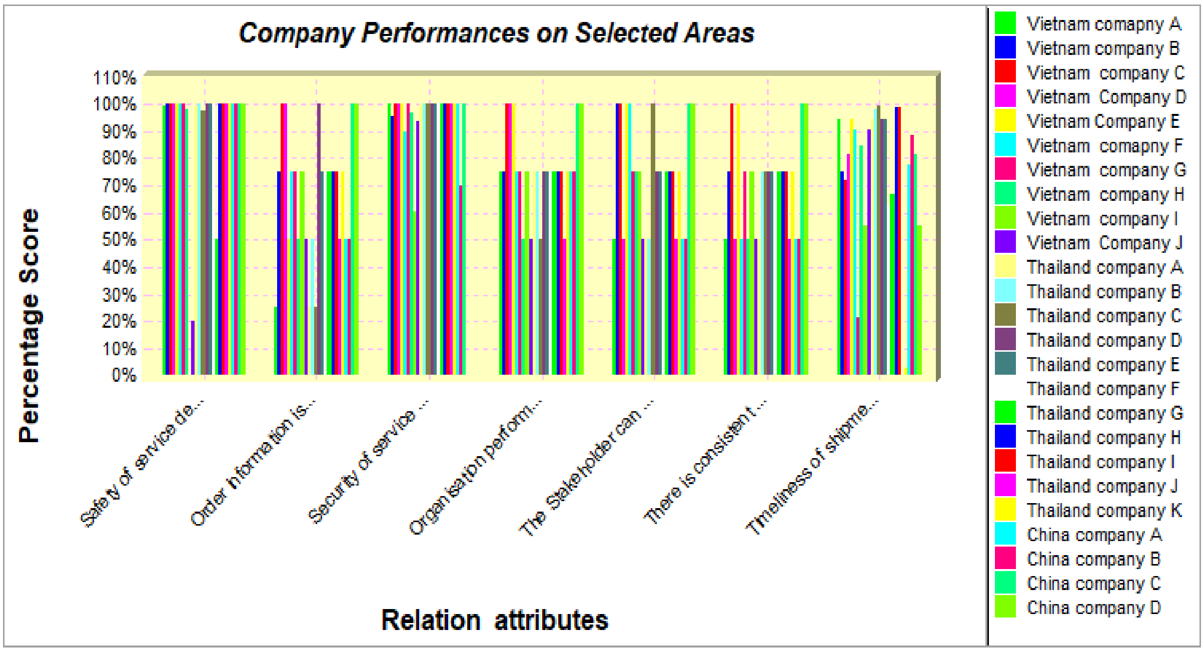


Figure 6.19. Relation attributes assessment

6.5.5.2. Quantitative data transformation of the CVI's influencing service quality risk hazard of the AFTL companies handling grain, bean, and cashew nut (GBC) products

The calculated data value index of the quantitative CVIs received from grain, beans, and cashew nuts (GBS) case companies during the survey are shown in Table 6.21. The rule-based technique was used to evaluate each company corresponding quantitative criterion $index\ value\ of\ h_n$ using the quantitative range value (Table 6.18). The corresponding belief degree of all GBC case company quantitative CVI's are presented in Table 6.22

6.5.5.2.1. For the GBC case companies qualitative CVI's data transformation

The belief of degree of the qualitative CVI's for GBC case companies was extracted as follows $S(e_i) = \{(H_1\beta_{1,ij}), (H_2\beta_{2,ij}), (H_3\beta_{3,ij}), (H_4\beta_{4,ij}), (H_5\beta_{5,ij})\}$. Where $\beta_{n,ij}$ was evaluated using equation (6.3). A total of eleven case companies handling GBC products participated in the evaluation of the qualitative CVI. Hence, Q_i is equal to 11 and $Q_{n,i}$ are the number of case-company expert whose qualitative QVI's was rated H_n. For instance, taking the indicator, "Application of IT and electronic data interface in customer service e_{32}" as an illustration

$$e_{32} = \{ e_{321},\ e_{322}, e_{323}\ \ e_{324}\ \ e_{325} \}$$

The belief degree of indicators $e_{321},\ e_{322}, e_{323}\ \ e_{324}\ \ e_{325}$ was calculated as follows

$$\beta_{1,321} = \frac{q_{1,321}}{Q} = \frac{2}{11} = 0.18;\ \beta_{2,321;} = \frac{q_{2,321}}{Q} = \frac{1}{11} = 0.09;\ \beta_{3,321} = \frac{q_{3,321}}{Q} = \frac{3}{11} = 0.27;$$

$$\beta_{4,321} = \frac{q_{4,321}}{Q} = \frac{3}{11} = 0.27;\ \beta_{5,321} = \frac{q_{5,321}}{Q} = \frac{2}{11} = 0.18$$

$$S(e_{321}) = \{ (H_1, 0.18), (H_2, 0.09), (H_3, 0.27), (H_4, 0.27), (H_5, 0.18)\}$$

$$\beta_{1,322} = \frac{q_{1,322}}{Q} = \frac{5}{11} = 0.45;\ \beta_{2,322;} = \frac{q_{2,322}}{Q} = \frac{0}{11} = 0;\ \beta_{3,321} = \frac{q_{3,322}}{Q} = \frac{2}{11} = 0.18;$$

$$\beta_{4,322} = \frac{q_{4,322}}{Q} = \frac{3}{11} = 0.27;\ \beta_{5,322} = \frac{q_{5,322}}{Q} = \frac{1}{11} = 0.09$$

$$S(e_{321}) = \{ (H_1, 0.45), (H_2, 0), (H_3, 0.18), (H_4, 0.27), (H_5, 0.09)\}$$

$$\beta_{1,323} = \frac{q_{1,323}}{Q} = \frac{5}{11} = 0.45;\ \beta_{2,323;} = \frac{q_{2,323}}{Q} = \frac{0}{11} = 0;\ \beta_{3,323} = \frac{q_{3,323}}{Q} = \frac{2}{11} = 0.18;$$

$$\beta_{4,323} = \frac{q_{4,323}}{Q} = \frac{2}{11} = 0.18;\ \beta_{5,323} = \frac{q_{5,323}}{Q} = \frac{2}{11} = 0.18$$

$$S(e_{321}) = \{ (H_1, 0.45), (H_2, 0), (H_3, 0.18), (H_4, 0.18), (H_5, 0.18)\}$$

$$\beta_{1,324} = \frac{q_{1,324}}{Q} = \frac{5}{11} = 0.45;\ \beta_{2,324;} = \frac{q_{2,324}}{Q} = \frac{1}{11} = 0.09;\ \beta_{3,324} = \frac{q_{3,324}}{Q} = \frac{1}{11} = 0.09;$$

$$\beta_{4,324} = \frac{q_{4,324}}{Q} = \frac{3}{11} = 0.27;\ \beta_{5,324} = \frac{q_{5,324}}{Q} = \frac{1}{11} = 0.09$$

$$S(e_{324}) = \{ (H_1, 0.45), (H_2, 0.09), (H_3, 0.09), (H_4, 0.27), (H_5, 0.09)\}$$

$$\beta_{1,325} = \frac{q_{1,325}}{Q} = \frac{7}{11} = 0.64;\ \beta_{2,325;} = \frac{q_{2,325}}{Q} = \frac{0}{11} = 0;\ \beta_{3,325} = \frac{q_{3,325}}{Q} = \frac{1}{11} = 0.09;$$

$$\beta_{4,325} = \frac{q_{4,325}}{Q} = \frac{2}{11} = 0.18;\ \beta_{5,325} = \frac{q_{5,325}}{Q} = \frac{1}{11} = 0.09$$

$$S(e_{325}) = \{ (H_1, 0.64), (H_2, 0), (H_3, 0.09), (H_4, 0.18), (H_5, 0.09)\}$$

Similarly, the belief degree of all the qualitative CVI's for GBC case companies are calculated and presented in Table 6.23

Table 6.23: Value of the quantitative index of Grain, Bean and Cashew nut (GBC) products.

Case company	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
GBC Case_Company 1	10	100	0	50	90	89	100	80	100	8	90
GBC case _Company 2	300	83	0	63	100	100	83	30	100	0	83
GBC case _Company 3	15	90	3	40	100	100	90	70	100	0	90
GBC case_Company 4	29.23	99	0	75	100	100	99	85	100	0	99
GBC case _Company 5	25.71	99	0	83	100	100	99	85	100	0	99
GBC case _Company 6	10	100	0	5	15	100	100	100	100	0	10
GBC case Company 7	66.67	75	3	60	100	96	75	90	100	0	75
GBC case _Company 8	285.71	100	0	88	95	100	100	98	50	0	95
GBC case _Company 9	160	99	0	88	88	100	99	90	99	1	86
GBC case _Company 10	16.67	75	2	67	80	99	75	25	50	11	60
GBC case _Company 11	150	98	0	83	93	100	98	83	60	2	92

Table 6. 24: Belief degree of the quantitative CVI's GBC case companies

	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
GBC Case_Company 1	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.06),(H_5\ 0.94)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.$ $(H_3 0.89)(H_4 0),(H_5\ )\}$	$\{(H_1\ 1),(H_2\ 0),(H_3 0)(H_4 0.47),(H_5\ 0.53)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.88)$ $(H_5\ 0.12)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0$ $(H_4 0),(H_5\ 1$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.80),(H_5\ 0.20)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.20)(H_4 0.80),(H_5\ 0)$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.44),(H_5\ 0.56)\}$
GBC Case_Company 2	$\{(H_1\ 0.52),(H_2\ 0.$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.7$ $(H_3 0.28)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.56)$ $(H_4 0.44),(H_5\ 0$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0.28)(H_4$ $(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.80$ $(H_3 0.20)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.76),(H_5\ 0.24)\}$
GBC Case_Company 3	$\{(H_1 0),(H_2 0),(H_3 0)(H_4 0.12),(H_5\ 0.88$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.60)$ $(H_4 0.40)(H_5\ 0)$	$\{(H_1\ 0.86),(H_2\ 0.14),(H$ $(H_4 0),(H_5\ 0)$	$\{(H_1\ 0),(H_2\ 0.$ $(H_3 0.47)$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0.60)(H_4$ $(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.20)(H_4 0.80)(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.44),(H_5\ 0.56)\}$
GBC Case_Company 4	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.29),(H_5\ 0.71)\}$	$\{(H_1\ 0),(H_2 0),(H_3 0)(H_4 0.16),(H_5\ 0.84)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.05)$ $(H_4 0.95),(H_5\ 0$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0.1$ $(H_5\ 0.84)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.60),(H_5\ 0.40)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.04)$ $(H_5\ 0.96)\}$
GBC Case_Company 5	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.12),(H_5\ 0.88)\}$	$\{(H_1\ 0),(H_2 0),(H_3 0)(H_4 0.16),(H_5\ 0.84)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.72),(H_5\ 0.28)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0.1$ $(H_5\ 0.84)\}\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.60),(H_5\ 0.40)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.04)$ $(H_5\ 0.96)\}$
GBC Case_Company 6	$\{(H_1\ 0),(H_2\ 0),(H_3 0)$ $(H_4 0.25),(H_5\ 0.75$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 1),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 0)\}$
GBC Case_Company 7	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.74),(H_5\ 0.26)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0.86),(H_2\ 0.14),(H$ $(H_4 0),(H_5\ 0)$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.68$ $(H_4 0.32),(H_5\ 0$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.32)$ $(H_5\ 0.68)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.40),(H_5\ 0.60)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.11)(H_4 0.89),(H_5\ 0)$
GBC Case_Company 8	$\{(H_1\ 0.35),(H_2 0.65),(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5 1)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.51),(H_5\ 0.49)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.24),(H_5\ 0.76)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.08)$ $(H_5\ 0.92)\}$	$\{(H_1\ 1),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.22),(H_5\ 0.78)\}$
GBC Case_Company 9	$\{(H_1\ 0),(H_2\ 0),(H_3 0.85)(H_4 0.15),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.16),(H_5\ 0.84)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.51),(H_5\ 0.49)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.56),(H_5\ 0.44)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0.1$ $(H_5\ 0.84)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.40),(H_5\ 0.60)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.08)$ $(H_5\ 0.92)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.15),(H_5\ 0.85)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.62),(H_5\ 0.38)\}$
GBC Case_Company 10	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.14),(H_5\ 0.86)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0.90),(H_2\ 0.10),(H$ $(H_4 0),(H_5\ 0)$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.39)$ $(H_4 0.61),(H_5\ 0$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.94),(H_5\ 0.06)\}$	$(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.08)$ $(H_5\ 0.92)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 1),(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.65)(H_4 0.35),(H_5\ 0)$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.78),(H_5\ 0.22)\}$

GBC Case_Company 11	$\{(H_1\ 0),(H_2\ 0),(H_3 0.73)(H_4 0.27),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)(H_3 0)(H_4 0.32),(H_5\ 0.68)\}$	$\{(H_1\ 1),(H_2$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)(H_3 0)(H_4 0.72),(H_5\ 0.28)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.33),(H_5\ 0.67)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2$ $(H_3 0)(H_4 0.3$ $(H_5\ 0.68)\}$	$\{(H_1\ ),(H_2\ 0),(H_3 0)(H_4 0.68),(H_5\ 0.32)\}$	$\{(H_1\ 0.20),(H_2\ 0.80),(H_3$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.30),(H_5\ 0.70)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.36),(H_5\ 0.64)\}$

Table 6.23 Belief degree of the qualitative CVI's GBC case companies

Qualitative CVI's		Belief of degree
$S(e_1)$	$S(e_{111})$	{ $(H_1, 0.09)$, $(H_2, 0)$, $(H_3, 0.27)$, $(H_4, 0.55)$, $(H_5, 0.09)$}
	$S(e_{112})$	{ $(H_1, 0.09)$, $(H_2, 0.09)$, $(H_3, 0.18)$, $(H_4, 0.55)$, $(H_5, 0.09)$}
	$S(e_{113})$	{ $(H_1, 0.36)$, $(H_2, 0.09)$, $(H_3, 0.09)$, $(H_4, 0.36)$, $(H_5, 0.09)$}
	$S(e_{114})$	{ $(H_1, 0.18)$, $(H_2, 0.00)$, $(H_3, 0.09)$, $(H_4, 0.36)$, $(H_5, 0.36)$}
$S(e_{13})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.18)$, $(H_4, 0.64)$, $(H_5, 0.18)$}
$S(e_{15})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.45)$, $(H_4, 0.27)$, $(H_5, 0.27)$}
$S(e_{16})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.45)$, $(H_4, 0.27)$, $(H_5, 0.27)$}
$S(e_{17})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.55)$, $(H_4, 0.27)$, $(H_5, 0.18)$}
$S(e_{18})$	$S(e_{181})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.45)$, $(H_4, 0.36)$, $(H_5, 0.18)$}
	$S(e_{182})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.45)$, $(H_4, 0.36)$, $(H_5, 0.18)$}
	$S(e_{183})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.27)$, $(H_4, 0.55)$, $(H_5, 0.18)$}
$S(e_{31})$		{ $(H_1, 0)$, $(H_2, 0.18)$, $(H_3, 0.55)$, $(H_4, 0.18)$, $(H_5, 0.09)$}
$S(e_{32})$	$S(e_{321})$	{ $(H_1, 0.18)$, $(H_2, 0.09)$, $(H_3, 0.27)$, $(H_4, 0.27)$, $(H_5, 0.18)$}
	$S(e_{322})$	{ $(H_1, 0.45)$, $(H_2, 0.00)$, $(H_3, 0.18)$, $(H_4, 0.27)$, $(H_5, 0.09)$}
	$S(e_{323})$	{ $(H_1, 0.45)$, $(H_2, 0)$, $(H_3, 0.18)$, $(H_4, 0.18)$, $(H_5, 0.09)$}
	$S(e_{324})$	{ $(H_1, 0.45)$, $(H_2, 0.09)$, $(H_3, 0.09)$, $(H_4, 0.27)$, $(H_5, 0.09)$}
	$S(e_{325})$	{ $(H_1, 0.64)$, $(H_2, 0)$, $(H_3, 0.09)$, $(H_4, 0.18)$, $(H_5, 0.09)$}
$S(e_{42})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.36)$, $(H_4, 0.27)$, $(H_5, 0.27)$}
$S(e_{44})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.27)$, $(H_4, 0.45)$, $(H_5, 0.27)$}
$S(e_{45})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.27)$, $(H_4, 0.45)$, $(H_5, 0.27)$}
$S(e_{46})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.36)$, $(H_4, 0.36)$, $(H_5, 0.27)$}

6.5.5.2.2 Synthesis of the risk evaluation of each CVI's index of the case companies handling GBC products.

The IDS software was used to synthesize the aggregate assessment of all the lower-level quality measuring attributes and combined with the higher-level attributes to estimate the overall quality performance of the company. Figure 6.21 present the assessment performance of the GBC product handling companies. Taking as an illustration case company A, was evaluated as 22.30% worst, 1.05% poor, 5.74% Average 11.07% good and 58.95% best. Moreso, the evaluation result also shows the degree of incompleteness in the final assessment of case Company H. i.e 32.06 % Worst, 2.09% Poor, 25.41% average, 2.29 % Good, 35.62% Best and 2.53 % unknown. This occurred due to an incomplete assessment of the attributes of company

H. (Yang and Xu, 2002). Similarly, to rank the quality performance of the companies, their utility values were estimated using equation (6.21)- (6.25) Thus, the utility value(u) for GBC product handling company A was calculated as 0.7128. The utility value of the other GBC product handling companies is presented in Figure 6.22

The participated companies are ranked thus: u (Company G) = 0.8810 > u (Company B) = 0.8518> u (Company F) =0.7940 > u (Company J) = 0.7651 > (Company A) = 0.7128 > u (Company K) = 0.6476 > u (Company L) = 0.6273 >u(Company D) = .0.6148 > u (Company E) = 0.5477 > u (Company H) = 0.5309 > u (Company I)= 0.5307. An average index value of 0.7058 (70.58%) was obtained as a benchmarked value to measure the service quality performance of AFTL companies handling GBC products in a future study.

Furthermore, The assessment result shows that the attributes in the operation and relational group i.e flexibility, the safety of service delivery, availability of order information, the security of service delivery, the organization performing the promised services, allowing the stakeholder to place order conveniently, a consistent procedure in the handling of orders and timeliness of shipment, pickup and delivery are the most influencing attributes to enhance the quality performance of the grain, cashew and nut handling companies, majority of the companies have a quality performance score higher than 50% on these attributes as shown in Figure 6.23

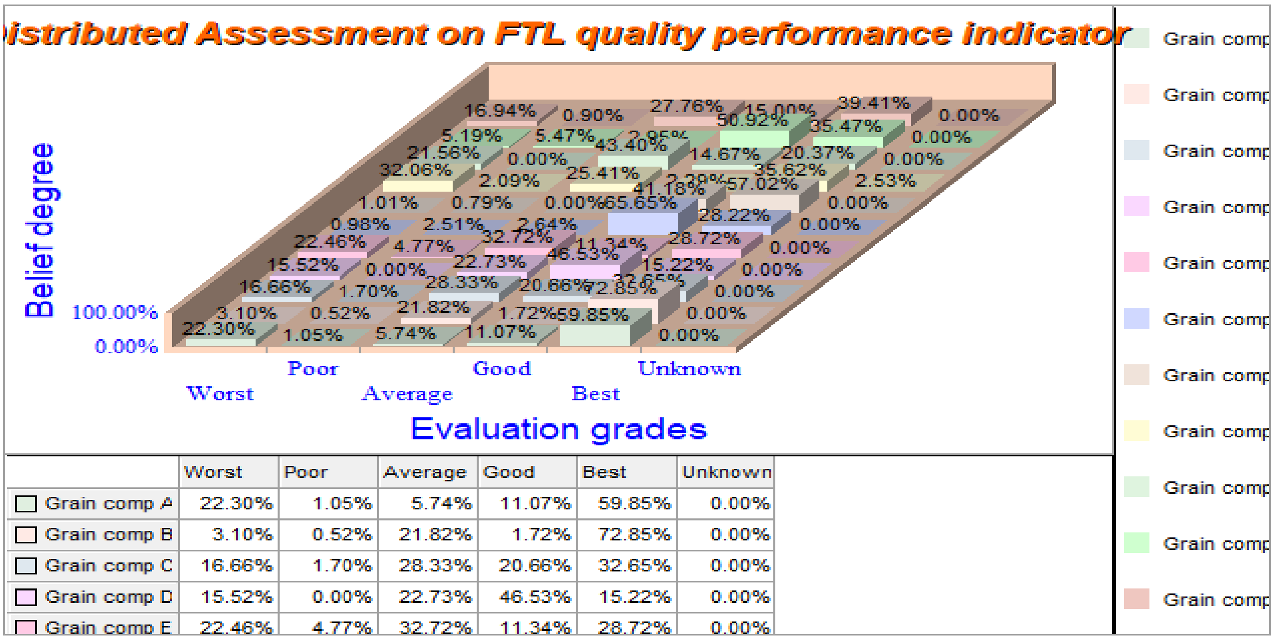


Figure 6. 20: Risk performance index of GBC product handling companies

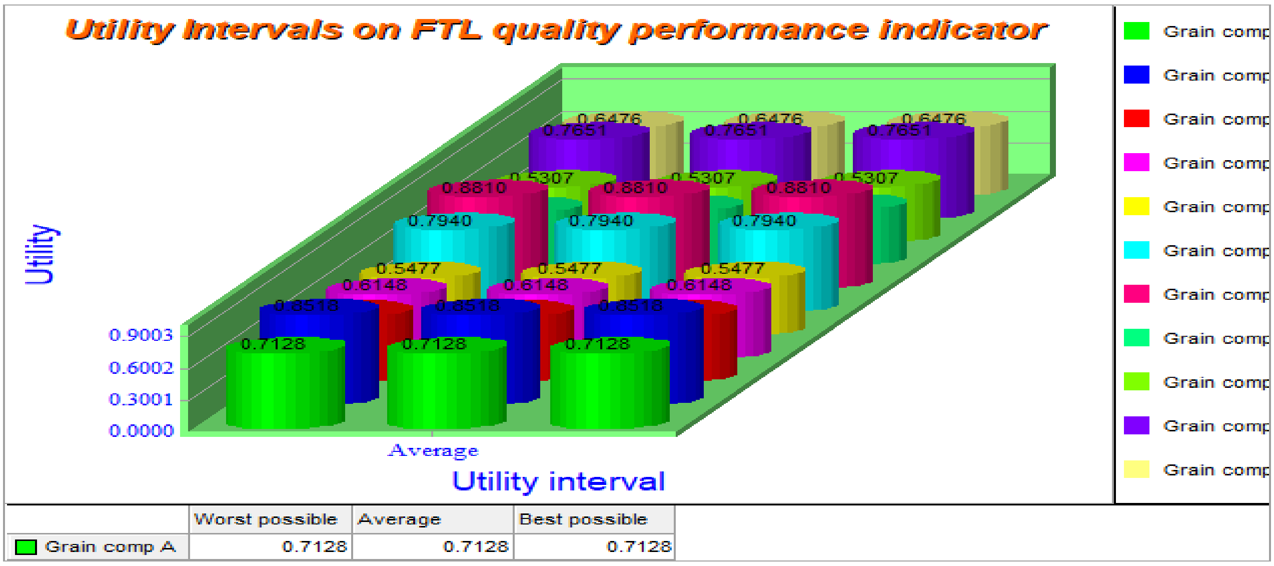


Figure 6. 21 The utility value of the index of grain, cashew and nut handling companies

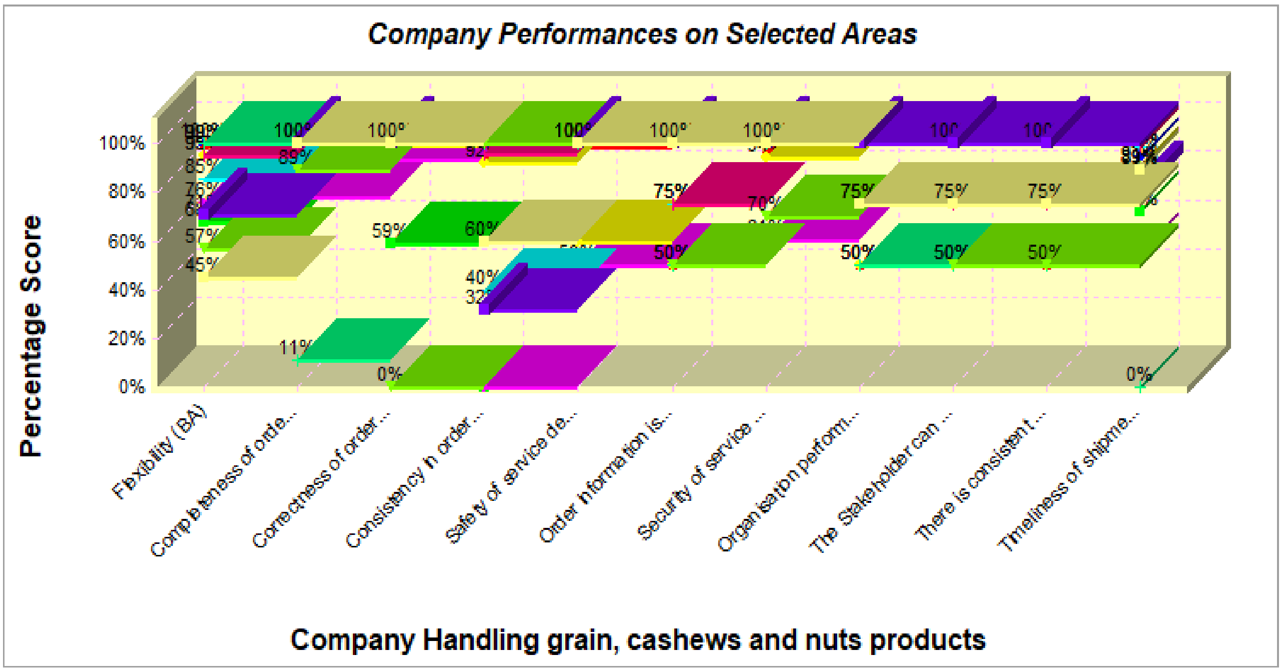


Figure 6. 22 Most influencing attributes on the quality performance of the company

6.5.5.3. Data transformation of the CVI's influencing service quality risk hazard of the AFTL companies handling seafood products

6.5.5.3.1. Quantitative CVI's data transformation

The calculated data value index of the quantitative CVI's received from seafood case companies during the survey are shown in Table 6.25

Take, for instance, Seafood case _company 4 with staff efficiency (e_{12}) value of 15 units of order per person, and time of shipment, pick up and delivery (e_{47}) value of 67,

$$\beta_{1,12} = \frac{5 - 15}{5 - 88.8} = 0.12, \quad \beta_{2,12} = 1 - \beta_{1,12} = 1 - 0.12 = 0.88$$

$$s(e_{12}) = \{ (H_1\ 0), (H_2\ 0), (H_3\ 0)\ (H_4\ 0.12), (H_5\ 0.88)\}$$

$$\beta_{4,47} = \frac{77.5 - 67}{77.5 - 55} = 0.47, \quad \beta_{5,47} = 1 - \beta_{4,47} = 1 - 0.47 = 0.53$$

$$s(e_{47}) = \{ (H_1\ 0), (H_2\ 0), (H_3\ 0.47)\ (H_4\ 0.53), (H_5\ 0)\}$$

Similarly, all the seafood case company's data input (h) values are transformed to a belief of degree as shown in Table 6.26

6.5.5.3.2**. Qualitative CVI's data transformation**

The belief of degree of the qualitative CVI's for seafood case companies are extracted as follows $S(e_i) = \{(H_1\beta_{1,ij}), (H_2\beta_{2,ij}), (H_3\beta_{3,ij}), (H_4\beta_{4,ij}), (H_5\beta_{5,ij})\}$,Where $\beta_{n,ij}$ was evaluated using equation (6.3). Five case companies handling seafood products participated in the evaluation of the CVIs. Hence, Q_i is equal to 5 and $Q_{n,i}$ are the number of case- company expert whose qualitative CVI's is rated H_n. For instance, taking the indicator, "Social responsibilities and concern for human safety (e_{18})" as an illustration

$$e_{18} = \{e_{181}, e_{182}, e_{183}\}$$

The belief degree of the CVI's $e_{181}, e_{182}, e_{183}$ are as follow

$$\beta_{1,181} = \frac{q_{1,181}}{Q} = \frac{0}{5} = 0; \beta_{2,181;} = \frac{q_{2,181}}{Q} = \frac{1}{5} = 0.20; \beta_{3,181} = \frac{q_{3,181}}{Q} = \frac{0}{5} = 0;$$

$$\beta_{4,181} = \frac{q_{4,181}}{Q} = \frac{2}{5} = 0.4; \beta_{5181} = \frac{q_{5,181}}{Q} = \frac{2}{5} = 0.4$$

$$S(e_{181}) = \{(H_1, 0), (H_2, 0), (H_3, 0.2), (H_4, 0.4), (H_5, 0.4)\}$$

$$\beta_{1,182} = \frac{q_{1,182}}{Q} = \frac{0}{5} = 0; \beta_{2,182;} = \frac{q_{2,182}}{Q} = \frac{0}{5} = 0; \beta_{3,182} = \frac{q_{3,182}}{Q} = \frac{1}{5} = 0.2;$$

$$\beta_{4,182} = \frac{q_{4,182}}{Q} = \frac{3}{5} = 0.6; \beta_{5182} = \frac{q_{5,182}}{Q} = \frac{1}{5} = 0.2$$

$$S(e_{182}) = \{(H_1, 0), (H_2, 0), (H_3, 0.2), (H_4, 0.6), (H_5, 0.2)\}$$

$$\beta_{1,183} = \frac{q_{1,183}}{Q} = \frac{0}{5} = 0; \beta_{2,183;} = \frac{q_{2,183}}{Q} = \frac{0}{5} = 0; \beta_{3,183} = \frac{q_{3,183}}{Q} = \frac{1}{5} = 0.2;$$

$$\beta_{4,183} = \frac{q_{4,183}}{Q} = \frac{3}{5} = 0.6; \beta_{5183} = \frac{q_{5,183}}{Q} = \frac{1}{5} = 0.2$$

$$S(e_{182}) = \{(H_1, 0), (H_2, 0), (H_3, 0.2), (H_4, 0.6), (H_5, 0.2)\}$$

Similarly, all the belief degrees of the qualitative CVIs for seafood case companies are calculated as shown in Table 6.27.

Table 6.25: Quantitative CVI's calculated data (h) values for the seafood case companies.

Case company	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
Seafood case_Company 1	20	80	0	75	75	73	80	100	100	0.267	60
Seafood case _Company 2	29.23	99	0.003	75	100	100	99	85	100	0	99
Seafood case _Company 3	25.714	99	0.0033	83	100	100	99	85	100	0	99
Seafood case_Company 4	15	83	0.8333	40	80	50	83	100	100	0	67
Seafood case _Company 5	22.5	88	0.625	50	89	95	88	0	100	0.0125	78

Table 6. 26: Value of the quantitative index of seafood handling companies

	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}
Seafood Case_Company 1	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.18),(H_5\ 0.82)\}$	$\{(H_1\ 0.20),(H_2\ 0.80),(H_3$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2 0),(H_3 0.05)$ $(H_4 0{,}95),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.18$ $(H_4 0.82),(H_5\ 0$
Seafood Case_Company 2	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.29),(H_5\ 0.71)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.16)$ $(H_5\ 0.84)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2 0),(H_3 0.05)$ $(H_4 0{,}95),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 1)\}$
Seafood Case_Company 3	$\{(H_1 0)(H_2 0),(H_3 0)(H_4 0.25),(H_5\ 0.75)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.16)$ $(H_5\ 0.84)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.72),(H_5\ 0.28)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 1)\}$
Seafood Case_Company 4	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.12),(H_5\ 0.88)\}$	$\{(H_1\ 0),(H_2 0.$ $(H_3 0.28)(H_4 0)$ $(H_5\ 0)\}$	$\{(H_1\ 0.96),(H_2\ 0.04),(H_3 0$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.53$ $(H_3 0.47)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.94),(H_5\ 0.06)\}$
Seafood Case_Company 5	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.21),(H_5\ 0.79)\}$	$\{(H_1\ 0),(H_2 0),(H_3 0.92$ $(H_4 0.08),(H_5$	$\{(H_1\ 0.97),(H_2\ 0.03),(H_3 0$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.11$ $(H_3 0.89)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.52),(H_5\ 0.48)\}$

	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
Seafood Case_Company 1	$\{(H_1\ 0),(H_2\ 0.16$ $(H_3 0.84)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0.20),(H_2\ 0.80),(H_3 0)$ $(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0.04)$ $(H_5\ 0.96)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.78)$ $(H_4 0.22),(H_5\ 0$
Seafood Case_Company 2	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.16),(H_5\ 0.84)\}$	$\{(H_1\ 0),(H_2 0)$ $(H_3 0)(H_4 0.60),(H_5\ 0.40)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.04),(H_5\ 0.96)\}$
Seafood Case_Company 3	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.16),(H_5\ 0.84)\}$	$\{(H_1\ 0),(H_2 0)$ $(H_3 0)(H_4 0.60),(H_5\ 0.40)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.04),(H_5\ 0.96)\}$
Seafood Case_Company 4	$\{(H_1\ 1),(H_2\ 0),(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0.72$ $(H_3 0.28)(H_4 0),(H_5\ 0)\}$	$\{\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0.47)$ $(H_4 0.53)(H_5\ 0)$
Seafood Case_Company 5	$\{(H_1\ 0),(H_2\ 0),(H_3 0)(H_4 0.40),(H_5\ 0.60)\}$	$\{(H_1\ 0),(H_2\ 0),(H_3 0.92)$ $(H_4 0.08),(H_5\ 0)\}$	$\{(H_1\ 1),(H_2\ 0)$ $(H_3 0)(H_4 0),(H_5\ 0)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0$ $(H_3 0)(H_4 0),(H_5\ 1)\}$	$\{(H_1\ 0),(H_2\ 0)$ $(H_3 0)(H_4 0.98)$ $(H_5\ 0.02)\}$

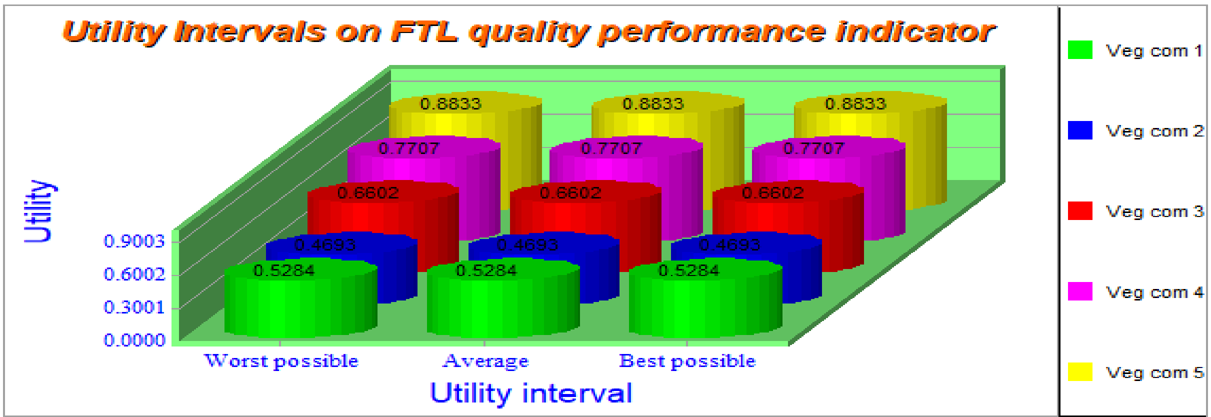
Table 6.27: Qualitative CVI's Belief of degree for the seafood company's data input

Qualitative CVI's		Belief of degree
$S(e_1)$	$S(e_{111})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.40)$}
	$S(e_{112})$	{ $(H_1, 0.20)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.20)$}
	$S(e_{113})$	{ $(H_1, 0.20)$, $(H_2, 0)$, $(H_3, 0.20)$, $(H_4, 0.40)$, $(H_5, 0.20)$}
	$S(e_{114})$	{ $(H_1, 0)$, $(H_2, 0.20)$, $(H_3, 0)$, $(H_4, 0.40)$, $(H_5, 0.40)$}
$S(e_{13})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.40)$, $(H_4, 0.40)$, $(H_5, 0.20)$}
$S(e_{15})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.20)$, $(H_4, 0.40)$, $(H_5, 0.40)$}
$S(e_{16})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.40)$}
$S(e_{17})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.40)$, $(H_4, 0.40)$, $(H_5, 0.20)$}
$S(e_{18})$	$S(e_{181})$	{ $(H_1, 0)$, $(H_2, 0.20)$, $(H_3, 0)$, $(H_4, 0.40)$, $(H_5, 0.40)$}
	$S(e_{182})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.20)$, $(H_4, 0.60)$, $(H_5, 0.20)$}
	$S(e_{183})$	{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.20)$, $(H_4, 0.60)$, $(H_5, 0.20)$}
$S(e_{31})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0.60)$, $(H_4, 0)$, $(H_5, 0.40)$}
$S(e_{32})$	$S(e_{321})$	{ $(H_1, 0.20)$, $(H_2, 0)$, $(H_3, 0.20)$, $(H_4, 0.60)$, $(H_5, 0)$}
	$S(e_{322})$	{ $(H_1, 0.20)$, $(H_2, 0.40)$, $(H_3, 0)$, $(H_4, 0.20)$, $(H_5, 0.20)$}
	$S(e_{323})$	{ $(H_1, 0.20)$, $(H_2, 0.40)$, $(H_3, 0)$, $(H_4, 0.20)$, $(H_5, 0.20)$}
	$S(e_{324})$	{ $(H_1, 0.20)$, $(H_2, 0.20)$, $(H_3, 0.20)$, $(H_4, 0.20)$, $(H_5, 0.20)$}
	$S(e_{325})$	{ $(H_1, 0.20)$, $(H_2, 0.40)$, $(H_3, 0)$, $(H_4, 0.40)$, $(H_5, 0)$}
$S(e_{42})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.40)$}
$S(e_{44})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.40)$}
$S(e_{45})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.40)$, $(H_5, 0.60)$}
$S(e_{46})$		{ $(H_1, 0)$, $(H_2, 0)$, $(H_3, 0)$, $(H_4, 0.60)$, $(H_5, 0.40)$}

6.5.5.4. Data transformation of the CVI's influencing service quality risk hazard of the AFTL companies handling vegetable products

Appendix 11 shows the calculated value index of the quantitative and qualitative CVI data received from vegetable case companies during the survey. The findings show that case Company A is evaluated as 39.72% worst, 3.25% poor, 8.31 % Average 3.40% good and 45.32% best, Company B is evaluated as 43.54% worst, 0.16 % poor, 13.13 % Average 11.39 % good and 21.78% best, Company C is evaluated as 15.56% worst, 1.06 % poor, 11.29 % Average 47.95 % good and 24.14% best, company D is evaluated as 4.10% worst, 2.59 % poor, 3.11 % Average 61.34% good and 28.87% best and company E is evaluated as 1.64% worst, 0.18 % poor, 0.42 % Average 38.75% good and 59.02% best.

Hence, the company's utility index is calculated as shown in Figure 6.24. Vegetable handling Company E has the highest utility index value of 0.8833 followed by vegetable handling company D with a utility index value of 0.7707, Vegetable handling company B had the least utility index value of 0.4693. Moreover, an average range utility index value of 0.6763 is obtained based on the average range value between the utility value of the highest performed company and the utility value of the lowest performed company. This value serves as a benchmark value to measure the quality performance of similar vegetable handling companies in a future study. Furthermore, comparing the quality performance of the company concerning individual attributes groups, most of the companies had a quality performance score higher than 50% except one with a 46% quality performance score in the attributes in the management group, and two of the company had 16% and 0% quality performance score in the attributes in the resource group and one of the company had 26% quality performance score as shown in Figure 6.25, this denotes that quality performance of FTL companies handling vegetable products are mostly influenced by the attributes in the management and resource group.



	Worst possible	Average	Best possible
Veg com 1	0.5284	0.5284	0.5284
Veg com 2	0.4693	0.4693	0.4693
Veg com 3	0.6602	0.6602	0.6602
Veg com 4	0.7707	0.7707	0.7707
Veg com 5	0.8833	0.8833	0.8833

Figure 6. 23: The utility value of the index of the company handling vegetable products

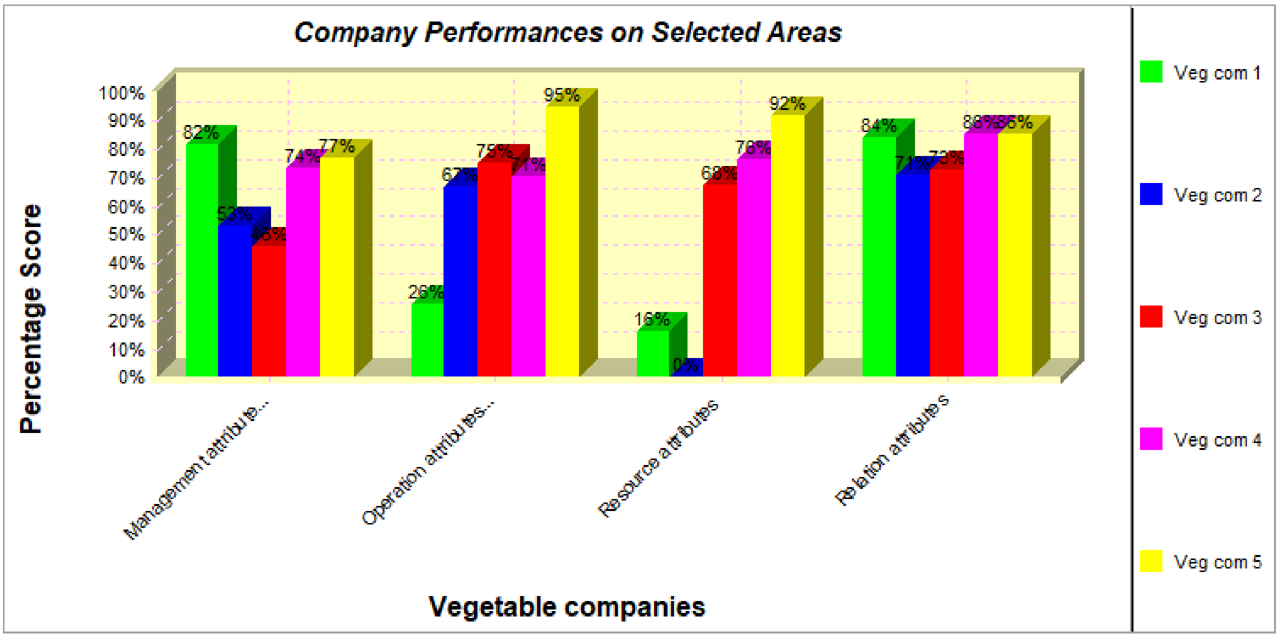


Figure 6. 24: Most influencing attributes on the quality performance of the company handling vegetable products.

Table 6.28: Summary of the comparative assessment of CVI's influencing service quality risk hazard of the AFTL companies handling Agro-food products

	General Agro-food product	***Grain, beans and cashew nut products.***	***Seafood products***	***Vegetable products***
A benchmarked quality performance value **(%)**	**66.40%**	**70.58%**	**60.83%**	**67.63%**
The Topmost influencing CVI's to enhance the quality performance of the AFTL companies	➢ Flexibility,	➢ Flexibility,	➢ Tangibles,	➢ Responsiveness to customer needs,
	➢ Completeness of order,	➢ The safety of service delivery,	➢ knowledge and understanding of the customer,	➢ knowledge and understanding of customer requirements,
	➢ The correctness of order,	➢ Availability of order information,	➢ Organisation degree of openness in the information exchange,	➢ Staff efficiency,
	➢ The safety of service delivery,	➢ The security of service delivery	➢ Collaboration with other partners,	➢ Tangibles,
	➢ The security of service delivery,	➢ The organisation performing the promised services,	➢ Upholding the moral and ethical standards,	➢ Collaboration with external partners.
	➢ Timeliness of shipment, pickup, and delivery	➢ Allowing the stakeholder to place orders conveniently,	➢ The safety of service delivery,	➢ The condition and availability of equipment and facilities,
		➢ A consistent procedure in the handling of orders	➢ The organisation performed the promised service,	➢ Application of IT and electronic data interface in customer services,
		➢ Timeliness of shipment, pickup, and delivery	➢ Allowing stakeholder to place their order conveniently,	➢ Consistency in storage and warehousing,
			➢ A consistent procedure for handling orders	

6.6. Conclusion

Food transport and logistic service quality play a critical role in contributing to global food safety standards. However, there is limited research on this topic, and the validated quality measuring attributes developed in this study are of great benefit to academics, practitioners, and stakeholders in the food transport and logistic chain. This chapter provides insight for AFTL service providers on how to enhance service quality and maintain competitive performance. Although the study identified and validated a comprehensive list of important CVIs to measure service quality in the AFTL chain and analysed the cause-and-effect interdependency relationship using empirical data from three developing nations (China, Thailand, and the Republic of Vietnam. The DEMATEL and ER algorithms were integrated into the multi-criteria hierarchy framework to assess the relative weight of the lower-level attributes and estimate the top-level goal (quality Performance). The study demonstrated the proposed model via a comparative analysis of the quality performance assessment of companies handling the transportation and logistics of agro-food products (i.e vegetables, seafood, grain, beans and cashew nut products) from China, Thailand and the Republic of Vietnam to the global market as presented in Table 6.28. The study contributes to the existing literature in the food supply chain, by first developing a standard grade for the evaluation of quantitative attributes in the AFTL chain, evaluating the most influencing attribute to enhance the quality performance of AFTL servicing companies i.e. flexibility, completeness of order, the correctness of order, the safety of service delivery, the security of service delivery, availability of order information, a consistent procedure in the handling of orders and timeliness of shipment, pickup and delivery and also serves as a rational way to self-assessed and benchmarked the quality performance of logistic companies based on the estimated quality performance benchmarked value for the AFTL companies handling grain, cashew, seafood, and vegetable products. This work closed the uncertainty gaps associated with the lack of assessor experience and its consequence of giving a subjective bias judgement during the AFTL company quality audit. The proposed quality performance benchmark value will provide the audit assessor with a logical way to justify the quality performance assessment score in the food supply industry.

CHAPTER SEVEN - IDENTIFICATION AND EVALUATION OF AFTL SERVICE QUALITY MITIGATION STRATEGIES

7.1. Introduction

This chapter discusses the final stage of the AFTL risk management process. It highlights the identification, validation, and evaluation of the mitigation strategies for the service quality risk in the AFTL chain. The study adopts a three-stage process for implementing mitigation strategies. First identifying the service quality control measures/indicators from the literature review, followed by an in-depth interview based on a structured questionnaire to validate the identified service quality control measure and the exploration of the new service quality mitigation strategies. The identified control measures are prioritised using the Fuzzy TOPSIS method.

7.2. Methodology for AFTL service quality mitigation strategy identification and evaluation

The proposed service quality mitigation strategy for the AFTL company as presented in figure 7.1 will be implemented following the below steps.

Step 1. An in-depth literature review to identify service quality mitigation strategies as applicable to the AFTL chain.

Step 2. Develop a semi-structured questionnaire to evaluate the identified service quality mitigation strategies and distribute it to an industry expert to provide their judgement based on experience about the prioritisation ranking of implementing the mitigation strategy on service quality variables. This is followed by the application of the fuzzy TOPSIS model to prioritise the importance of mitigation strategies.

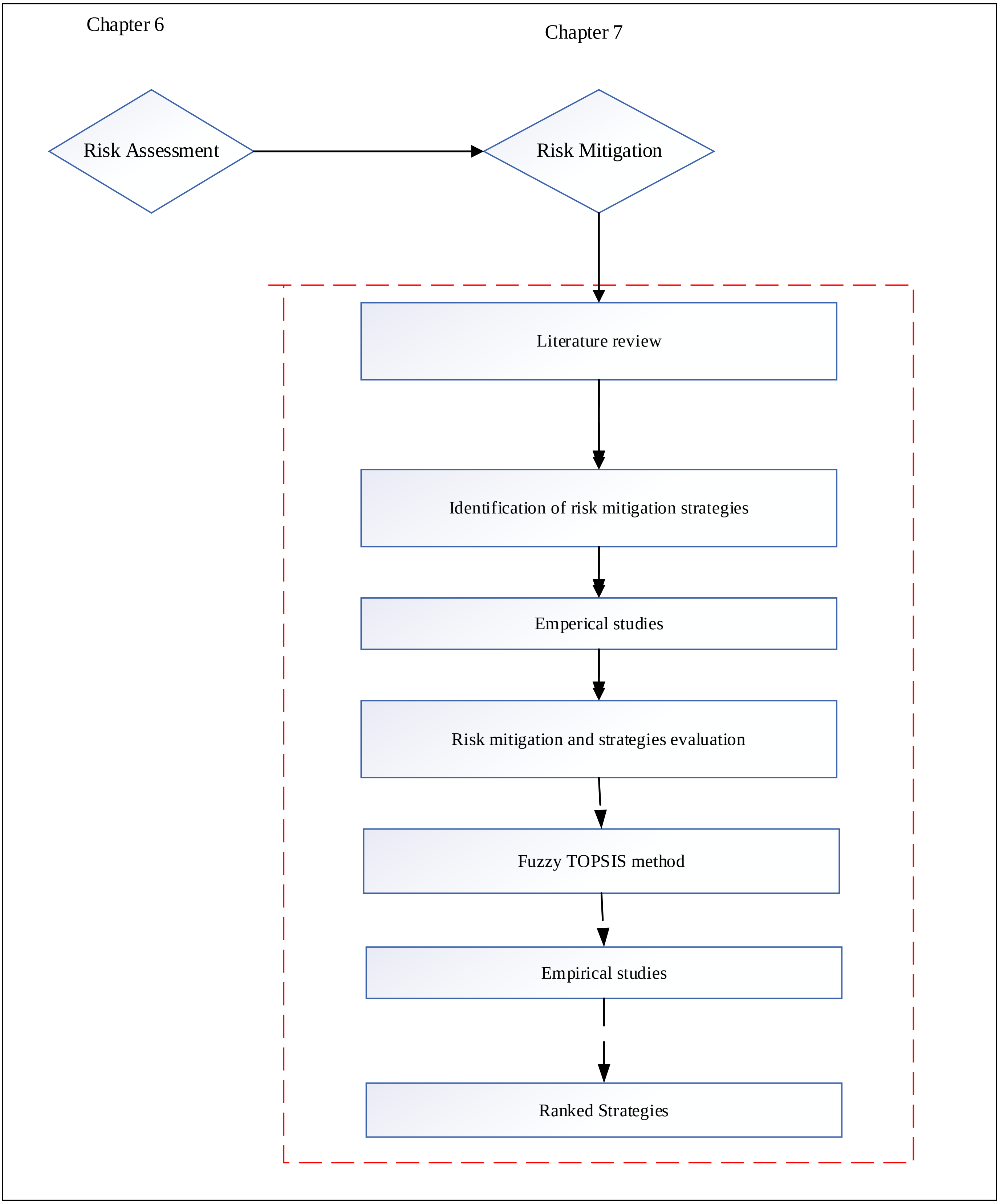


Figure 7. 1: Risk mitigation model for service quality in the AFTL chain.

7.3. Identification of the service quality risk control strategies from the literature review

7.3.1. Literature Review

A service quality mitigation strategy plays a vital role in an organisation achieving its objectives and gaining a competitive edge. It is defined as the steps taken by a service provider to ensure consistency in the quality of service delivery Sichtmann et al., (2011). According to Aljohani et al., (2017), organisation strategies to control service quality risk can be derived from two groups, namely the formal and informal strategies of control. Formal strategies of control refer to the drafted management control measures that enable stakeholders to behave in a manner that will support the organizational objectives. These strategies are further categorised into three-stage (Input, process and output) control actions. The input stages are the control strategies available to the management before actions are implemented such as recruitment of the right employee, training programme, manpower development, resources allocation and strategic planning. The process stage represents the standard operating and documented procedures developed by the management to assess their stakeholder's behaviour or thoughts in meeting up with the organisation's objectives and the Output stage actions represent the tools available to management to assess the stakeholder's behaviour concerning their performance's standard such as rewards and recognition. (Rosenzweig et al., 2019) Contrary, the informal strategies of control are the un-written mitigation designed by the management to influence the employee behaviour in meeting up with their objectives, with an argument that organisation service quality will improve whenever the stakeholders and employees are satisfied with the internal working environment such as the organisation policies and procedure, tools, management support, communication, goal alignment, and teamworking respectively (Aljohani et al., 2017). In attempts to minimise the deterioration in services quality, various service quality control strategies derived from the above classification had been proposed in the management literature, such as 1) The adoption of team collective efficacy a process whereby the organisation select a group of independent employee that understood the process of their services to have a collective efficacy and shared a common belief or confidence in team capability, to organise and executes the actions that will provide the standard level of quality the organisation required (Schepers et al., 2008), 2) the adoption of the dashboard and balanced scorecard that shows scores based on the weight of key indicators that measured the quality of service performed. A scorecard will provide a readily available value of the organisation's service quality index and provide the managers immediate information to compare the value against all other outlets (Wilson, 2000), 3) the adoption of quality assurance (QA) management strategies that ensure the organisation service quality meets the requirement of the service users by creating value and having an in-depth understanding of the customer wants and defining the service users demand rightfully. It is determined by inspection, testing, and auditing as to whether the company processes and system conform with the contractual agreement (Bretholt et al., 2010). Although, the QA management strategy has drawbacks when quality variables are multi-dimensionally or when the performance measurements are imprecise, especially when dealing with third-party certified companies (Dean and Terziovski, 2010), 4) the adoption of the six sigma methodology, a statistically-based quality control program that assists an organization to improve in the service performance quality following a five steps process of (DMAIC) "Define (define the problem and determine which processes need improvement), Measure (collect all the necessary data from the client to measure the current process), Analyse (identify the root causes of the poor performances from the provided data), Improve (improve the process by taking actions to reduce the number of defects), and Control (reduce defects via a change in the process)" (Nakhai and Neves, 2009). Although, the Six Sigma methodology has a wider application in the management of quality in the cooperative organization (Prajogo, 2005a). However, its application has drawbacks, 1) it requires a highly repetitive process with no or very low human behaviour component, 2) the tool is not designed to depict the relationship between key performance metrics i.e poor information quality relationship between service performance measures, 3) it is difficult to gather data to measure stakeholder satisfaction hence providing insufficient help in improving service quality and meeting stakeholder expectation (Prajogo, 2005a). Finally, the implementation of total quality management (TQM) practices, is an approach that is widely used in the academic literature as explained below.

7.3.2. The implementation of total quality management practices (TQM)

TQM is a general management philosophy that "embodies a set of generic core principles which are unconstrained by industry-unique considerations" (Prajogo, 2005). TQM principles and techniques are a universally adopted set of practices implemented by managers aiming for a high standard of performance based on the component of the organizational structure such as leadership, management of people, customer focus, use of information technology, process management, strategic and quality planning (Motwani, 2001). Is a holistic approach that seeks management quality through the development of strategy and framework for implementation with a focus on meeting stakeholder needs and organisation objectives (Talib et al., 2012). Empirical evidence had suggested that the implementation of TQM practices in the service industry had a positive correlation with the management of the quality of performance (Brah et al., 2002). Many quality managers and practitioners from various service sectors had embraced and provided different sets of principles and practise essential to the implementation of good TQM, (Motwani, 2001; Prajogo, 2005; Fotopoulos and Psomas, 2010; Talib and Rahman, 2010; Talib et al.; 2012). For instance, Prajogo (2005) demonstrated that the implementation of the TQM model based on Malcolm Baldrige National Quality Award

(MBNQA) criteria and its soft principles that highlight attitudes and behaviours such as leadership, customer focus, empowerment, involvement, and cultural elements has a significant impact on service quality. However, there are no unique TQM practices adopted in the literature for the service industry to yield the desired quality outcome. Although, Woon, (2000) in their study argued that the soft element of TQM that emphasized attitude and behaviour are more applicable to the service organisation and that service firms can selectively apply the element in practice. Table 7.1 presents the comprehensive list of the soft elements of TQM reviewed from the academic literature that is widely acceptable by TQM practitioners, scholars, and prestigious quality awarding bodies (MBNQA), European Quality Award (EQA), Asia-Pacific Business excellent and standard award, and the Republic of Vietnam quality award) in managing organisation performance quality. Based on the list, a conceptual framework of the eleven validated soft elements of the TQM principle and practices were proposed to mitigate the causal variables on the service quality risk in the AFTL chain, as illustrated in Figure 7.2

Table 7. 1: Review elements and dimensions of TQM practices

	Kanji and Wallace, (2010)	**Brah et al (2000)**	Brah et al., (2002)	Tsang et al., (2018)	Hasan and Kerr, (2003)	Prajogo, (2005)	Hoang et al., (2006)	Rahman and Siddiqui, (2006)	Mahapatra, (2006)	Sila, (2007)	Bayraktar et al., (2008)	Fotopoulos and Psomas, (2010)	Sadikoglu et al., (2010)	Talib and Rahman, (2010)	Faisal and Zillar (2010)	Kumar et al., (2011)	**Talib et al., (2012)**	Basu and Bhola, (2016)	Rosenzweig et al., (2019)
Transformation Leadership and Top-management commitment	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Customer focus and satisfaction	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	
Employee training and development		x	x	x	x		x		x		x	x	x	x	x	x	x	x	x
Continuous improvement and innovation	x			x								x	x	x	x	x	x	x	
Supplier management				x	x				x	x		x	x	x	x		x	x	
Employee involvement		x	x		x	x								x	x		x		
Analysis of Information	x						x			x		x	x	x	x		x		
Process management	x	x	x				x		x	x		x	x				x	x	
Organisation quality culture	x					x			x										
Quality Performance measurement /Benchmarking	x	x	x		x			x	x		x			x	x		x		
Quality assurance	x			x					x								x		
Human resource management	x								x	x			x				x	x	
Strategic planning							x		x			x					x	x	
Employee encouragement														x	x		x		
Teamwork and involvement	x			x		x	x					x				x	x	x	x
effective communication	x			x												x	x		
Quality system and policies				x														x	x
Employee satisfaction					x				x										
Employee appraisal									x										

Reward and recognition			x						x		x								x
Relentless improvement reward		x						x			x								
Strengthening the employee base								x											
Employee empowerment		x					x									x			
Product and Service design		x	x		x		x				x						x	x	
Cleanliness and open organisation		x	x				x												
Vision											x								
Feedback/ service reporting																x		x	x
Content management																		x	

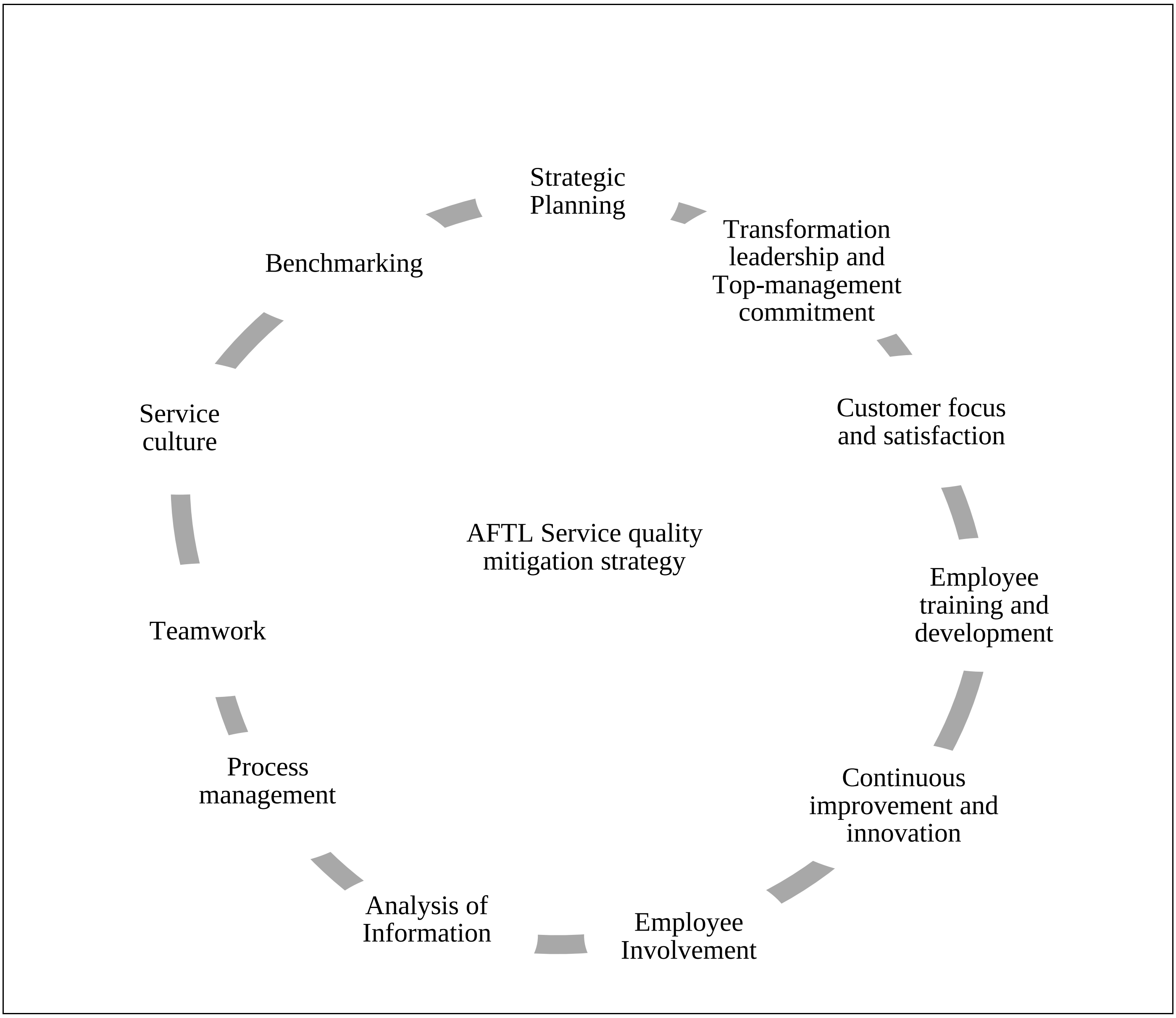


Figure 7. 2: Conceptual framework

7.3.2.1. Overview of the identified mitigation strategies

7.3.2.1.1. Transformation leadership and top management (Strategy one)

Transformation leadership aim to create a radical shift in the values, culture, structure and routine activities of AFTL companies Canterino et al., (2018). It is a participative style of leadership that improve morality, internal motivation, and the performance of an employee by changing the employee's mindset, behaviour and organisational effectiveness. To address the uncertainty, complexity, and deterioration of quality in service delivery, AFTL companies need to adopt an agile and transformative leadership style that can adapt to the magnitude, orientation, and characteristics of every problem faced by the firm. According to the global megatrend future state 2030 report produced by KPMG International (2014).

"*Organisations need to be prepared and be able to translate their challenges into a clear vision and action as faces a volatility, uncertainty, complexity and ambiguity world and a global megatrend"*

A recent supply chain management report stated that: *"Transformational leadership has a positive impact on developing organisational sustainability capabilities to enhance organisational sustainable supply chain management performance. they are referred to as those styles of leaders who try to show the organizations a new route for improvement and progress by generating new ideas and perspectives, mobilizing the organization by motivating managers, employees, and members of the organization to radical changes, transforming organizational pillars to achieve necessary readiness and capabilities to move in this new route as well as achieving higher levels of idealized performance. Transformational leaders change their followers, empower them to develop and create new needs, tendencies and values because that their requirements are met" (Amin et al., 2019).*

On the other hand, leaders directly or indirectly account for fifty per cent of the variance in the firm's service quality performance (Canterino et al., 2018). Adoption of a transformation leadership style by AFTL companies will truly motivate staff, encourage them to put the firm interest above personal interest, improve their motivation, morality and work closely with other staff through developing idealism and values in achieving shared goals (Juhro and Aulia, 2017)(Juhro and Aulia, 2017). As part of the strategies, the main task for the leaders in AFTL companies is to build and enhance the organisation structure that reflected the new business strategy and develop new shared values and the type of attitude that will unify staff throughout the organisation. Leaders can allow staff to grow their talent and creativity, promote a culture that encourages team decision-making and behaviour control, inspires staff self-confidence to perform work and change staff attitude to achieve a greater commitment to transformational goals.

7.3.2.1.2. Customer focus and satisfaction (Strategy Two)

Customer focus as a key aspect of a firm strategy on performance had amply been documented by management scholars (Lado et al., 2012). Is defined as "the process of identifying and establishing, maintaining, enhancing, and when necessary terminating relationships with customers and other stakeholders" (Grönroos, 2004). According to Lado et al., (2012), It is a strategic tool to drive supply chain relational capabilities and performance, practices by commending the virtue of getting closer to the customers, integrating the organisation operates with a customer mindsets, periodically conducting a survey to identify customer needs and building a long-lasting relationship with the customers. A food logistic manager during the survey acknowledges the relevance of the customer focus and satisfaction strategies. He stated that:

"As a food supplier, we implement a customer focus strategy while handling and transporting our food products, to ensure there is no drop in the quality of service we provide and to gain the trust of customers in our deliverables"

Hence, in the effort to pursue quality standards and to mitigate the service quality risk on performance, AFTL firm needs to adopt a customer focus and satisfaction strategy as a tool to manage the emerging customer requirements and future expectations.

7.3.2.1.3. Employee training and development (Strategy Three)

According to the chartered institute of personnel development (2011), "Employee training and development is an important strategy to establish organisation effectiveness." It's a tool that enables an organisation to shape its employee's competence in their service delivery. To improve service delivery and reduce the quality gap, systematic training and employee development strategies can help to promote employees' learning of competencies in terms of knowledge, skills and attitudes otherwise considered essential to competently execute their routine activities (Schmitt and Singh, 2012). The importance of employee training and development strategy to enhance organizational performance in an emerging global environment had been supported by various scholars in the academic literature, to mention a few; Bell et al., (2017) in their reports explain that employee training and development, "is *a strategic tool to govern team process, organisational outcome and enhance staff capabilities, allowing the organisation to update and empower their personal and professional characteristic so that their staffs can generate and develop ideas for innovation*."

Urbancová et al., (2021)(Urbancová et al., 2021), also reported that employee training and development, "*is a systematic process of changing poor working behaviour and the level of staff knowledge, abilities and skill, employee motivation, which help to reduce poor performance gap and increase the labour productivity".*

The adoption of employee training and development strategies as a useful tool to mitigate the deterioration in service quality in the AFTL chain will, foster the organisation's staff learning, enhance the human resource practices and enables employee and management to develop their knowledge and skills in fitting the organisational needs. Although employee training and development in an organisation does not have a standard way to be managed and implemented, AFTL firm can develop employee training and development strategies based on their value, belief and practices (Polo et al., 2018)

7.3.2.1.4. Continuous Improvement and Innovation (Strategy Four)

The council of supply chain management professionals defined continuous improvement and innovation as "the implementation of a new or significantly improved organizational business model, practice or technological application within the context of planning, implementing and controlling procedures for the efficient and effective transportation and storage of goods, including services and related pieces of information, from the point of origin to the point of consumption to conform to customer requirements." Historically, improvement and innovation strategies had played a vital role in increasing efficiency (Aziz and Samad, 2016; Salunke et al., 2019; El-Kassar and Singh, 2019). It enables organisations to develop a new, unique and differentiated service by continually gathering market-specific information and keeping up with new business trends, a determinant of achieving a competitive advantage (Lee and Song, 2015; Tavasszy, 2020). This is also supported by a quote from a recent report published by Tavasszy, (2020). He stated that: *"Logistic firm aiming to achieve economic goals and increase diversity in service delivery need to be* *innovative in its shipment distribution channel based on the customer wishes, supplier choices, intelligent logistic outsourcing, a telematics system in global transport flow for identifying transport unit in service and be responsive to the changes in customer needs"* (Tavasszy, 2020).

Therefore, the AFTL firm needs to implement continuous improvement and be more innovative in their business by integrating new technologies, developing new mobility concepts, new organisation structure, new process technologies and new plans for the organisation staff. Its implantation will allow AFTL companies to mitigate service quality risk and realise long-term strategic competitiveness.

7.3.2.1.5. Employee Involvement (Strategy five)

According to (Bosak et al., 2017), "Employee involvement" is defined as the opportunities that are given to an employee in a workplace to contribute their views and actively participate in day-to-day decisions on how services are delivered" i.e having employees directly participating in the work-related decision, contributing their views and taking active roles in decision making at the workplace. Employee involvement is an advocated tool to improve organisation performance, it involved advancing employee skills, enhancing employee incentives and improving their participation. in the company process. A quote from a logistic report stated that:

"Employee involvement is an important strategy in a dynamic environment. Most activities within the transport and logistic industry require group interaction rather than individual effort, thus transport and logistic company working with a high level of employee involvement are more likely to realise their potential." (Feisel et al., 2011).

"Organisation will generate a better performance when employees are provided with a platform to contribute their efforts i.e. high involvement."(Fu et al., 2013)

"*Involving employees with the organisation process and during the execution of the task, and providing them with the opportunities to make a significant contribution to the organisation's success, will enable the employee to understand their roles and gradually develop a sense of humour in identifying task"*(Kuk, 2004).

Moreover, AFTL company obtaining maximum benefit from employee involvement by creating a problem-solving group and delivering feedback information will find it advantageous to establish strong performance quality.

7.3.2.1.6. Analysis of Information (Strategy six)

The Malcolm Baldrige National Quality awarding (MBNQA) body comment information analysis as a scope of management tools to maintain a customer focus and drive quality excellence entails the sharing and collection of tangible details from the customer about the firm service delivery and identifying the changing needs of the customers. The Empirical studies in the literature reviewed that service firms that consistently gathered relevant information on service delivery and analysed them before making management decisions to inhibit performance in their organisation will be well successful than those that do not (Teh et al., 2009). The efficient use of information analysis help service organisation reduces the detrimental conflict of their customers by working closely with them to jointly develop a process that creates a better opportunity for the firm (Narasimhan et al., 2002). To mitigate the causal variables in the FTL chain and improve the service quality performance, AFTL firm should adopt information and analysis strategies to collect the relevant information on the causal variables and analyse the need and expectations of the customer. The reliability of such information will reduce the conflict among the organisation's functional departments and enable their employee to have a better understanding of their role and the action needed to improve the quality-of-service delivery.

7.3.2.1.7. Process management (Strategy seven)

The concept of process management lacks a generalizable definition in the academic literature. Based on the comment of Navarro, (2021) from a business perspective, “process management” is a sequence of activities, within the AFTL chain that gives the organisation value to input and delivers either an internal or external output to a customer. Is a strategy used for continual improvement of organisation processes and for creating value for the customer (Cronemyr et al., 2013) Its application involves 1) defining a need to measure organisation task scope from design, 2) establishing realistic goals, and 3) developing a dedicated team within the organisation that will lead the firm into a directional path to achieve its strategic goal and gain competitive advantage in the market (Navarro, 2021). Process management as a quality performance strategy had been highly recommended for service organisations aiming to achieve a higher quality in their service delivery. To mention a few comments from experts and scholars thus:

"The Implementation of the process management methodology had helped several organisations to successfully identify their customer need and determined their way to work to achieve customer satisfaction." Process management provides the organisation with the structural process needed to manage, prioritise, and increase efficiency and effectiveness (Navarro, 2021)

*"Process Management is a way of organising quality work to improve customer satisfaction and reduce internal costs and thus improve company profit" (*Cronemyr et al., 2013).

"The process management improves the service quality of the organisation and increases the employee productivity in the most efficient and effective manner to achieve desired performance" (Sit et al., 2009).

However, the provision of proper guidance on the appropriate action, based on the adoption and implementation of the process management strategy, can help mitigate the causal service quality risk in the AFTL chain.

7.3.2.1.8. Teamwork (Strategy Eight)

The concept of "Teamwork" as a service quality mitigation strategy is positively associated with employee job satisfaction and commitments. According to Yang, (2006) organisations implementing a teamwork practice, work for improving quality as a result of a committed and involved workforce. Ooi et al., (2007) also suggested that teamwork facilitates the meeting of organisation goals. It provides an atmosphere of mutual participation and team involvement to drive a common goal. Implementation of a teamwork strategy will help AFTL company to manage the causal variables.

7.3.2.1.9. Service culture (Strategy Nine)

Organizational culture has a powerful effect on the performance and long-term effectiveness of the organization performance. It refers to the various elements within the organisation sphere such as values, rules, habits, ideals and symbols the employees hold in common. These features influence the shared value and the way employees react to the situation. A good service culture will enhance the internal organisation structure, employee capacity, trust and confidence in the firm which are related to the service performance quality of the company.

7.3.2.2.0. Benchmarking (Strategy Ten)

Benchmarking is a process of comparing an organisation's internal performance information with those of best-in-class performers from outside the organisation. Is a continuous systematic process, acting as a yardstick to determine if an organisation's strategic plans are having the desired effect (Sit et al., 2009). The importance of benchmarking strategy to improve organisation service delivery was highlighted in the study of Yusuf et al., (2007). Its application involves benchmarking the organisation's activities with the competitors and making a judgement on developing the most appropriate measures to collect tangibles data on the competitor's strength and assess the strength against the firm performance (Yusuf et al., 2007)

According to Bryson, (2018) *"Benchmarking strategy has become the impetus for transmitting good organisation practises, offering a significant value through the diffusion of new ideas, innovating and best practises."*Gloet and Samson, (2019) also commented that *"Benchmarking strategy provides a focus and formalised way to managing changes which can create an environment for success. It is a proactive process to change a company operating structurally to achieve superior performance, by allowing managers to gather tangible information to compare their company's performance with a leading-edge performer*

Moreover, the adoption of benchmarking strategy to mitigate the causal service quality risk in the AFTL chain will enable the companies to evaluate their operational activities against the causal variables, by comparing all their internally generated data with externally derived data, making it easier for the firm to identify the challenges before they are overwhelming. Hence, acting as a yardstick to measure and improve performance.

7.3.2.2.1. Strategic planning (Strategy eleven)

Strategic planning is one of the most important tools of management to position a firm and prioritise its usage of resources according to the set goals (Aldehayyat et al., 2011). Alosani et al., (2019) argued that in today's dynamic environment, strategic planning remains one of the most effective factors to enhance organisation performance. Organisations used strategic planning as a managerial toolkit to tackle uncertain situations and bridge their performance gaps. It enables service firms to focus on the factors that have a high impact on their service delivery by identifying their strength and weakness and plans to maximise strengths, overcome the weakness and determine resources to accomplish the set goals (Salkic, 2014). According to Teh et al., (2009) strategic planning has four approaches namely,

- Improving the relationships with customers, suppliers, and business partners and understanding their needs.
- Development and deployment of appropriate plans,
- Diversification of products and services
- Attracting and holding on to quality staff

Falshaw et al., (2006), also suggested that the implementation of a strategic planning system enables a firm to connect its long-term goals to its operational plan and unify actions to improve effectiveness and performance. In agreement, Posch and Garaus, (2020) commented that strategic planning will enable the organisation to enhance its innovation, and motivation, stimulate new ideas, set strategies and procedures for each new idea, build up teams, control results and evaluate all the available options to attain success. Bryson, (2018) also mentioned some of the benefits of implementing a strategic planning system in a service organisation. To mention a few, 1) enhancing the strategic thinking and actions within the companies, 2) greater improvement in the quality of services delivery 3) greater improvement in the organisation's decision-making process, 4) clarity in the direction of the firm and enhancement coordination between the department and staff. Therefore, strategic planning is sometimes seen as an option to manage the causal variables and improve the AFTL company's service quality performances

7.4. The evaluation of the risk mitigation strategies

The selection and ranking of the possible alternates, often require the use of both quantitative and qualitative assessment to establish the relative importance of the verified strategies concerning the objective of ranking and selecting the service quality risk mitigation strategies. It usually results in an uncertain, imprecise, indefinite presentation of subjective data which makes the decision-making process more complex and challenging (Yang et al, 2010). Fuzzy Techniques for order preference by similarity to an ideal solution (TOPSIS) is one of the most practical and useful methods to handle this imprecision and subjectiveness (Chen et al., 2006.; Yang et al., 2009). Fuzzy logic provide the flexibility needed to handle the imprecise information due to the lack of knowledge, using the concept of fuzzy number to pursue the best alternative of each strategy in a simpler mathematical form (Yang et al., 2009b). TOPSIS method provides the ranking and selection of the possible alternatives based on their largest distance from the negative ideal solution (NIS) i.e solution that maximises the cost strategies and minimises the benefits strategies and the shortest distance from the positive ideal solution (PIS) i.e solution that maximise the benefit criteria and minimise the cost criteria). The practical application of this method in solving multi-criterial- decision making (MCDM) problems had been published in various academic journals such as in the innovative performance in higher education (Cai et al., 2010), cold chain performance improvement (Joshi et al., 2011) transportation system (Awasthi et al., 2011), and third party logistic selection (Singh et al., 2018). The procedural steps for fuzzy TOPSIS application based on (Yang et al., 2010) are presented in Figure 7.3

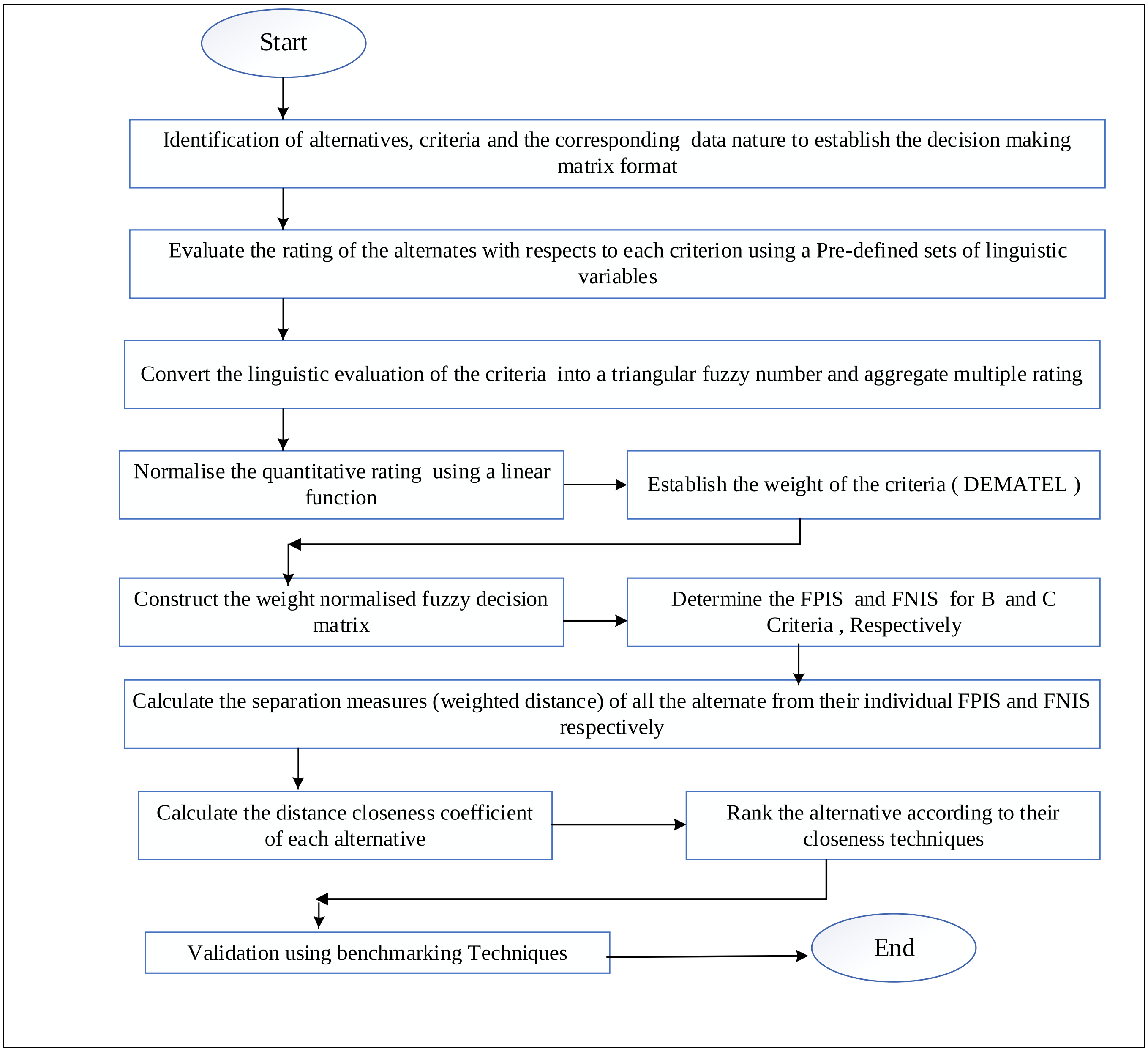


Figure 7. 3: Flow chart of the fuzzy TOPSIS method

Step 1. Assessing the importance of the criteria using a pre-defined linguistic weighting variable. It is assumed that there is J a possible alternative called A=$\{A_1, A_2\ A_{3,} \ldots\ldots A_M\}$ which are to be analysed against $\dot{m}$ criteria, $C = \{C_1, C_2\ C_{3,} \ldots\ldots C_n\}$. the criteria weight is denoted by W_i $(j = 1, 2, \ldots. n)$. The performance ratings of each expert $D_K(K = 1, 2, \ldots. K)$ for each alternative $A_i(i = 1, 2, \ldots. m)$ with respect to criteria $C_j(j = 1, 2, \ldots. n)$are denoted by $R_k = X_{ijk}$ $(i = 1,2, \ldots. m;\ j =$

$1,2 \ldots n$; $k = 1,2 \ldots \ldots K)$ with membership $\mu Rk\ (\dot{x})$. The decision-maker uses the linguistic variable in table 7.2 to evaluate the rating of each alternative concerning the various criteria

Table 7. 2: Linguistic variable for the rating

Very poor (VP)	(1,1, 3)
Poor (P)	(1, 3, 5)
Medium (M)	(3, 5, 7)
Good (G)	(5, 7, 9)
Very Good (VG)	(7, 9, 9)

Step 2. Convert the linguistic evaluation of the criteria C_j into a triangular fuzzy number and aggregate the fuzzy rating X_{ij} and weighting W_j of the alternatives concerning the criterion.

Assuming K experts are involved in the MCDM analysis, then the importance of the criteria and the fuzzy rating of the expert and kth experts can be described as $R_k = (ak, bk\ , ck\ ), k\ =\ 1,2, \ldots . K$, and the aggregated fuzzy rating of the expert is presented as $\underline{R} = (a, b, c)\ k\ =\ 1,2, \ldots . k$ where

$$a = \{a_k\}\ , b\ =\ \frac{1}{k}\sum_{k=1}^{k}, bk_1\ c\ =\ \{c_k\} \qquad (7.1)$$

For the Kth experts, the fuzzy rating is given as $X_{ijk}\ =\ \left(a_{ijk}\ b_{ijk}\ \ c_{ijk}\right), i\ =\ 1, 2, \ldots \ldots\ m\ , j = 1, 2 \ldots \ldots \ldots n$, then their aggregated fuzzy rating X_{ij} of the alternatives concerning each criterion are presented as $X_{ijk}\ \left(a_{ij}\ b_{ij}\ \ c_{ij}\right)$ where

$$a_{ij} = \left\{a_{ijk}\right\}, b\ =\ \frac{1}{k}\sum_{k=1}^{k}, b_{ijk}\ c\ =\ \left\{c_{ijk}\right\} \qquad (7.2)$$

Step 3. Construct a normalised fuzzy decision matrix $\tilde{R}$ for the alternates as follow

$$\widetilde{R}\ \ =\ \left[\tilde{r}_{ij}\right] m\ . n \qquad (7.3)$$

Where B and C are the set of benefit and cost criteria respectively then $\tilde{r}_{ij}$ can be represented as

$$\tilde{r}_{ij}\ \ =\ \left(\frac{a_{ij}}{c_{\bar{j}}}\ , \frac{b_{ij}}{c_{\bar{j}}}\ , \frac{c_{ij}}{c_{\bar{j}}}\right)\ ,\ j\ \epsilon\ B$$

$$\tilde{r}_{ij}\ \ =\ \left(\frac{a_{\bar{j}}}{c_{ij}}\ , \frac{a_{\bar{j}}}{b_{ij}}\ , \frac{a_{\bar{j}}}{a_{ij}}\right)\ ,\ j\ \epsilon\ C$$

$c_{\bar{j}} \;=\; c_{ij} \quad if \quad j \in B$

$$a_{\bar{j}} \;=\; a_{ij} \quad if \quad j \in C \qquad (7.4)$$

Step 4. Construct the weighted normalised fuzzy decision matrix $\tilde{V}$. This is computed by multiplying the normalised fuzzy decision matrix $\tilde{R}$ with the aggregated weight $\tilde{w}$ as follow

$$\tilde{V} = \left[\widetilde{V_{\iota J}}\right] M.n \qquad i = 1,2,\ldots\ldots\ldots m\,, j = 1,2\ldots\ldots\ldots\ldots n$$

$$\left[\widetilde{V_{\iota J}}\right] = \left(\tilde{r}_{ij}\right).(\,\tilde{w}_j\,) \qquad (7.5)$$

Step 5. From the normalised fuzzy decision matrix $\tilde{V}$, determine the Fuzzy positive ideal solution (FPIS) and Fuzzy negative ideal solution (FNIS) of the alternative as follow

$$A* = \left(\widetilde{V_\iota} *, \widetilde{V_2} * \ldots\ldots.. \;\widetilde{V_n} *\right) = \left\{(max_i V_{ij} \mid i = 1,\ldots.m)\, j = 1,2,\ldots..n\right\} \qquad (7.6)$$

$$A^- = \left(\widetilde{V_\iota}^-, \widetilde{V_2}^- \ldots\ldots.. \;\widetilde{V_n}^-\right) = \left\{(Min_i V_{ij} \mid i = 1,\ldots.m)\, j = 1,2,\ldots..n\right\} \qquad (7.7)$$

Where the V_{ij} are the normalised positive triangular fuzzy numbers with a value range belonging to the close interval $[0,1]$.

Step 6. Estimate the distance of each alternate from FPIS and FNIS respectively. the distance of each alternate from $A*$ and A^- can be calculated using Euclidean distance measurement between two fuzzy number as follow

$$d_1{}^{+} = \sum_{j=1}^{n}, d\left(\widetilde{V_{\iota J}}, \widetilde{V_J} *\right) \sum_{j=1}^{n}, \sqrt{\frac{1}{3}\left[(\,a_{ij}^{v} - 1)^2 + (\,b_{ij}^{v} - 1) + (\,c_{ij}^{v} - 1)\,\right]} \quad i = 1, 2, \ldots\ldots m$$

$$d_1{}^{-} = \sum_{j=1}^{n}, d\left(\widetilde{V_{\iota J}}, \widetilde{V_n}^-\right) \sum_{j=1}^{n}, \sqrt{\frac{1}{3}\left[(\,a_{ij}^{v} - 0)^2 + (\,b_{ij}^{v} - 0) + (\,c_{ij}^{v} - 0)\,\right]}\; i = 1, 2, \ldots\ldots m \qquad (7.8)$$

where $\widetilde{V_{\iota J}}$ is $\left(a_{ij}^{v}\;, b_{ij}^{v}\,,\; c_{ij}^{v}\;\right)$

Step 7. Calculate the closeness coefficient of each alternate as follow

$$cc_{i=} \frac{d_1{}^{-}}{d_1{}^{-} + d_1{}^{+}}, \; j = 1,2\ldots\ldots, m \qquad (7.9)$$

Step 8. According to the closeness coefficient, rank the alternates. The best alternative can be identified as the one with the largest cc_i values

7.5. An empirical study on the ranking and selection of the appropriate risk mitigation strategies using the Fuzzy TOPSIS method.

To have a holistic integrated risk management model, the identified causal variables influencing AFTL service quality risk hazard must be mitigated. In this section, the fuzzy TOPSIS method was applied to evaluate the priorities and ranked the eleven verified mitigation strategies as presented in Figure 7.2. The assessment follows three processes, 1) collection of data via questionnaire survey 2) application of the proposed Fuzzy TOPSIS techniques, and 3) analysis and discussion of the result. Details of the individual process are discussed below.

7.5.1. Data collection method via a questionnaire survey.

The questionnaire survey was designed to collect raw data from the experts on the relative importance of the strategies in implementing appropriate risk management solutions, the survey was collected for 16 weeks from the 26th of May to the 30th of September 2021. The initially designed questionnaire was rigorously reviewed by quality managers, logistic managers and academia and later administered in a pilot survey to address the concern about the structure, content, rationality, ambiguity, and reliability of the questionnaire design. After the minor changes were reflected and reviewed, LBS ethical approval was obtained. To make data collection easier, the questionnaires were transformed into e-survey using Bristol online survey tools, thus the generated online survey link containing the instrument design was emailed to the participants. The questionnaire is shown in (Appendix six). It consists of two-part; part A asked about the respondent demographic and company information and Part B was concerned about the relative importance of the alternates in mitigating the causal variables, where the experts were asked to evaluate the alternates using a five-point linguistic variables scale of “Very poor” “Poor” “Medium” “Good” and “V. Good”. A total of 172 respondents participated in the study and after a further screening of the responses and professional background knowledge of the respondent, a total of 105 responses (61.04%) were valid. The sample size corresponded to the number of samples adequately used in the literature with the application of TOPSIS techniques (Tian et al., 2017. All the valid responses are from the experts in the food supply chain, transport and logistics firm and shipping firm holding a managerial position or higher. Table 7.3 show the profile of the respondent and the participating firm.

Table 7. 3: Demographic profile of the respondent

Participating firm	Position in the company	Location	Participants
Global logistic Firm	Logistic projects coordinating lead, Integrated Logistic support officer, Head of procurement, Manager, General managers, directors	Thailand, Republic of Vietnam, Europe	19
Agri-food production firm	Agriculture Engineers, Logistic coordinators, Researcher/consulting, farmers, Directors	Republic of Vietnam	26
Food suppliers	Head of Procurement, General manager, Procurement Specialist	Republic of Vietnam	12
Transport and Logistic firm	Marine logistic officer, warehouse and logistic officer, Logistic coordinator, Managers, Logistic lead,	Republic of Vietnam, Thailand, Europe	15
Shipping Companies	Quality assurance Analysts, superintendent Managers, Directors,	Thailand, Europe	14
Ocean freight and forwarder	Managers, Directors, General manager	Thailand, Europe	5
University	Researchers, Professors, senior lecturer	Republic of Vietnam, Europe, UK	14

7.5.2 The computation of the Fuzzy TOPSIS method

In the section, the computation of the expert opinion on the importance level of the eleven (11) mitigation strategies (i.e., alternates) in managing the CVI's influencing the service quality risk using the Fuzzy TOPSIS method was analysed. Figure 7.4 shows the hierarchical structure of the multi- criterial CVIs.

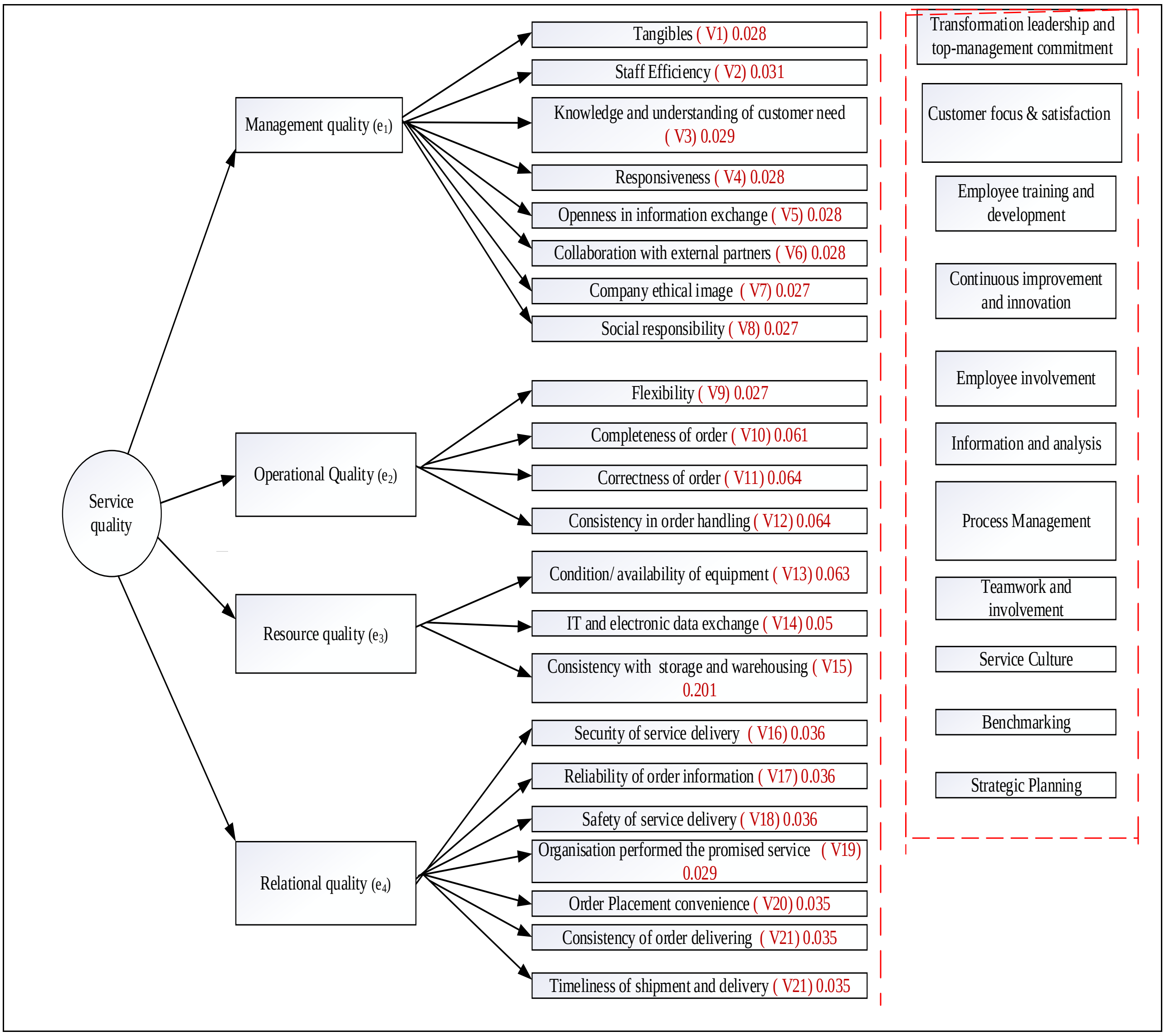


Figure 7. 4: Decision hierarchy of the multi-causal variables mitigation strategies

Following the Fuzzy TOPSIS algorithm steps below the analysed result will facilitate the priority ranking of the alternate in mitigating the service quality risk hazard in the AFTL chain

Step 1: the participating decision experts were consulted to evaluate the performance of the mitigation strategies in managing each of the causal variables using a linguistic grade. The linguistic grading scale presented in Table 7.2 defined the various rating as each alternate can be better assessed based on the subjective judgement and preference of the experts. For example, the assessment grade assigned by the three experts for sub-criteria variables "Tangibles" and their corresponding TFNs to construct the fuzzy decision matrix for step 2 are shown in Tables 7.4 and 7.5. It is worthy to be noted that all the decision-makers are given equal weight.

Table 7. 4: Assessment grading of three experts under sub-criteria "Tangibles"

		Participant expert		
Sub-criteria	Alternate	Expert1	Expert 2	Expert 3
Tangibles	Transformation leadership and top-management commitment (S1)	M	G	M
	Customer focus and satisfaction (S2)	G	G	VG
	Employee training and development (S3)	M	M	VG
	Continuous improvement and innovation (S4)	G	G	G
	Employee involvement (S5)	G	VG	G
	Information and analysis (S6)	M	G	VG
	Process management (S7)	M	G	M
	Teamwork and involvement (S8)	G	VG	G
	Service culture (S9)	G	G	VG
	Benchmarking (S10)	G	M	G
	Strategic planning (S11)	G	VG	M

Table 7. 5: Linguistic evaluation of the criteria converted into a TFN

Sub-criteria	Alternate	Expert 1	Expert 2	Expert 3
Tangibles	Transformation leadership and top-management commitment (S1)	(3,5,7)	(5,7,9)	(3,5,7)
	Customer focus and satisfaction (S2)	(5,7,9)	(5,7,9)	(7,9,9)
	Employee training and development (S3)	(3,5,7)	(3,5,7)	(7,9,9)
	Continuous improvement and innovation (S4)	(5,7,9)	(5,7,9)	(5,7,9)
	Employee involvement (S5)	(5,7,9)	(7,9,9)	(5,7,9)
	Information and analysis (S6)	(3,5,7)	(5,7,9)	(7,9,9)
	Process management (S7)	(3,5,7)	(5,7,9)	(3,5,7)
	Teamwork and involvement (S8)	(5,7,9)	(7,9,9)	(5,7,9)
	Service culture (S9)	(5,7,9)	(5,7,9)	(7,9,9)
	Benchmarking (S10)	(3,5,7)	(3,5,7)	(5,7,9)
	Strategic planning (S11)	(5,7,9)	(7,9,9)	(3,5,7)

Step 2. The aggregated decision expert rating of each alternative A_1 to the criterion C_j is computed using equation 7.1 to determine the aggregated fuzzy rating X_{ij} of the alternative. A_j , for instance, the value corresponding to the alternate S_1 on the variable V_1 " Tangibles" given as $a_{11} b_{11}\ c_{11}$ is equal (1, 7.889, 9) a_{11}=1, is the minimum value of all the a_{ij} component b_{11}= 7.889 is the mean value of all the b_{ij} component and c_{11} = 9 is the maximum value of all the c_{ij} components. Similarly, all the aggregated decision matrix values of $a_{ij} b_{ij}\ c_{ij}$ in each cell were calculated as shown in Appendix twelve.

Step 3. All the causal variables influence the firm service quality in the AFTL chain, the study objective was to mitigate their effect, hence the management of the strategies to mitigate such effects are termed as cost criteria i.e., non-beneficial criteria in which the minimum value is desired. Thus, their normalised fuzzy decision matrix is computed using equation 7.4.

For instance, the corresponding normalised matrix value to the alternate S_1 on the variable V_1 "Tangibles" is computed as (0.11, 0.121,1) i.e. the ratio of the minimum value of the $a_{\underline{\bar{j}}}$ in the $a_{ij}b_{ij}\ c_{ij}$ matrix to their corresponding $a_{11}b_{11}\ c_{11}$ rating value. The normalised fuzzy decision matrix of all the causal variables and the mitigation strategies are computed as shown in Appendix twelve

Step 4. The weightage value of the causal variables was determined using the DEMATEL technique discussed in (Chapter 6) to establish the weighted normalised fuzzy decision matrix using equation 7.5. The computed weighted normalised fuzzy decision matrix for the criterion was computed as shown in Appendix twelve

Step 5. Determine the Fuzzy positive ideal solution and Fuzzy negative ideal solution. The FPIS and FNIS of the criteria can be defined using equation 7.7. for example, the FPIS (A^*) and FNIS (A^-) with regards to criteria " Tangibles" were obtained by looking at the maximum C_{ij} i.e. the maximum value in the c_j component of the fuzzy number (0.003, 0.004, 0.009) and by looking at the minimum value a_{ij} i.e the minimum value in the a_j component of the fuzzy number (0.003, 0.003, 0.006). Similarly, the corresponding FPIS and FNIS of all the criteria were computed shown in Appendix twelve

Step 6-Calculate the distance of the alternate to FPIS (A^*) and FNIS (A^-)

The distance of the alternate from FPIS (A^*) and FNIS (A^-) was first calculated using equation (7.8). For instance, the FPIS (A^*) and FNIS (A^-) distance of alternate S_1 with regards to "Tangibles" can be computed as

$$d(S_1\,A^*)) = \sqrt{\frac{1}{3}[(\,0.003 - 0.003)^2\ + (\,0.00355 -\ 0.00376)^2 + (\,0.028 -\ 0.00933)^2]}$$

$$d(S_1\,A^*)) =\ \ 0.0108$$

$$d(S_1\,A^-)) = \sqrt{\frac{1}{3}[(0.003 - 0.003)^2 + (0.00355 - 0.0032)^2 + (0.028 - 0.0056)^2]}$$

$$d(S_1\,A^-)) = 0.0129$$

similarly, the FPIS (A^*) and FNIS (A^-) distance of the alternate S$_1$ with regards to the other variables are measured and their cumulative distances ${d_1}^+$ and ${d_1}^-$ are computed as shown in Table 7.5

Step 7: The closeness coefficient cc_i for each alternate was computed using Eq. (7.9). For example, the closeness coefficient cc_i for alternate S$_1$ is measured as follows:

$$cc_{i=} \frac{{d_1}^-}{{d_1}^- + {d_1}^+} = \frac{0.118}{0.118 + 0.182} = 0.39306$$

Similarly, the cc_i of all the alternatives are computed and the values are used for their priority ranking as shown in Table 7.6

Table 7.5: Cumulative distance (${d_1}^+$) and ${d_1}^-$ from each alternative to the FPIS and FNIS

Alternates	Cumulative distances (${d_1}^+$) to the FPIS	Cumulative distances (${d_1}^-$) to the FNIS
S1	0.182	0.118
S2	0.224	0.076
S3	0.209	0.093
S4	0.192	0.103
S5	0.194	0.088
S6	0.186	0.128
S7	0.206	0.100
S8	0.188	0.079
S9	0.135	0.149
S10	0.208	0.069
S11	0.185	0.120

Table 7. 6: Closeness Coefficient and ranking order of the risk mitigation strategies.

Alternates	Cumulative distances (${d_1}^+$) to the FPIS	Cumulative distances (${d_1}^-$) to the FNIS	CC$_I$	Rank
Transformation leadership and top-management commitment (S1)	0.182	0.118	0.3931	3
Customer focus and satisfaction (S2)	0.224	0.076	0.2529	10
Employee training and development (S3)	0.209	0.093	0.3074	8
Continuous improvement and innovation (S4)	0.192	0.103	0.3492	5
Employee involvement (S5)	0.194	0.088	0.3127	7
Analysis of Information (S6)	0.186	0.128	0.4081	2
Process management (S7)	0.206	0.100	0.3266	6

Teamwork (S8)	0.188	0.079	0.2967	9
Service culture (S9)	0.135	0.149	0.5239	1
Benchmarking (S10)	0.208	0.069	0.2477	11
Strategic planning (S11)	0.185	0.120	0.3925	4

7.5.3. Validation of Fuzzy TOPSIS using sensitive analysis approach

To validate the soundness and reliability of the study proposed fuzzy TOPSIS model in handling the imprecise and inconsistency in an uncertain environment, The study adopts a sensitivity analysis approach to investigate the objective similarity of the priority ranking result of the alternate as the weight of the criteria changes. Thus, a change in the priority ranking of the alternate as the weight of the criteria alters, proves the feasibility and reliability of the proposed fuzzy TOPSIS model in an uncertain environment (Bianchini, 2018).

Table 7.7 present the result of the closeness coefficient of each alternate cc_i with a change in the sub-criteria weight in three different scenarios. As the weighted condition of the criteria differs, the ranking priorities of the mitigation strategies also vary. In the original ranking of the alternate with the weighted conditions of the criteria, safety culture (S9) with cc_i value 0.5239 is ranked top priority mitigation strategies and others are ranked as follows. analysis of information (S6) > transformation leadership and top-management commitment (S1) > strategic planning (S11) > continuous improvement and innovation (S4) > process management (S7) > employee involvement (S5) > employee training and development (S3) > teamwork (S8) > customer focus and satisfaction (S2) > benchmarking (S10) (Table 7.6). However, if the weighting of the criteria differs, the priority ranking of the alternate will change. For instance in scenario one as illustrated in figure 7.5. Continuous improvement and innovation (S4) are the top implementation strategies to mitigate the causal variables weighted in such a condition followed by transformation leadership and top-management commitment (S1) > service culture (S9),> benchmarking (S10) > employee training and development (S3) > process management (S7) > strategic planning (S11) > analysis of information (S6) > employee involvement (S5) > teamwork and involvement (S8) > customer focus and satisfaction (S2). The Fuzzy TOPSIS application is considered sensible in prioritization ranking and selection of alternates. Thus, based on the weighted condition of the causal variables, FTL firm management can prioritize their strategic implementation following the firm conditions.

Table 7. 7: Validation result of Fuzzy TOPSIS using sensitivity analysis

Scenario 1

Criteria	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}	V_{22}
Weight	0.064	0.064	0.063	0.05	0.201	0.036	0.036	0.036	0.029	0.035	0.036	0.028	0.031	0.029	0.028	0.028	0.028	0.027	0.027	0.027	0.061	0.064

Alternate	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
CC_I	0.4594	0.3970	0.4443	0.4918	0.4223	0.4274	0.4421	0.4119	0.4492	0.4473	0.4379
Ranking	2	11	5	1	9	8	6	10	3	4	7

Scenario 2

Criteria	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}	V_{22}
Weight	0.038	0.021	0.009	0.048	0.018	0.038	0.02	0.034	0.02	0.068	0.064	0.064	0.063	0.05	0.201	0.036	0.036	0.046	0.029	0.015	0.056	0.025

Alternate	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
CC_I	0.3984	0.3315	0.3510	0.3865	0.3721	0.4334	0.3721	0.3203	0.5246	0.2949	0.4422
Ranking	4	10	8	5	6	3	6	9	1	11	2

Scenario 3

Criteria	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}	V_{19}	V_{20}	V_{21}	V_{22}
Weight	0.02	0.021	0.049	0.028	0.02	0.036	0.017	0.071	0.044	0.084	0.033	0.15	0.036	0.101	0.107	0.016	0.029	0.035	0.021	0.025	0.028	0.029

Alternate	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11
CC_I	0.4620	0.3848	0.4031	0.4263	0.4195	0.4485	0.4337	0.4341	0.4920	0.4177	0.4615
Ranking	2	11	10	7	8	4	5	6	1	9	3

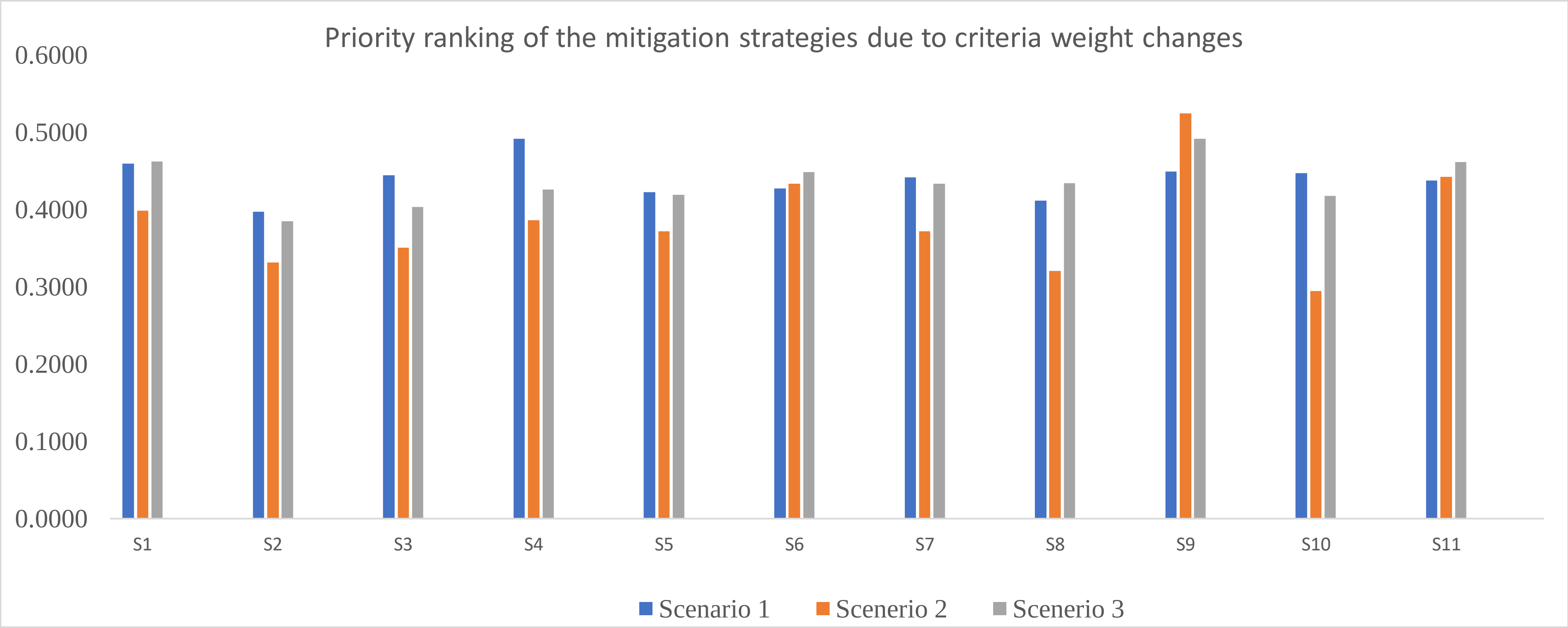


Figure 7. 5: Sensitivity analysis

7.6. Discussion and managerial implication

The findings from our study have significant managerial implications and insight that may allow AFTL companies to better manage the causal service quality risk variables and prioritise the implantation of the mitigation strategy while developing a strategic plan. It is paramount for AFTL chain practitioners to have a deeper understanding of both the causal service risk variables and the relevance of their mitigation strategies. This study contributed to the knowledge by identifying and showing the priority ranking of the verified mitigation strategies via empirical studies and their relevance in managing the causal service risk variables under uncertain environments. The application of the fuzzyTOPSIS technique allows the prioritisation ranking of the relevance of the eleven mitigation strategies to the causal variables. AFTL companies while developing a strategic plan, the alternative with the highest ranking should be given priority i.e strategy(S9) "service culture," strategy(S6) " information and analysis," strategy(S1) "transformation leadership and top management commitment," strategy (S11) "strategic planning" and strategy(S5) "continuous improvement and innovation" more especially strategy (S9) " service culture" with a strong relevance with quality performances, this is also in line from the view of academic scholars which stated that organisation service culture will not only change, guide or display the behaviour of the employee but will contribute immensely by influencing the feelings, thought interaction, satisfaction and affective reaction within the organization. (Alosani et al., 2019), thus for an organisation to be successful and achieve quality in their product and services, they need to deploy a service quality culture(Tummala and Schoenherr, 2011). Furthermore, strategy(S6) "analysis of information" is the next dominant mitigation strategy. This result of the study supports the argument of Sit et al (2009) that analysis of information is an important predictor to improve organisation performance in a service organisation. As such it is paramount that the senior management ensures that analysis of information of the organisation is widely communicated and shared among the staff. The least relevant is the strategy(S10) “benchmarking.” This makes it more paramount for AFTL managers to understand how to optimise their participation level in a service quality benchmarking consortium. Larger AFTL firms could use benchmarking consortium to their competitive advantage over the smaller AFTL companies which might have less access to data information and therefore receive less benefit. Although the larger AFTL companies will be contributing a majority of the data information in the benchmarking consortium. However, as the firm becomes larger it might also receive a negative performance impact because what they contribute to the benchmarking consortium might be relatively large to the size of the benchmarking benefit they receive. Moreso, AFTL companies will mostly be using the data information from the same benchmarking consortium as their competitors, meaning they will be using the same data as their competitors in pursuit of their goals. Thus, it is paramount for AFTL company managers to optimise their participation level in a benchmarking consortium and avoid benchmarking their organisation with the same data information as their competitors.

7.7. Conclusion

This chapter strengthens academic and managerial understanding of the last step in the AFTL risk management process. It presents the identification and evaluates the relevance and importance of the strategy to manage the AFTL service quality risk variable in an uncertain environment. The study empirically verified eleven service quality risk mitigation strategies and evaluate their relevance priority ranking using the fuzzy TOPSIS model. The application of the fuzzy TOPSIS was relevant to handle the imprecise and inconsistency that might exist during the decision-making process on the strategy. The verified eleven mitigation strategies are ranked according to their priorities. “Service culture(S9) “is the best mitigation strategy to manage the causal service quality risk affecting the AFTL chain, the strategy “information and analysis(S6) was ranked second, followed by the strategy “Transformation leadership and top management commitment” and “Strategic Planning”. Thus, AFTL firms can prioritise the implementation of these strategies in mitigating the causal service quality risk variables. Furthermore, the study does suffer from limitations and gives room for further research. Although the internal validity of the identified mitigation strategies from the list reviewed from the literature was strong, further empirical studies could be more perfect than the present studies by pre-testing all the reviewed factors and assessing those variables that are more closely representing the mitigation variables hence further research on refining the construct of the mitigation variables are warranted. The study was also unable to test in detail the impact of the eleven strategies and their improvement initiatives on the causal service risk factors. The research reported here only prioritizes the relevance and importance of the mitigation strategies.

CHAPTER 8 CONCLUSION

8.1. Introduction

This chapter presents a summary overview of the research. Initially, the chapter reviewed the research's important findings and how each finding addresses the set and described research objectives and research questions in the previous chapters. This is followed by a highlight of the research contribution to the existing knowledge and its practical application, the research limitation, and the future research area of improvement for further studies.

8.2. Research findings

The findings from the literature review revealed several research gaps. The primary research gap identified was the lacked an integrated management framework to assess and support management decisions in the risk factor identification, risk assessment and risk mitigation strategy in the food transport logistic chain. The second research gap identified was that the risk factors present in the food transport logistic chain had only been considered as a random variable with a limited focus on the assessment of their cause-effect interdependency relationships. The third research gap identified was the deficiencies in the risk assessment model techniques previously used in food supply network research. Review shows that most of the previously used models have shown some drawbacks and insufficiency in their practical applications. There was a need for more flexible and more comfortable use of a model, that can evaluate the hazardous risk factors in a coordinated approach under the challenge of data uncertainties and prioritize them without losing their easiness and vagueness. The fourth research gap identified was the lack of research assessing the causal variables influencing the hazardous risk factors. The fifth research gap identified was the lack of studies examining the risk mitigation strategies under different risk contexts in the food supply chain. To address these gaps, research questions were developed. To answer the question, a robust research methodology that delineates the research method and data collection process was followed and the integrated framework developed in the thesis supports managers and stakeholders in making a strategic decision on food transport logistic chain risk management. A summary of how the research findings address the thesis research question and objectives is as follows

(**RQ 1) How to identify and rank the top priority risk affecting the safety of the agro-food product during the transport and logistics process, especially in a developing country?**

All the various risk factors associated with the AFTL chain were identified through a careful review of the literature following a Delphi technique with industry experts, to explore the viability of the risk classification and to verify the impact of the literature-reviewed risk factors in the assessment of risk in FTL chain. The risk factors were categorised and subdivided into classes according to their risk source and experts in the food industry from the Republic of Vietnam were selected to verify the concerning risk factors in a real-life industry concern. a hierarchy of 46 validated risk factors was constructed that formed the basis of the integrated risk management structure. However, the major challenge in the assessment of validated food transport logistic risk factors was that their objective data were limited and often only available to a certain level. To address such uncertainty in the assessment of these risk factors, and rank the top priority risks, the fuzzy rule base and Bayesian network model were combined within the context of FTL assessment. The top priority risk factors of high-risk levels are analysed as leadership in food safety management, food supplier transparency, deterioration in service quality and the adaptation to food standard regulation respectively

RQ2: How is an uncertainty treatment theory approach useful in evaluating and quantifying the risk factors affecting the safety and sustainability of agro-food products during the transportation and logistics phase

In assessing the risks with the uncertainty of data presented in an FTL chain, the advanced quantitative risk assessment models based on uncertain treatment theories such as Bayesian algorithm, Fuzzy logic, DEMATEL techniques, Evidential reasoning algorithm and fuzzy TOPSIS were employed in the thesis in handling data uncertainties. However, a careful review of the literature reveals that the uncertain treatment models are often used in a combined manner to overcome the drawbacks when using them individually in practice. Fuzzy logic has the advantages of tackling uncertainty caused by vagueness in reasoning that influences human judgements due to their lack or insufficient evidence, Similarly, risk assessment based on a BN model was used to capture the non-linear relationship between the risk factors in the form of prior probabilities, the combination of the Fuzzy logic and BN models facilitates the study risk assessment process and enable the extension of more risk parameters in food supply chain risk management. The DEMATEL techniques analyse the cause-and-effect interdependency relationship between the causal variable indicators, The ER technique is unique in its ability to deal with both assessments of quantitative and qualitative variables with uncertainty, it was adopted to address the problem of vagueness, uncertainty and inadequacy of data associated with the casual variable indicators that influence the top priority risk hazard in food transport logistic chain. The strongest point of the model is its ability to enable the experts involves in the decision-making problem to reach their decision either subjectively or quantitatively, allowing judgement on the causal variables to be assessed in terms of both verbal descriptors and a quantitative manner (Yang et al, 2008). The analysed result derived from the application of the ER model will serve as useful tools to benchmark the impact level of the causal variables indicator influencing the top priority risk hazard in the AFTL chain

Fuzzy TOPSIS was adopted to handle imprecision and subjectiveness while ranking and choosing the best risk mitigation strategies based on their largest distance from the negative ideal solution (NIS) i.e solution that maximises the cost strategies and minimises the benefits strategies and the shortest distance from positive ideal solution (PIS) i.e., the solution that maximises the benefit criteria and minimises the cost criteria). The usefulness and application of the models were discussed in chapters five to chapter eight of the thesis.

RQ3: What are the core activities leading to the presence of the top risk factors in RQ2?

The multi-causal variable indicators influencing the top priority risk hazards were identified from the literature following a brainstorming exercise with seven domain experts, (five academic and two industry members, each with more than 15 years of working experience in the FTL industry from the Republic of Vietnam the world-leading rice and cocoa export country to verify those that are applicable in the measurement of the top risk factor in a real-life industry concern. Although due to the time limitation, the thesis limits the assessment of those causal variables influencing the top risk hazard (deterioration of service quality). The thirty-five multi-criteria causal variables indicators applicable to measure the service quality performance in the FTL chain were grouped under four main dimensions and assessed using the methodology discussed in chapter six.

RQ4 How to determine the best risk control measures of the activities in RQ3 in the context of a developing country

The study empirically verified eleven service quality risk control measures and evaluate their relevance priority ranking using the fuzzy TOPSIS model. The application of the fuzzy

TOPSIS as discussed in chapter eight was relevant to handling the imprecise and inconsistency that might exist during the decision-making process on the strategy.

8.3. Contribution of research to the knowledge in the field.

The agriculture and food industry is a key economic sector in all countries of the world (Wasilewski et al., 2018). Self-sufficiency in food safety and affordability of quality has been an argument. Although foods supply globally from diversified sources, greater challenges have been broadly recognized concerning longer and dispersed supply chains with increased delivery time and cost, quality deterioration, social-economic reliability, and environmental impact. Hence, the need for systematic methodologies and analytical tools to address this concern has been widely recognized among academics and practitioners. Nevertheless, the incorporation and integration of mathematical techniques, engineering models and management methods for improving the resilience and sustainability of the transport logistic network of the food supply chain while maintaining their competitiveness in terms of cost-effectiveness and operational efficiency are still largely unexplored. The outcome of the study will be the main criteria to justify the effectiveness of the strategy framework of food supply chain transport logistic solution. The study contributes to the literature by 1) providing an integrated risk management model for the food transport logistic chain that uncovers the top priority risk factor (leadership in food safety management, low supplier transparency, deterioration in service quality and adaptation to changes in food standards) influencing the hazards in AFTL chain, 2) defined and verified the CVI's influencing the top AFTL risk with a high probability of undetected (service quality) and evaluating the attributes (cause group) that can influence other attributes 3) applying a multiple complex risk assessment and an advanced uncertainty modelling technique that scholars recently started applying to risk, but remain largely underused in the AFTL network to evaluating the CVI's and to set up a benchmarking quality performance values , that compare the service quality performance with another service provider, in other to enhance firm competitiveness and exceed the customer expectation 4) defined a grading scale values for the assessment of the quantitative CVI's in the food supply chain.

8.4. Research limitations

The study research aim had been achieved by the development of integrated risk management for risk assessment and modelling of food transport logistic risk in an uncertain and vague environment. However, due to time and cost constraints, the research was limited creating a research gap for future studies. The limitations of this research are as follow.

1) Concerning the investigated risk factors proposed in chapter 4, the Identified risk in the real-life situation applied only to the Agro-food products supply network. Which then form the representative case study. It would have been better if the screening of these risk factors and the generic methodology can be tailored and applied to model transport and logistic risks of other food products.
2) A questionnaire survey was developed to generate risk input based on the five risk assessment parameters due to the lack of accurate industry-specific data. However, the confidentiality nature of the transport logistic industry while conducting empirical studies highlights the challenges of gathering survey data. Hence, the research sample size and the subjective nature of the responses could be a source of bias. Future work is needed to collect more responses from a larger population sample located in different countries and regions to further verify the research findings
3) Evaluating the root causes influencing the top priority risk hazard due to time and cost constraints the research was limited to the evaluation of the root cause influencing only one of the top risk factors (service quality risk) and its mitigation strategies. With no more

analysis on the other risk factors of high-risk levels, which is more essential in terms of a complete process of risk management. it would be useful if future work can be conducted to evaluate the other high-risk factors as well as proposed risk control and mitigation strategies.

4) This thesis uses three developing nations (the Republic of Vietnam, China and Thailand) as a representative case study for evaluating the causal variables indicator that influences the risk factors of high-risk levels in AFTL. It would be useful if a comparative study in a developed and widened geographical nation could be conducted based on the proposed risk management model of the current study to have a fresh insight into the development of the FTL risk management framework.

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Appendix One

The questionnaire used in Survey part A to verify and assess the relative importance of the review risk factors

Research on risk analysis for transport logistics networks questionnaire

Dear Sir/Madam

I am Rasheed Onakoya, a doctoral researcher at Liverpool John Moores University Business School, supervised by Dr Zhuohua Qu and Prof. Zaili Yang.

I would be very pleased if you can take part in this study "Risk analysis of transport logistics networks - The case of Agri-food products". The study aims to develop a novel safety assessment framework to analyse the risks affecting the safety of global food transportation in an uncertain environment. The new framework will help identify various hazards affecting the safety of food transportation in the supply chain, enhancing its resilience and offering safety management decision support to the stakeholders.

If you kindly accept it, you will help us use your professional judgement and experience to comment on the rationality and reliability of the proposed assessment framework, including answering questions on the risk indicators and the risk parameters intended for the study.

I am looking forward to hearing from you.

Sincerely,

Rasheed Onakoya ***LLM, MM, MICS, MNI***
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Section A Respondent file

1/7 What is the type of your organisation

Shipping carrier	Shipping agency	Shipowner	Freight forwarder	Others (please state)
☐	☐	☐	☐	☐

2/7 What is your position in your company

Senior Executive	Area or country manager	Department manager	Supervisor	Operations	Others (please state)
☐	☐	☐	☐	☐	☐

3/7 How many years have you worked with a transport logistic company

< 5 years	6-10 years	11-15 years	16-19 years	>20 years
☐	☐	☐	☐	☐

4/7 What is the number of employees in your company

1- 9	10-49	50-249	250-499	500 or more
☐	☐	☐	☐	☐

5/7 What freight mode do you typically deal with within your organization

Maritime	Road	Rail	Multimodal	Others
☐	☐	☐	☐	☐

6/7 What direction of_transport and logistic activities is your organization primary dealing with

Export	Import	Export and Import	Domestic	International

☐	☐	☐	☐	☐

7/7 What kind of product does your organisation deal with

Vegetables	Grains, Beans and Nuts	Meat and poultry	Fish and seafood	Dairy foods	Others (please indicate)
☐	☐	☐	☐	☐	☐

<u>Section B</u>: Verification and relative importance of the review risk factors questionnaire

Part A: Introduction and explanation

The global food products transport process comprises three phases: land transport phase, port operation phase, and maritime transport phase. Thus, several risk factors associated with each stage were identified from the literature as presented in Figure 1. The framework comprises four-level our levels (I, II, III, and IV). the first level represents the food product transportation overall risk; the second level represents the risk types emerging from either internal or external risk sources (Ho *et al.*, 2015); the third level represents the risk sources. The External risks arise from two risk sources: security and the environment which are caused by either a natural uncertainty (Lam and Bai, 2016) or uncertain economy/political events (Manuj and Mentzer, 2008). The internal risks emerge from four different risk sources: operations (Radivojević and Gajović, 2014), an organisation (Ackerley, Sertkaya and Lange, 2010), infrastructure/technological (Fahimnia *et al.*, 2015) and supply (Diabat, Govindan and Panicker, 2012). The fourth level represents the risk factors from distinct sources as presented in Tables 1-6.

On reviewing the structure presented in Figure 1, and table 1-6, please answer the questions below

Question 1. Are there any elements used in the framework that should NOT be included in Figure 1? If yes, please list it here.

Question 2. Are there any additional elements that should be added to Figure 1? If yes, please list it here.

Question 3. Is the classification appropriate? If not, please state how they should be organised and the reason here.

Question 4. Are there any additional risk factors that should be included in Tables 1-6? if yes, please modify the tables accordingly

Question 5. Are all the risk factors listed in Tables 1-6 correctly grouped? If not, please modify the tables accordingly.

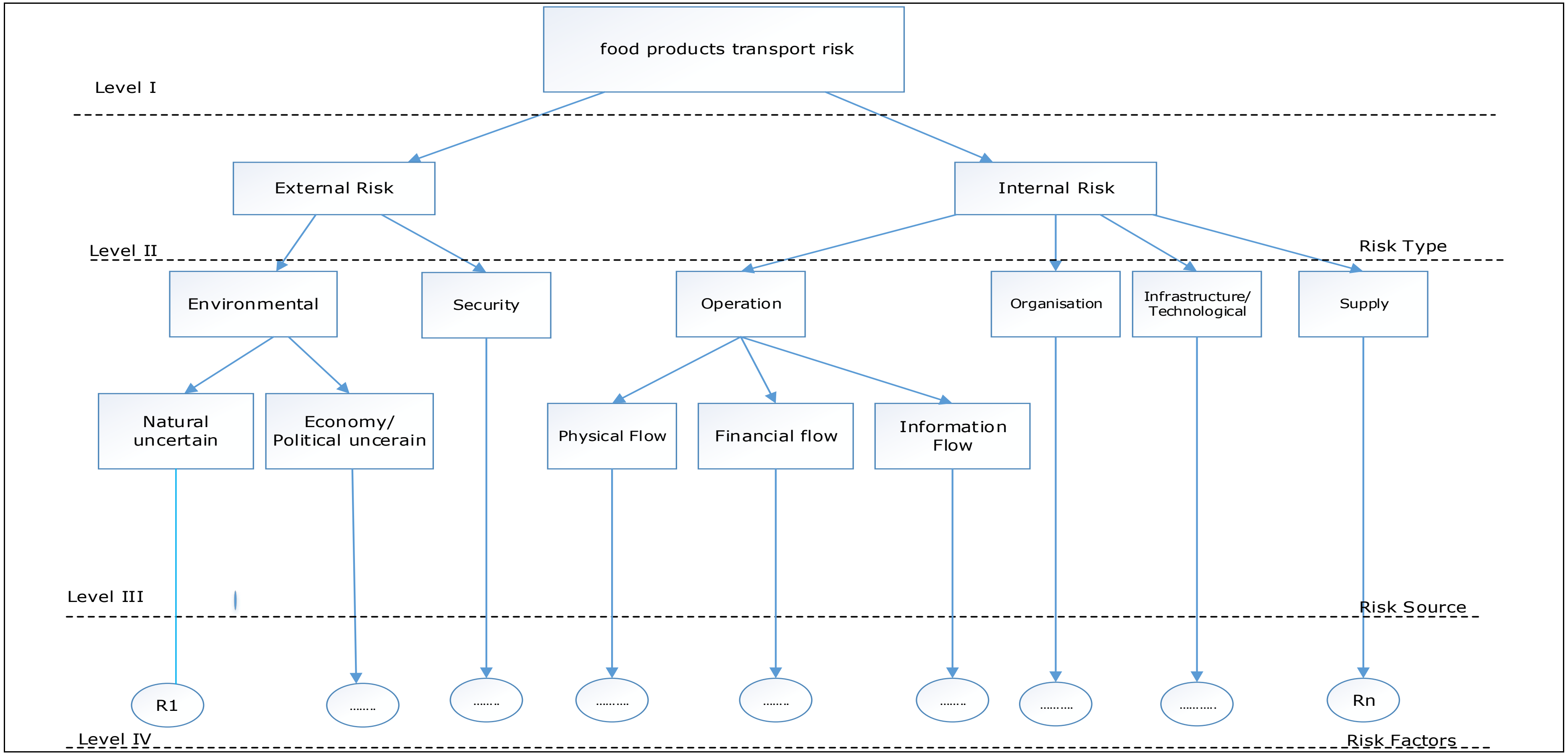

Figure 1: Classification of transportation risk factors

Risk factors of environmental risk source

Environmental	Natural uncertain	R1. Severe Thunderstorm
		R2. Tsunami
		R3. Weather changes
		R4. Flood
		Kindly add any other risk factors considered appropriate.
	Economy /political uncertain	R1. Political unrest
		R2. Government transport policies
		R3. Social and cultural grievances
		R4. External legal issues
		R5. Labour strike
		R6. Worker Union relation
		Kindly add any other risk factors considered appropriate.

Risk factors of security risk source

Security	R1. War
	R2. Terrorist attack
	R3. Piracy attack
	R4. Theft
	R5. Sabotage
	R6. Tampering
	R7. Pilferage and non-delivering
	R8. People Smuggling
	R9. Cyberattack
	Kindly add any other risk factors considered appropriate.

Risk factors of operation risk source

operation	Finance flow	R1. Changes in the currency exchange rate
		R2. Payment delays from shippers
		R3. The shipper is going into bankruptcy.
		R4. Unrealised contract with partners
		R5. Shippers breaking contract
		R6. Partners with bad credit
		R7. Higher Transportation cost
		Kindly add any other risk factors considered appropriate.
	Physical flow	R1. Port Strike
		R2. Port Congestion
		R3. Excessive inventory
		R4. Quality Problem
		R5. Improper loading /discharging practises.
		R6. Delay due to port capacity
		R7. Damage to ship or quay due to improper berth operation
		R8. Ship collision and sinking
		R9. Underutilised Hold space capacity
		R10. Poor Handling
		R11. Fire Accident
		R12. Product Damage in transits
		R13.Temperature Abuse
		R14.Cross-contamination
		R15. Insufficient holding space
		R16.Transportation providers fragmentation
		R17.Transportation route Bottleneck
		R18.Excessive handling due to a border crossing or change in transport
		R19.Customer clearance at the port
		R20.Paperwork and scheduling
		R21.Late truck Deliveries
		R22.In-transits Loss
		R23.Timely availability of the vehicle
		R24.Truck Accident
		R25.Lack of outbound effectiveness
		R26.Human Error

		R27.The capacity problem in railroad traffic
		R28.Permit of the transportation company
		R29.Infringe of traffic regulation
		R30.Improper holding practices for products awaiting shipment.
		R31. Poor pest control
		R32.Transport solution alternatives
		R33.Improper sanitation and backhauling hazardous material
		R34. Shipment delay
		Kindly add any other risk factors considered appropriate
	Information flow	R1.Communication failure among partners
		R2. Lack of security information sharing
		R3.Information Distortion
		R4.Lack of IT compatibility among partners
		R5. Risk of Network Coverage
		Kindly add any other risk factors considered appropriate

Risk factors of organisation risk source

organisation	R1.Labour skilled personnel
	R2. Employee wages
	R3.Overburden Employee
	R4. Poor Motivation among the workforce
	R5. Quality of Drivers
	R6. Stress on the workforce
	R7. Long employing working time.
	R8. Drunken drivers
	R9. Poor employee hygiene
	Kindly add any other risk factors considered appropriate.

Risk factors of infrastructure/technology risk source

Infrastructure / technology	R1. Obsolete Technology
	R2. Storage and warehouse
	R3. Lack of sufficient cargo handling equipment
	R4. Lack of intermodal /multimodal equipment
	R5. A breakdown at a critical railway crossing or yard
	R6. Irrigation and road condition
	R7. Transportation breakdown
	R8. Risk of applying sensing technology
	R9. Temperature monitoring /control
	R10. Negligently equipment maintenance
	R11. Poor Transportation unit design and construction
	R12. Power system
	Kindly add any other risk factors considered appropriate.

Risk factors of supply risk source

Supply	R1. Poor packaging and preservation
	R2. Inaccurate shipment from the supplier
	R3.Low Supplier transparency
	R4. Supply interruption
	R5. Low supplier integration
	R6.Failure of the partnership
	R7. Poor quality of supplied goods
	R8.Order Fluctuation
	R9. Urgent ordering
	R10.Traceability
	R11.Long term production downtimes
	R12.Short term production downtimes
	R13.The poor performance of sub-contractor
	R14. Poor logistics contract
	R15.Global sourcing network
	Kindly add any other risk factors considered appropriate.

Appendix Two

The questionnaire used in Survey part B for AHP techniques

Research on risk analysis for transport logistics networks questionnaire

Dear Sir/Madam

I am Rasheed Onakoya, a doctoral researcher at Liverpool John Moores University Business School, supervised by Dr Zhuohua Qu and Prof. Zaili Yang. I would be very pleased if you can take part in this study "Risk analysis of transport logistics networks - The case of Agri-food products". The study aims to develop a novel safety assessment framework to analyse the risks affecting the safety of global food transportation in an uncertain environment. The new framework will help identify various hazards affecting the safety of food transportation in the supply chain, enhancing its resilience and offering safety management decision support to the stakeholders. The purpose of the questionnaire is to evaluate the risk assessment parameters using a pairwise comparison scale to determine the priority (weight) of concern.

Your information is completely anonymous and will be mainly used along with other experts' decisions in computing the comparison matrix

I would be pleased if you can take part in the study considering your professional judgement and experience in risk management.

I am looking forward to hearing from you.

Sincerely,

Rasheed Onakoya ***LLM, MM, MICS, MNI***
Doctoral Researcher
Liverpool Business School
Redmond Building, Brownlow Hill,
Liverpool,
L3 5UG

Section A Respondent file

1/7 What is the type of your organisation

Shipping carrier	Shipping agency	Shipowner	Freight forwarder	Others (please state)
☐	☐	☐	☐	☐

2/7 What is your position in your company

Senior Executive	Area or country manager	Department manager	Supervisor	Operations	Others (please state)
☐	☐	☐	☐	☐	☐

3/7 How many years have you worked with a transport logistic company

< 5 years	6-10 years	11-15 years	16-19 years	>20 years
☐	☐	☐	☐	☐

4/7 What is the number of employees in your company

1- 9	10-49	50-249	250-499	500 or more
☐	☐	☐	☐	☐

5/7 What freight mode do you typically deal with within your organization

Maritime	Road	Rail	Multimodal	Others
☐	☐	☐	☐	☐

6/7 What direction of transport and logistic activities is your organization primary dealing with

Export	Import	Export and Import	Domestic	International
☐	☐	☐	☐	☐

7/7 What kind of product does your organisation deal with

Vegetables	Grains, Beans and Nuts	Meat and poultry	Fish and seafood	Dairy foods	Others (please indicate)
☐	☐	☐	☐	☐	☐

Section B: AHP Questionnaire

Part A: Introduction and explanation

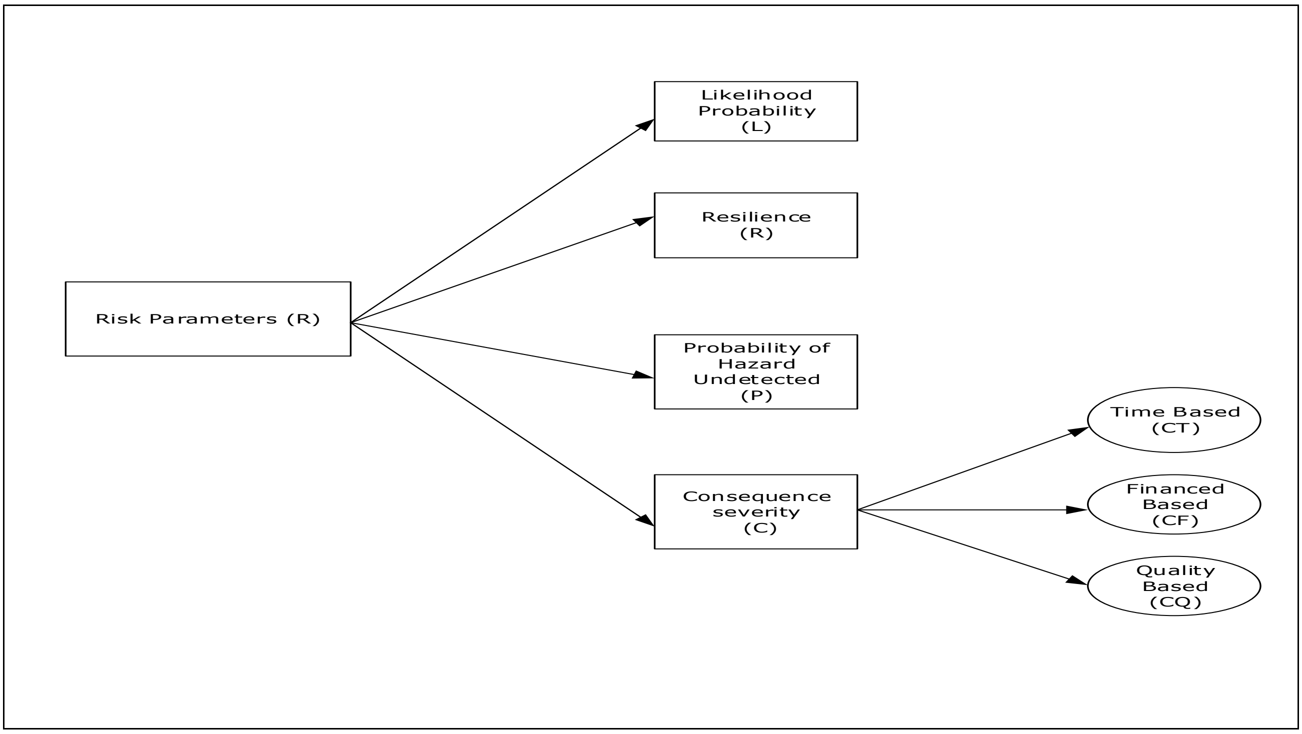

Figure 1. Hierarchy structure of the risk parameters

Level of importance	Rating
Extreme importance	9
Between extreme importance	8
Very strong importance	7
Between strong and very strong importance	6
Strong importance	5
Between moderate and equal importance	4
Moderate importance	3
Between moderate and equal importance	2
equal importance	1

Fundamental scale for making a pairwise judgement

The hierarchy structure of the risk parameters is illustrated in Figure 1 and the fundamental scale for making their pairwise judgement is presented in Table 1. The pairwise scale varies from 1 to 9. 1 indicates equal importance and 9 indicates extreme importance of the risk parameters. In your opinion as an expert,

Part B: Questionnaire

Question 1

How important is the Likelihood probability of hazard (L) when it is compared with the Resilience (R), Probability of hazard detected (P), and the severity consequence of the hazard (C) in the assessment of risk in food transport safety?

Question 2

How important is Resilience (R) when it is compared with the Probability of hazard undetected (P) and the severity consequence of the hazard (C) in the assessment of risk in food transport safety?

Question 3

How important is the Probability of hazard undetected (P), when it is compared with the severity consequence of the hazard (C) in the assessment of risk in food transport safety?

		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
L																			R
L																			P
L																			C
R																			P
R																			C
P																			C

Comparing risk parameter group clusters

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
CT																		CF
CT																		CQ
CF																		CQ

Comparing the severity of the consequence group clusters

Appendix Three

The questionnaire used in Survey part C for AFTL risk verification for chapter five

Research on risk analysis for transport logistics networks

Dear Sir/Madam

My name is Rasheed Onakoya, and who is currently a doctoral candidate at Liverpool Business School. I am writing to you to invite you to participate in my research study "Risk analysis of transport logistics networks - The case of Agri-food products" The study aims to propose a novel risk management methodology to identify, evaluate and mitigate the causal factors on the deterioration of quality in the Food Transport Logistic (FTL) chain. The framework will help to analyse the causal relationship of the FTL service quality dimensions. If you kindly accept it, you will help us using your professional judgement and experience to provide valuable knowledge in assessing the global transport logistic service quality as applicable to your organisation that will contribute to academia and practice. Participation in this study is voluntary, and no personal data will be collected throughout the study. Please read the participant information sheet and complete the questionnaire attached to this email, to be sure you are willing to take part in the survey, please respond within two weeks

Yours faithfully

Rasheed Onakoya *LLM, MM, MICS, MNI*

Doctoral Researcher

Liverpool Business School

Redmond Building, Brownlow Hill,

Liverpool L3 5UG

Section A Respondent file

1/7 What is the type of your organisation

Shipping carrier	Shipping agency	Shipowner	Freight forwarder	Others (please state)
☐	☐	☐	☐	☐

2/7 What is your position in your company

Senior Executive	Area or country manager	Department manager	Supervisor	Operations	Others (please state)
☐	☐	☐	☐	☐	☐

3/7 How many years have you worked with a transport logistic company

< 5 years	6-10 years	11-15 years	16-19 years	>20 years
☐	☐	☐	☐	☐

4/7 What is the number of employees in your company

1- 9	10-49	50-249	250-499	500 or more
☐	☐	☐	☐	☐

5/7 What freight mode do you typically deal with within your organization

Maritime	Road	Rail	Multimodal	Others
☐	☐	☐	☐	☐

6/7 What direction of transport and logistic activities is your organization primary dealing with

Export	Import	Export and Import	Domestic	International
☐	☐	☐	☐	☐

7/7 What kind of product does your organisation deal with

Vegetables	Grains, Beans and Nuts	Meat and poultry	Fish and seafood	Dairy foods	Others (please indicate)
☐	☐	☐	☐	☐	☐

Section B: Questionnaire for the verified AFTL risk factor assessment

Part A: Introduction and Explanation

The 46 risk factors presented in Table 7, are the verified risk hazards influencing the activities of the Agro-food transport logistic network. These Risk factors need to be investigated further in this research, by evaluating them in detail in terms of their likelihood probability, resilience impact on performances, the probability of the risk undetected, and their consequence severity in terms of time-based, financed based and quality based. Using your professional experience and Knowledge, please answer the question below.

Question 1. In which grade will you rank the Likelihood probability of each of the risk factors presented in Table 7?

Question 2. In which grade will you rank the resilience impact on performances of each of the risk factors presented in Table 7?

Question 3. In which grade will you rank the probability of each of the risk factors presented in Table 7 undetected?

Question 4. In which grade will you rank the consequence severity on time of each of the risk factors presented in Table 7?

Question 5. In which grade will you rank the consequence severity on financed of each of the risk factors presented in Table 7?

Question 6. In which grade will you rank the consequence severity on the quality of each of the risk factors presented in Table 7?

Note: *The linguistic grade of each risk parameter is explained below*

Risk factors assessment table

Risk Factors	Risk Parameter																													
	A. Likelihood probability **HU**: Highly *Unlikely* **U**: Unlikely **L**: *Likely* **H**: *Highly Likely* **D**: *Definite*					**B. Resilience impact** **VL**: *Very Low* **L**: *Low* **M**: *Medium* **H**: *High* **VH**: *Very high*					**C. Probability of risk undetected** **HU**: *Highly Unlikely* **U**: *Unlikely* **L**: *Likely* **H**: *Highly Likely* **D**: *Definite*					**D. Consequence**														
																D-1 Time based **VL**: *Very Low* **L**: *Low* **M**: *Medium* **H**: *High* **VH**: *Very high*					**D-2 Financed based** **VL**: *Very Low* L: *Low* **M**: *Medium* **H**: *High* **VH**: Very high					**D-3 Quality based** **VL**: *Very Low* **L**: *Low* **M**: *Medium* **H**: *High* **VH**: *Very high*				
	HU	**U**	**L**	**HL**	**D**	**VL**	**L**	**M**	**H**	**VH**	**HU**	**U**	**L**	**HL**	**D**	**VL**	**L**	**M**	**H**	**VH**	**VL**	**L**	**M**	**H**	**VH**	**VL**	**L**	**M**	**H**	**VH**
Natural uncertain																														
R1. Flood																														
Economy /political uncertain																														
R2. Government transport policies																														
R3. External legal issues																														
R4. Labour strike																														
R5. Worker Union relation																														
Security																														
R6. Pilferage and non-delivering																														
R7. Cyberattack																														
Operation finance flow																														
R8. Changes in the currency exchange rate																														
R9. Payment delays from shippers																														
R10. Higher Transportation cost																														
Operation physical flow																														
R11. Excessive inventory																														
R12. Service Quality Problem																														
R13. Poor Handling																														
R14. Fire Accident																														
R15. Product Damage in transits																														
R16.Temperature Abuse																														

R17.Cross-contamination																														
R18. Insufficient holding space																														
R19.Timely availability of the vehicle																														
R20.Truck Accident																														
R21.Human Error																														
R22. Improper sanitation and backhauling hazardous material																														
R23.Poor pest control																														
Operation information flow																														
R24.Communication failure among partners																														
Organisation																														
R25.Labour skilled personnel																														
R26. Employee wages																														
R27.Overburden Employee																														
R28. Poor Motivation among the workforce																														
R29. Leadership in food safety management																														
R30. Adaptation to food standard regulation change																														
R31. Poor employee hygiene																														
Infrastructure / Technology																														
R32. Obsolete Technology																														
R33. Storage and warehouse																														
R34. Lack of sufficient cargo handling equipment																														
R35. Risk of applying sensing technology																														
R36. Humidity monitoring /control																														

R37. Negligently equipment maintenance																														
R38. Power system																														
Supplier																														
R39 Poor packaging																														
R40. Poor preservation																														
R41. Inaccurate shipment from the supplier																														
R42.Low Supplier transparency																														
R43. Low supplier integration																														
R44.The poor performance of sub-contractor																														
R45. Poor logistics contract																														
R46.Global sourcing network																														

Parameters	Linguistic Grade	Definition
Likelihood Probability	Highly unlikely	Has never or rarely occurred
	Unlikely	Unlikely to occur except in exceptional circumstances
	Likely	Could occur at some time during transit
	Highly Likely	Expected to occur during transit
	Definite	Occur during the transit
Resilience Impact	Very Low	No impact /Insignificant concerning the whole operation
	Low	Minor impact / degraded operation capabilities
	Medium	Causes short-term difficulties to accomplish the operation
	High	Causes long-term difficulties to accomplish the operation
	Very High	Discontinue of operation
Probability of Risk undetected	Highly unlikely	The occurrence Likelihood of possible consequence is highly unlikely given the occurrence of the risk event (extremely unlikely to occur during operations)
	Unlikely	The occurrence Likelihood of possible consequence is unlikely but possible given that the risk event happens (improbable to occur even on rare occasions during operations)
	Likely	Consequences likely happen given that the risk event occurs
	Highly Likely	Consequences likely occur given the occurrence of the risk event (often exists during operation)
	Definite	Possible consequence happens given the occurrence of a risk event, which o be detected through regular checks or maintenance. (likely to occur repeatedly during operation).
Consequence severity	Very Low	No damage to food products, negligible disruption of an operation, negligible damage to property and environment.
	Low	Minor damage to food products; slight equipment or system damage but fully functional and serviceable; little or no environmental damage. Require minor intervention
	Medium	Minor damage to food products, minor incapability of systems, equipment or facilities that disrupt operations over 3hours, and minor damage to the environment.
	High	Severe damage to food products and prolonged disruption of operation, significant damage to property or marine environment
	Very High	Total Loss of food products. Extreme damage to property or environment

Appendix Four

The questionnaire used in Survey part D for DEMATEL in Chapter six

Research on risk analysis for transport logistics networks

Questionnaire

Dear Sir/Madam

My name is Rasheed Onakoya, and who is currently a doctoral candidate at Liverpool Business School. My research topic is "Risk analysis of transport logistics networks - The case of Agri-food products". The study aims to propose a novel risk management methodology to identify, evaluate and mitigate the causal factors of the deterioration of quality in the food transport logistic (FTL) chain. The purpose of the questionnaire is to develop a contextual framework to analyse the cause-effect interrelationship of the FTL service quality dimensions using the Decision-Making Trial and Evaluation Laboratory Model (DEMATEL). It is necessary to compare the extent to which the quality dimension indicators (QDIs) influence the service quality in the FTL chain and your assistance would be greatly appreciated in making this a meaningful questionnaire. Participation in this study is voluntary and your details will be kept confidential throughout the study. If you have any questions about this study, please contact me via email at r.a.onakoya@2018.ljmu.ac.uk or you can contact my supervisor, Dr Zhuohua Qu at (+44)1512314726 or by email at Z.qu@ljmu.ac.uk.

Yours Faithfully

Rasheed Onakoya *LLM, MM, MICS, MNI*
Doctoral Researcher
Liverpool Business School
Redmond Building, Brownlow Hill,
Liverpool, L3 5UG

Section A Respondent file

1/7 What is the type of your organisation

Shipping carrier	Shipping agency	Shipowner	Freight forwarder	Others (please state)
☐	☐	☐	☐	☐

2/7 What is your position in your company

Senior Executive	Area or country manager	Department manager	Supervisor	Operations	Others (please state)
☐	☐	☐	☐	☐	☐

3/7 How many years have you worked with a transport logistic company

< 5 years	6-10 years	11-15 years	16-19 years	>20 years
☐	☐	☐	☐	☐

4/7 What is the number of employees in your company

1- 9	10-49	50-249	250-499	500 or more
☐	☐	☐	☐	☐

5/7 What freight mode do you typically deal with within your organization

Maritime	Road	Rail	Multimodal	Others
☐	☐	☐	☐	☐

6/7 What direction of transport and logistic activities is your organization primary dealing with

Export	Import	Export and Import	Domestic	International

☐	☐	☐	☐	☐

7/7 What kind of product does your organisation deal with

Vegetables	Grains, Beans and Nuts	Meat and poultry	Fish and seafood	Dairy foods	Others (please indicate)
☐	☐	☐	☐	☐	☐

Section B - Decision-Making Trial and Evaluation Laboratory (DEMATEL) Model

<u>Part 1 Introduction and explanation</u>

The questionnaire is designed to evaluate the direct influence among dimensions and sub-criteria indicators (Table 1). The evaluation of the degree of direct influence one dimension/indicator exerts on each indicator other dimension/indicators are based on the scale of 1, 2, 3 and 4, where “Very High influence” = 4, “High influence” = 3, “Medium influence” = 2, “Low influence” = 1, “No influence”= 0.

Table 1 below provides a list of dimensions and their sub-dimension indicators with detailed explanations.

Table 1. CVIs indicators definition

Dimension	Sub -dimension indicators -
(A) Management quality: Is defined as the management activities that contribute to the consistent efficiency of the organisation in providing quality services to meet stakeholder needs	**(AA) Tangibles**. **-** Reflects how visually appealing the company equipment and the facilities are associated with the service provided by major competitors
	(AB) Staff efficiency- Reflects the ability of the staff to contribute to service delivery.
	(AC) Knowledge and understanding of customer needs and requirements - Reflects the ability to understand customer needs and requirements concerning major competitors
	(AD) Responsiveness - Reflects the ability to respond to customer orders and provide prompt service.
	(AE) Openness in information exchange - Reflects the degree of openness in the information exchange between all parties in the transport logistic system regarding the 'plan' 'source' and 'delivering ' process
	(AF) Collaboration with external partners - Reflects the degree to which the firm collaborates with its partners concerning major competitors
	(AG) Company ethical image - Reflects on how the organisation's ethical culture is perceived by the customer concerning major competitors

	(AH) Social responsibilities - Reflect the perception the customer has on the service delivered as requiring a social responsibility norm and concern for human safety, engagement in communities' activities and the company performance statement and vision toward community responsibility
	(AI) Equipment efficiency - Reflects the ability of the equipment to contribute to service delivery
(B) Operational quality: Is defined as the activities performed by the organisation that contributes to consistent quality productivity and efficiency	**(BA) Flexibility -** Reflect the degree to which organisations adapt to the changing demands of the users
	(BB) Completeness of order - Reflect the completeness and accuracy of the order information
	(BC) The correctness of order - Reflect the number of a mistake in order
	(BD) Consistency in order handling - Reflect the consistency in order handling
(C) Resource quality: This is defined as the extra resources provided by the firm to its stakeholder to meet the quality of services efficiently.	**(CA) Condition and availability of equipment and facilities -** It reflects the customer expectation of the equipment and facilities of the firm
	(CB) Application of IT and electronic data interface in customer service - Reflect the degree to which the IT and electronic data interface is used
	(CC) Consistency in storage and warehousing - Reflect the consistent utilisation of storage and warehousing.
	(CD) Shipment tracking capacity - The availability of information about the shipment
	(CE)Product tracing and tracking capacity - The availability of information about the product during transit
(D) Relational quality: Is defined as the activities that bring the organisation closer to its stakeholder in other to under their needs and expectation and to provide an efficient quality of services	**(DA) Safety of service delivery -** It reflects the number of accidents occurring during product transportation journey in a certain period
	(DB) Reliability of order information - How the firm performs the order information dependably and accurately
	(DC) Reliability of available service - How dependably and accurately does the firm make the service available
	(DD) Reliability of documentation - How the firm performs the order documentation dependably and accurately
	(DE) Security of service delivery - The number of the recorded threat to the transport logistic activities
	(DF) Speed of service performance - Services performance speed
	(DG) Order placement convenience - How convenient in placing orders within the organisation
	(DH) Consistency of order handling - Consistency of order handling
	(DI) Timeliness of shipment, pickup and delivery - Reflect the duration of the delivery activities.
	(DJ) Competitive price of service - Reflect the position of the company relative to its competitors on service delivery cost efficiency.

Instruction and Sample question:

Please provide the judgement of the degree of influence of the main dimensions in the column to the target dimensions list at the top of the table.

For example, in the table below, select the degree of influence of "(B) Operational quality" on the main dimensions "(A) Management Quality" in your opinion. If the "(B) Operational quality" has a "medium influence" on "(A) Management Quality", please tick 2.

Concerning: Organisation service quality concept	**The degree of the influence below the main dimension directly has on the targeted main dimension (A) Management Quality**				
Main dimension	**Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence**				
	0	1	2	3	4
(B) Operational quality			√		

Part 2 Questionnaire

(1) Evaluate the degree of influence of the main dimensions over another, please tick (√) in the appropriate box

a). **Concerning the Organisation service quality concept**	**The degree of the influence below main dimensions directly have on the targeted main dimension "(A) Management Quality"**				
Main dimension	**Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence**				
	0	1	2	3	4
(B) Operational quality					
(C) Resource Quality					
(D) Relational quality					

c). Concerning: Organisation service quality concept	**The degree of the influence below main dimensions directly have on the targeted main dimension "(C) Resource quality"**				
Main dimension	**Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence**				
	0	1	2	3	4
(A) Management Quality					
(B) Operational Quality					
(D)Relational quality					

d). Concerning: Organisation service quality concept	**The degree of the influence below main dimensions directly have on the targeted main dimension "(D) Relational quality"**				
Main dimension	**Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence**				
	0	1	2	3	4
(A) Management Quality					
(B) Operational Quality					
(C) Resource quality					

(2). Evaluate the degree of influence of the sub-criterial of the "(A) Management quality" dimension over another, please tick (√) in the appropriate box

a). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(AA) Tangible"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

b). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(AB) Staff efficiency"				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

c). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria " (AC) Knowledge and understanding of customer need and requirement"				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

d). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria " (AD) Responsiveness"				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

e). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria “(AE) Openness in information exchange”				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

f). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria “ (AF) Collaboration with an external partner”				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AG) Company ethical image					
(AH) Social responsibilities					
(AI) Equipment efficiency					

g). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria “(AG) Company ethical image”				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AH) Social responsibilities					
(AI) Equipment efficiency					

h). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria “(AH) Social responsibilities”				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					

(AG) Company ethical image					
(AI) Equipment efficiency					

i). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(AI) Equipment efficiency"				
Sub-criteria	Degree of influencing 0: No influence, 1:Low influence, 2:Medium influence: 3: High influence, 4:Very high influence				
	0	1	2	3	4
(AA) Tangibles					
(AB) Staff efficiency					
(AC) Knowledge and understanding of customer needs and requirements					
(AD) Responsiveness					
(AE) Openness in information exchange					
(AF) Collaboration with an external partner					
(AG) Company ethical image					
(AH) Social responsibilities					

(3). Evaluate the degree of influence of the sub-criterial of the "(B) Operational quality" dimension over another, please tick (√) in the appropriate box

a). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(BA) Flexibility"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(BB) Completeness of order					
(BC) Correctness of order					
(BD) Consistency in order handling					

b). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(BB) Completeness of order"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(BA) Flexibility					
(BC) Correctness of order					
(BD) Consistency in order handling					

c). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(BC) Correctness of order"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(BA) Flexibility					
(BB) Completeness of order					
(BD) Consistency in order handling					

d). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(BD) Consistency in order handling"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(BA) Flexibility					
(BB) Completeness of order					
(BC) Correctness of order					

(4). Evaluate the degree of influence of the sub-criterial of the "(C) Resource quality" dimension over another, please tick (√) in the appropriate box

a). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(CA) Condition and availability of equipment and facilities"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(CB) Application of IT and electronic data interface in customer service					
(CC) Consistency in storage and warehousing					
(CD) Shipment tracking capacity					
(CE) Product tracing and tracking capacity					

b). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria " (CB) Application of IT and electronic data interface in customer service"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(CA) Condition and availability of equipment and facilities					
(CC) Consistency in storage and warehousing					
(CD) Shipment tracking capacity					
(CE) Product tracing and tracking capacity					

c). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria " (CD) Shipment tracking capacity"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(CA) Condition and availability of equipment and facilities					
CB) Application of IT and electronic data interface in customer service					
(CC) Consistency in storage and warehousing					
(CE) Product tracing and tracking capacity					

d). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(CE) Product tracing and tracking capacity"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(CA) Condition and availability of equipment and facilities					
CB) Application of IT and electronic data interface in customer service					
(CC) Consistency in storage and warehousing					
(CD) Shipment tracking capacity					

(5). Evaluate the degree of influence of the sub-criterial of the "Relational quality" dimension over another, please tick (√) in the appropriate box

a). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DA) Safety of service delivery"				
Sub-criteria	**Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence**				
	0	1	2	3	4
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

b). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DB) Reliability of order information"				
Sub-criteria	**Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence**				
	0	1	2	3	4
(DA) Safety of service delivery					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

c). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DC) Reliability of available of service"				
Sub-criteria	**Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence**				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

d). Concerning: Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria " (DD) Reliability of documentation"				
Sub-criteria	**Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence**				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DE) Security of service delivery					
(DF) Speed of service performance					

(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

e). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DE) Security of service delivery"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

f). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DF) Speed of service performance"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

g). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DG) Order placement convenience"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

h). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DH) Consistency of order handling"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					

(DG) Order placement convenience					
(DI) Timeliness of shipment and delivery					
(DJ) Competitive price of service					

i). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DI) Timeliness of shipment and delivery"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DJ) Competitive price of service					

j). Concerning Organisation service quality concept	The degree of the influence below sub-criteria directly have on the targeted sub-criteria "(DJ) Competitive price of service"				
Sub-criteria	Degree of influencing 0: No influence, 1: Low influence, 2: Medium influence: 3: High influence, 4: Very high influence				
	0	1	2	3	4
(DA) Safety of service delivery					
(DB) Reliability of order information					
(DC) Reliability of available service					
(DD) Reliability of documentation					
(DE) Security of service delivery					
(DF) Speed of service performance					
(DG) Order placement convenience					
(DH) Consistency of order handling					
(DI) Timeliness of shipment and delivery					

Appendix Five

The questionnaire used in Survey part E for Evidential Reasoning (ER) in Chapter Seven

Research on risk analysis for transport logistics networks questionnaire

Dear Sir/Madam

My name is Rasheed Onakoya, and who is currently a doctoral candidate at Liverpool business school. My research topic is "Risk analysis of transport logistics networks - The case of Agri-food products". The study aims to propose a novel risk management methodology to identify, evaluate and mitigate the causal factors of the deterioration of quality in the food transport logistic (FTL) chain. The purpose of the questionnaire is to develop a contextual framework to evaluate the cause/effect of quality deterioration in the FTL chain. I would be very pleased if you can take part in this study given your professional knowledge in the food supply network or transport logistic chain. The questionnaire is anonymous thus your response can not be attributed to you or your organization. All the information gathered in this survey will be treated in the strictest confidence, as this has always been the policy of Liverpool business school. If you have any questions about this study, please contact me via email at r.a.onakoya@2018.ljmu.ac.uk or you can contact my supervisor, Dr Zhuohua Qu at (+44)1512314726 or by email at Z.qu@ljmu.ac.uk.

Yours faithfully

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Questionnaire for service quality

Question 1. What is your position in the company?

Question 2. The number of years in your organisation:

Question 3. What is the number of employees in your organisation?

Question 4. What direction of transport and logistic activities is your organization primary dealing with? International

Question 5. What freight mode does your organisation typically deal with? Sea

Question 6. Does your organisation have its freight mode? No

- In a typical month, how many trips does it cover?---------------------------

Question 7. What kind of product does your organisation deal with?

Question 8. Is your organisation concerned about the deterioration of quality in the transport logistic chain?

Question 9. Have you had concerns/incidents in the past 12 months, relating to the quality of services rendered to any stakeholder?

Question 10. Does your organisation receive monthly/annual orders from its stakeholder? No.

- In a typical month, how many times do your organisation receive the full order?.................................
- In a typical month, what is the total quantity of orders received ?----------------
- In a typical month, what quantity from the total order received is delivered----

Question 11. Does your organisation allow special/urgent/unexpected orders? No.

- In a typical month, how many special/urgent/unexpected orders are allowed? -------------

- In a typical month, how many special/urgent/unexpected orders are received?------------

Question 12. Does your organisation have storage/warehouse facilities? If you answer “yes”

- What is the total volume of storage/warehouse that is available? In a typical month, what volume of the storage/warehouse is in use?

Question 13. Does your organisation have dedicated personnel to deal with the order? If you answer “yes”

- In a typical month, what number of personnel is available?

- How many hours are the personnel allowed to work in a day?
- **Question 14.** Does your organisation have sufficient equipment to handle the orders? If you answer “yes”

- In a typical month, how much of the equipment is in use?

Question 15. In the past 12 months, does your organisation encounter any security threats on orders?

- What is the number of the recorded security threat?--------------------------------

Question 16. In the past 12 months, does your organisation encountered any accidents during product transportation? If you answer “yes”

- In a typical month, what is the number of accidents recorded per trip?

Question 17. In the past 12 months, has your organisation received complaints of any mistake orders during delivery? If you answer “yes”

- In a typical month, how many mistake order is delivered?

Question 18. In the past 12 months, does your organisation receive complaints about late order delivery? If you answer "yes"

- In a typical month, what quantity from the order received is not delivered on time?

Question 19. Evaluate the physical appearance of the transport-related infrastructure in keeping with the quality of service provided.

	Very low	Low	Medium	High	Very High
Road infrastructure	○	○	○	○	○
Sea infrastructure	○	○	○	○	○
Rail infrastructure	○	○	○	○	○
Warehousing /trans-loading facilities	○	○	○	○	○

Question 20. Evaluate the techniques used in checking and tracking products during transit

	Very low	Low	Medium	High	Very High
Application of IT and electronic data interchange	○	○	○	○	○
Temperature sensor tracker	○	○	○	○	○
Humidity sensor tracker	○	○	○	○	○
Application of Internet of thing (IoT) technology	○	○	○	○	○
Application of radio frequency identification (RFID) technology	○	○	○	○	○
Application of Artificial Intelligence (AI) and machine learning	○	○	○	○	○

Question 21. Have the following indicators improved or worsened in your organisation?

	Much worse	Worse	About the same	Improved	Much improved
Staff competency in understanding customer requirements	○	○	○	○	○
Organisation's degree of openness in the information exchange between all parties in the transport logistic system regarding 'Plan' 'Source' and 'delivering ' process	○	○	○	○	○
Upholding moral and ethical standards while making a decision	○	○	○	○	○
Collaboration with other partners	○	○	○	○	○
Social responsible behaviour and concern for human safety	○	○	○	○	○
Engagement in community activities	○	○	○	○	○
Operating in an environmentally safe area	○	○	○	○	○
Knowledge in understanding how business insight is exercised between different divisions in your organisation and your client	○	○	○	○	○

Question 22. Based on your experience in the transport logistic chain, please select the option that best describes the outcome of services in your organisation

	Strongly disagree	Disagree	Sometimes	Agree	Strongly agree
The organisation performed the promised services dependably and accurately	○	○	○	○	○
Order information is readily available	○	○	○	○	○
Information on customer orders is always accurate	○	○	○	○	○
The stakeholder can place orders conveniently	○	○	○	○	○

There is a consistent procedure for handling orders	○	○	○	○	○

The questionnaire used in Survey part E for Evidential Reasoning (ER) in Chapter Six (Chinese Version)

运输物流网络风险分析研究

亲爱的先生/女士：

我们的研究课题是“运输物流网络的风险分析——以农产品为例”。本研究旨在提出一种新的风险管理方法，这个方法可以识别、评估导致食品运输物流链(FTL)质量下降的指标因素。问卷的目的是建立情境框架以评估FTL链质量下降的原因以及影响。鉴于您对食品供应网络或运输物流链的专业知识，如果您能够参加本研究，我将感到非常荣幸。问卷是匿名的，本调查中收集的所有信息将得到最严格的保密。如果您对本次研究有任何疑问，可以通过电子邮件lvmeilin@dlmu.edu.cn联系我们。非常感谢您的参与。

问卷调查部分

对于以下问题，如果您回答“是”，请在“是”后括号处打勾并回答之后的标注问题，继续下一题；如果您回答“否”，请在“否”后括号处打勾，直接进行下一题。

问题1. 您在公司的职位是什么？ 采购经理

问题2. 您在公司工作的时间（年）：_____9 年

问题3. 贵公司有多少员工? _____15人

问题4. 您的公司经营运输物流活动的形式是什么？（请在选择项后面打勾）

进口（ ）出口（ ）进出口（ √ ）国内市场（ ）国际市场（ ）

问题5. 您的公司通常采用哪种货运方式?（请在选择项后面打勾）

海上（ √ ）公路（ ）铁路（ ）多通道（ ）

其他(请在括号中说明)（ ）

问题6. 贵公司是否有自己的货运模式?

是（ ）否（ √ ）

- 在一个月份中通常可以完成多少次货运? _____16-20次

问题7. 贵公司主要处理哪类商品的运输？（请在选择项后面打勾）

蔬菜（ ）谷物，豆类和坚果（ ）肉类家禽（ ）鱼类海鲜（ ）

奶制品（ ）其他(请在括号中说明)（ 水果类 ）

问题8. 贵公司是否担心运输物流链的效率下降？

是（ ）否（ √ ）

问题9. 过去的12个月中，您是否对向客户(利益相关者)提供的服务质量感到担忧？

是（ ）否（ √ ）

问题10. 您的公司是否收到利益相关者的月度/年度订单？

是（ √ ）否（ ）

- 通常一个月收到多少次订单？________
- 通常一个月收到订单的总数量是多少？________

➢ 通常一个月收到的订单中交付的数量是多少? ____________________________

问题11. 您的公司是否允许特殊/紧急/计划之外的订单?

是（　　√　　）否（　　　　）

➢ 通常一个月允许多少特殊/紧急/计划之外的订单? ________________________

➢ 通常一个月能接到多少特殊/紧急/计划之外的订单? _____________________

问题12. 贵公司是否有储存/仓库设施?

是（　　　　）否（　√　　）

➢ 可用的存储/仓库的总容量是多少？______________________________________

➢ 通常一个月仓库的使用量是多少？______________________________________

问题13. 贵公司是否有待命人员处理订单（专门处理订单的工作人员）？

是（　√　　）否（　　　　）

➢ 通常一个月待命员工数量是多少？__________________________________

➢ 待命员工一天的工作时长是多少？____________________________________

问题14. 贵公司是否有足够的设备处理订单?

是（　　　　）否（　√　　）

➢ 通常一个月处理订单的设备数量是多少？________________________________

问题15. 在过去的12个月中，您的公司是否在订单上遇到任何安全威胁（比如丢单或订单突然故障等）？

是（　　　　）否（　√　　）

➢ 已记录的安全威胁数量是多少？____

问题16. 在过去的12个月中，您的公司在产品运输过程中是否遇到任何事故？

是（　　　　）否（　　√　）

➢ 通常一个月里每次货运记录的事故数量有多少？__________________________

问题17. 在过去的12个月中，您的公司是否收到关于交付过程中错误订单的投诉（比如质量问题，送错货，送错时间等）？

是（　　　　）否（　√　　）

➢ 通常一个月里错误订单的数量有多少？________________________________

问题18. 在过去的12个月中，您的公司是否收到关于延迟交货的投诉？

是（　　　　）否（　　√　　）

➢ 通常一个月里没有按时交付的订单数量有多少？________________________

问题19. 评估与交通有关的基础设施，以保持其提供的服务质量。

	非常差	差	一般	好	非常好
道路基础设施	○	○	●	○	○
海洋基础设施	○	○	○	●	○
铁路基础设施	○	○	○	●	○
仓储/转运设备	○	○	○	●	○

问题20. 评估在运输过程中检查产品状态所使用的技术。

	非常差	差	一般	好	非常好
IT技术与电子数据交换	○	○	○	●	○
温度传感追踪器	○	○	○	●	○
湿度传感追踪器	○	○	○	●	○
物联网技术（IoT）的应用	○	○	○	○	●
射频识别（RFID）的应用	○	○	○	○	●
人工智能（AI）和机器学习的应用	○	○	○	○	●

问题21. 在您的公司中，下列指标是改善了还是恶化了?

	较恶化	恶化	不变	改善	较改善
员工理解客户需求的能力	○	○	○	○	●
运输物流系统中所有关于“计划”、“来源”和“交付”过程的各方之间信息交换的程度	○	○	○	○	●
在做决定时坚持道德伦理标准	○	○	○	●	○
与其他合作伙伴的关系	○	○	○	○	●
社会责任和人文关注的情况	○	○	○	●	○
社会活动的参与程度	○	○	●	○	○
在环境安全区域内操作	○	○	●	○	○
对于客户需求及各部门之间的需求的了解程度	○	○	○	●	○

问题22. 根据您在运输物流链方面的经验，请选择最能描述您所在公司服务成果的选项。

	极其不同意	不同意	有时同意	同意	强烈同意
公司能够可靠准确地履行所承诺的服务	○	○	○	●	○
订单信息很容易获得	○	○	●	○	○
客户订单的信息总是准确的	○	○	●	○	○
客户（利益相关者）可以方便地下单	○	○	●	○	○
处理订单有统一的程序	○	○	○	●	○

再次感谢您参与这次调查

您填写的信息将会保密

The questionnaire used in Survey part E for Evidential Reasoning (ER) in Chapter Six (**Vietnamese Version)**

Research on risk analysis for transport logistics networks

PHÂN TÍCH NHỮNG RỦI RO TRONG MẠNG LƯỚI VẬN CHUYỂN HÀNG HÓA

Kính thưa Qúy Ông/ Qúy Bà

Tên tôi là Rasheed Onakoya, hiện tại tôi đang nghiên cứu sinh tiến sỹ tại trường Đại Học Liverpool Business. Đề tài nghiên cứu của tôi là " Phân tích những rủi ro trong mạng lưới vận chuyển hàng hóa trong sản phẩm nông nghiệp". Mục đích của nghiên cứu này là đưa ra một phương pháp mới nhằm phân tích, đánh giá những rủi ro và giảm nhẹ những thiệt hại ảnh hưởng lên chất lượng của thực phẩm trong quá trình vận chuyển (FTL). Mục đích chính của bảng câu hỏi này là phát triển khung dữ liệu để phân tích những yếu tố ảnh hưởng trong quá trình vận chuyển thực phẩm, phương pháp phân tích được sử dụng ở đây là Decision-Making Trial và Evaluation Laboratory Model (DEMATEL). Cần so sánh mở rộng những yếu tố ảnh hưởng đến chất lượng vận chuyển thực phẩm trong chuỗi vận chuyển cung cấp thực phẩm và sự giúp đỡ của bạn rất có ý nghĩa trong quá trình điều tra bảng câu hỏi dưới đây. Nghiên cứu này là tình nguyện và thông tin của bạn được giữ bí mật trong suốt quá trình nghiên cứu. Nếu bạn có bất cứ câu hỏi nào, làm ơn hãy liên hệ trực tiếp với tôi qua email r.a.onakoya@2018.ljmu.ac.uk hoặc bạn có thể liên hệ với giáo sư hướng dẫn Tiến Sỹ Zhuohua Qu on (+44)1512314726 or và địa chỉ email Z.qu@ljmu.ac.uk.

Dear Sir/Madam

My name is Rasheed Onakoya, and who is currently a doctoral candidate at Liverpool business school. My research topic is "Risk analysis of transport logistics networks - The case of Agri-food products". The study aims to propose a novel risk management methodology to identify, evaluate and mitigate the causal factors of the deterioration of quality in the food transport logistic (FTL) chain. The purpose of the questionnaire is to develop a contextual framework to evaluate the cause/effect of quality deterioration in the FTL chain. I would be very pleased if you can take part in this study given your professional knowledge in the food supply network or transport logistic chain. The questionnaire is anonymous thus your response can not be attributed to you or your organization. All the information gathered in this survey will be treated in the strictest confidence, as this has always been the policy of Liverpool business school. If you have any questions about this study, please contact me via email at r.a.onakoya@2018.ljmu.ac.uk or you can contact my supervisor, Dr Zhuohua Qu at (+44)1512314726 or by email at Z.qu@ljmu.ac.uk.

Yours faithfully

Rasheed Onakoya *LLM, MM, MICS, MNI*
Doctoral Researcher
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Questionnaire (bảng câu hỏi)

Question 1. What is your position in the company?

Câu 1: chức vụ của bạn trong công ty là gì? **Giám đốc (chủ sở hữu)**

Question 2. The number of years in your organisation:------

Câu 2: Bạn đã làm trong công ty được bao nhiêu năm? :

Question 3. What is the number of employee in your organisation?

Câu 3: Số lượng công nhân trong công ty bạn là bao nhiêu?

Question 4. What direction of transport and logistic activities is your organization primary dealing with?**- the product is broken, and the quality is not good when the transit (get wet and steam)**

Câu 4: Trong khi vận chuyển hàng hóa công ty bạn gặp phải những trở ngại nào? **Hàng hóa bị bể và vàng uế, nhũn**

Question 5. What freight mode does your organisation typically deal with?

Câu 5: Công ty bạn thường sử dụng hình thức vận chuyển nào?

Question 6. Does your organisation have its freight mode**? if you answer "yes", yes but not much**

- In a typical month, how many trips does it cover?

Câu 6: Công ty của bạn có tự vận chuyển hàng hóa hay không? **(nhưng ít)**

- Trong một tháng, thường có bao nhiêu chuyến...

Question 7. What kind of product does your organisation deal with

Câu 7: Những dạng hàng hóa nào mà công ty của bạn thường vận chuyển

Question 8. Is your organisation concerned about the deterioration of quality in the transport logistic chain?—

Câu 8: Công ty của bạn có lo ngại về việc suy giảm chất lượng trong chuỗi vận chuyển hàng hóa không? Có (rủi ro vì sản phẩm không đủ chất lượng)

Question 9. Have you had concern/incident in the past 12 months, relating to the quality of services rendered to any stakeholder ?.

Câu 9: Bạn có gặp sự cố gì trong vòng 12 tháng qua, Liên quan đến chất lượng dịch vụ hoặc bất kỳ những rủi ro nào?

Question 10. Does your organisation receive monthly/annual orders from its stakeholder? if you answer "

- In a typical month, how many times do your organisation receive the full order?
- In a typical month, what is the total quantity of orders received?
- In a typical month, what quantity from the total order received is delivered?
- Câu 10: Tổ chức của bạn có nhận được đơn đặt hàng hàng tháng/hàng năm không? Nếu có
- Trong một **năm**, tổ chức của bạn nhận được bao nhiêu đơn đặt hàng?
- Trong một **năm**, tổng số lượng đơn đặt hàng nhận được là bao nhiêu?

- Trong một **năm**, tổng số lượng đơn đặt hàng mà công ty của bạn đã giao là bao nhiêu?
- **Question 11**. Does your organisation allow special/urgent/unexpected orders? if you answer "yes"

  - In a typical month, how many special/urgent/unexpected orders are allowed? –
  - In a typical month, how many special/urgent/unexpected orders are received?-

Câu 11: Tổ chức của bạn có nhận các đơn đặt hàng đặc biệt / khẩn cấp / bất ngờ không? nếu có

- Trong một tháng, bao nhiêu đơn đặt hàng đặc biệt / khẩn cấp / bất ngờ được phép? Nhiều nhất
- Trong một tháng, bao nhiêu đơn đặt hàng đặc biệt / khẩn cấp / bất ngờ được nhận?

Question 12. Does your organisation have storage/warehouse facilities? If you answer "yes"

- What is the total volume of storage/warehouse that is available?
- In a typical month, what volume of the storage/warehouse is in use?

Câu 12: Công ty của bạn có nhà kho/ nơi chứa hàng hóa không? Nếu có

- Diện tích tổng của nhà kho/ nơi chứa hàng hóa của công ty bạn là bao nhiêu?
- Trong một tháng, diện tích nhà kho/ nơi chứa hàng hóa của công ty bạn được sử dụng bao nhiêu?

Question 13. Does your organisation have on standby personnel dealing with the order? If you answer "yes"

- In a typical month, what number of personnel are available?
- How many hours are the personnel allowed to work in a day ?-

Câu 13: Công ty của bạn có những người làm ở bộ phận tiếp nhận đơn đặt hàng không? Nếu có

- Trong vòng một tháng, số người làm việc là bao nhiêu?
- Số giờ làm của người làm việc ở bộ phận tiếp nhận là mấy giờ/ngày?

Question 14. Does your organisation have sufficient equipment to handle the orders? If you answer "yes"

- In a typical month, how much of the equipment is in use?

Câu 14: Công ty bạn có đủ các dụng cụ để xử lý các đơn đặt hàng hay không? Nếu có

- Trong một tháng, có bao nhiêu dụng cụ được dùng?

Question 15. In the past 12 months, does your organisation encounter any security threats on orders? If you answer "yes"

- What is the number of the recorded security threat?--

Câu 15: Trong vòng 12 tháng qua, công ty của bạn có gặp bất kỳ mối đe dọa nào đến những đơn hàng? Nếu có

- Bao nhiêu lần công ty của bạn gặp phải những rủi ro?

Question 16. In the past 12 months, does your organisation encountered any accidents during product transportation? If you answer "yes"

- In a typical month, what is the number of accidents recorded per trip?
- Câu 16: Trong vòng 12 tháng qua, công ty của bạn có gặp bất kỳ tai nạn nào đến những đơn hàng? Nếu có
- Trong vòng 1 tháng, số vụ tai nạn được ghi nhận trên mỗi chuyến đi là bao nhiêu?

Question 17. In the past 12 months, has your organisation received complaints of any mistake orders during delivery? If you answer "yes"

- In a typical month, how many mistake order is delivered ? Câu 17: Trong vòng 12 tháng qua, công ty của bạn có gặp phải những lời phàn nàn hoặc gặp những lỗi khi vận chuyển hàng hóa? Nếu có
- Trong vòng 1 tháng, bao nhiêu lỗi gặp phải trong các chuyến giao hàng?

Question 18. In the past 12 months, does your organisation receive complaints about late order delivery? If you answer **"yes"**

- In a typical month, what quantity from the order received is not delivered on time?

Câu 18: Trong vòng 12 tháng qua, công ty của bạn có nhận được bất kỳ lời phàn nàn nào từ việc giao hàng bị trễ? Nếu có

- ➢ Trong vòng 1 tháng, số lượng bạn giao hàng không đúng thời gian là bao nhiêu chuyến?

Question 19. Evaluate the physical appearance of the transport-related infrastructure in keeping with the quality of service provided.
Cơ sở hạ tầng của công ty có phù hợp với dịch vụ vận chuyển hàng hóa không?

	Very low Rất thấp	Low Thấp	Medium Trung bình	High cao	Very High Rất cao
Road infrastructure – đường bộ	○	○	○	**○**	○
Sea infrastructure – cảng, đường biển	○	○	**○**	○	○
Rail infrastructure – cơ sở hạ tầng đường sắt	**○**	○	○	○	○
Warehousing /trans-loading facilities – nhà Kho/chuyển tải	○	○	**○**	○	○

Question 20. Evaluate the techniques used in checking product condition during transit
Các kỹ thuật được sử dụng trong việc kiểm tra tình trạng sản phẩm trong quá trình vận chuyển

	Very low Rất thấp	Low Thấp	Medium Trung bình	High cao	Very High Rất cao
Electronic data interchange – trao đổi dữ liệu điện tử	○	○	**○**	○	○
Temperature sensor – cảm biến nhiệt độ	○	○	○	**○**	○
Humidity sensor – cảm biến độ ẩm	○	○	○	○	**○**

Question 21. Have the following indicators improved or worsened in your organisation?
Các chỉ số sau được cải thiện hoặc trở nên tồi tệ hơn trong tổ chức của bạn?

	Much worse Rất tệ	Worse Tệ	About the same Không thay đổi	Improved Đã được cải thiện	Much improved Được cải thiện rất nhiều

Staff competency in understanding customer requirements Năng lực của nhân viên trong việc hiểu yêu cầu của khách hàng	○	○	○	**○**	○
Organisation's degree of openness in the information exchange between all parties in the transport logistic system regarding 'Plan' 'Source' and 'delivering ' process Mức độ mở của tổ chức trong việc trao đổi thông tin giữa tất cả các bên trong quá trình vận chuyển liên quan đến 'Kế hoạch' 'Nguồn' và 'phân phối'	○	○	○	○	**○**
Upholding moral and ethical standard while making a decision Nâng cao tiêu chuẩn đạo đức và duy trì đạo đức trong khi đưa ra quyết định	○	○	**○**	○	○
Collaboration with other partners Liên kết với những công ty khác	○	○	○	**○**	○
Social responsibilities and concern for human safety Trách nhiệm của xã hội và quan tâm đến sự an toàn của con người	○	○	○	○	**○**
Knowledge in understanding how business insight is exercised between different divisions in your organisation and your client Có kiến thức hiểu biết về kinh doanh được thực hiện giữa các bộ phận khác nhau trong tổ chức của bạn và khách hàng.	○	○	**○**	○	○

Question 22. Based on your experience in the transport logistic chain, please select the option that best describes the outcome of services in your organisation
Với nền tảng kinh nghiệm của bạn trong chuỗi vận chuyển hàng hóa, làm ơn hãy chọn những chủ đề mô tả tốt nhất của dịch vụ vận chuyển của cơ quan bạn

	Strongly disagree	Disagree Không đồng ý	Sometimes Thỉnh thoảng đồng ý	Agree Đồng ý	Strongly agree Rất đồng ý

	Rất không đồng ý				
The organisation performed the promised services dependably and accurately Tổ chức thực hiện các dịch vụ đã hứa một cách đáng tin cậy và chính xác	○	○	○	○	○
Order information is readily available Thông tin đặt hàng có sẵn	○	○	○	○	○
Information on customer orders is always accurate Thông tin về đơn đặt hàng của khách hàng luôn chính xác	○	○	○	○	○
The stakeholder can place orders conveniently Khách hàng có thể đặt hàng thuận tiện	○	○	○	○	○
Accuracy with order documentation Độ chính xác với tài liệu đặt hàng	○	○	○	○	○
There is a consistent procedure in handling orders Có một quy trình nhất quán trong việc xử lý các đơn đặt hàng	○	○	○	○	○

THANK YOU ONCE AGAIN FOR YOUR KIND PARTICIPATION IN THIS SURVEY

YOUR ANSWER WILL BE KEPT CONFIDENTIAL.

Appendix Six

The questionnaire used in Survey part F for the TOPSIS method

Dear sir /Madam

My name is Rasheed Onakoya, and who is currently a PhD candidate at Liverpool John Moore's University Business School, My research topic is " Research on risk management for transport logistics networks - The case of Agri-food products". The study aims to develop a novel safety risk assessment methodology to identify, evaluate and mitigate the risks affecting the safety of global food transportation under uncertain environments. The purpose of the questionnaire is to examine the best solution to the top priority risk (service quality) mitigation of the transport logistic chain in the agro-food sector.

I would be pleased if you can take part in this study given your professional judgement and experience in the food sector, supply chain management and risk management.

Participation in this study is voluntary, and the Information gathered will be treated with the strictest confidence. The questionnaire is anonymous, and your response can not be attributed to you or your organization. If you have any questions about the study, please feel free to contact me via email at r.a.onakoya@2018.ljmu.ac.uk or you can contact my supervisor, Dr Zhuohua Qu at (+44)1512314726 or by email at Z.qu@ljmu.ac.uk

Sincerely,

Rasheed Onakoya ***LLM, MM, MICS, MNI***

Doctoral Researcher

Liverpool Business School

Redmond Building, Brownlow Hill, Liverpool,

L3 5UG

List of Semi-structured Interview Questions for Chapter Eight

1. What is the type of your organisation?
2. What is your job title?
3. For how many years have you worked in the food transport logistic industry or food supply chain

< 5 years	6-10 years	11-15 years	16-19 years	>20 years
☐	☐	☐	☐	☐

4. Do you believe the below strategies could mitigate service quality performance in the Food transport and logistic industry?

1). Transformation leadership is a top management commitment
2). Employee involvement
3). Continuous improvement and innovation
4). Employee training and development
5). Teamwork and involvement
6). Customer focus and satisfaction
7). Process management
8) Strategic planning
9) Information and analysis system
10) Benchmarking
11) Service culture

Thanks for participating in the study

Appendix Seven

Participant information sheet /consent form

LJMU's Research Ethics Committee Approval Reference:

Title of Study: Risk analysis of transport logistics networks - The case of Agri-food products

You are invited to take part in a study. Before you decide it is important for you to understand why the study is being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for taking the time to read this.

1. Who will conduct the study?

Study Team

Rasheed Onakoya
Dr Zhuohua Qu
Prof. Zaili Yang
Dr Jackie Douglas
Dr Dong Li

Principal Investigator: Rasheed Onakoya

Co-investigator: Dr Zhuohua Qu

School/Faculty within LJMU: Liverpool Business School

2. What is the purpose of the study?

This research project aims to develop a novel safety assessment framework to analyse the risks affecting the safety of global food transportation in an uncertain environment

This study hopes to answer the following questions

Q1. How the risk hazards under the highly uncertain environment existing in the transport logistic network of the food supply chain can be identified?

Q2. How does the interdependency between probability and severity influence the risk analysis?

Q3. How do the analytical methods play a role in risk evaluation and how the risk effects can be estimated and evaluated?

3. Why have I been invited to participate?

You have been invited because of your professional knowledge and experience in food supply chain risk assessment

4. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. You can withdraw at any time by informing the investigators without giving a reason and without it affecting your rights/any future treatment/service you receive.

5. What will happen to me if I take part?

We will talk you through the study procedures and give you the chance to ask any questions.

6. Will I be recorded and how will the recorded media be used? N/A

7. What are the possible benefits of taking part?

Whilst will be no direct benefits to you for taking part in the study, it is hoped that this work will provide a reference for the managers and decision-makers in both the public and private sectors when deciding on food transportation safety in an uncertain environment

8. What will happen to the data provided and how will my taking part in this project be kept confidential?

When you agree to take part in a study, we will use your data in the ways needed to conduct and analyse the study and if necessary, to verify and defend, when required, the process and outcomes of the study. Personal data will be accessible to the study team. When we do not need to use personal data, it will be deleted or identifiers will be removed. However, your consent form, contact details, audio recordings etc. will be retained for 3 years. Responsible members of Liverpool John Moores University may be given access to data for monitoring and/or auditing of the study to ensure that the study is complying with applicable regulations.

We will not tell anyone that you have taken part in the focus group, although there is of course a possibility that another member of the group might recognise you. We will also not name you in any of our reports or publications. In addition, all participants in the focus group will be asked to respect the confidentiality of their fellow participants.

9. Limits to confidentiality

Please note that confidentiality may not be guaranteed; for example, due to the limited size of the participant sample, the position of the participant or information included in reports, participants might be indirectly identifiable in transcripts and reports. The investigator will work with the participant in an attempt to minimise and manage the potential for indirect identification of participants.

10. What will happen to the results of the study?

The investigator intends to publish the result in a PhD thesis

11. Who is organising and funding/commissioning the study?

This study is organised by Liverpool John Moores University

12. Who has reviewed this study?

This study has been reviewed by, and received ethics clearance through, the Liverpool John Moores University Research Ethics Committee (Reference number: xxx).

13. What if something goes wrong?

If you have a concern about any aspect of this study, please contact the relevant investigator who will do their best to answer your query. The investigator should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you wish to make a complaint, please contact the chair of the Liverpool John Moores University Research Ethics Committee (researchethics@ljmu.ac.uk) and your communication will be re-directed to an independent person as appropriate.

14. Data Protection Notice

Liverpool John Moores University is the sponsor for this study based in the United Kingdom. We will be using information from you to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. Liverpool John Moores University will process your data for research. Research is a task that we perform in the public interest. Liverpool John Moores University will keep identifiable information about you for a few years after the study has finished.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways for the study to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

You can find out more about how we use your information at URL and/or by contacting secretariat@ljmu.ac.uk.

If you are concerned about how your data is being processed, please contact LJMU in the first instance at secretariat@ljmu.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's Office (ICO). Contact details, and details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

16. Contact for further information

Rasheed Onakoya ***LLM, MM, MICS MNI***

Researcher

Liverpool Business School

Redmond's Building,

Brownlow Hill,

Liverpool, L3 5UG

E: r.a.onakoya@2018.ljmu.ac.uk

Thank you for reading this information sheet and for considering taking part in this study.

Appendix Eight (consent form)

LIVERPOOL JOHN MOORES UNIVERSITY CONSENT FORM

Risk analysis of transport logistics networks - The case of Agri-food products

Liverpool Business School

1. I confirm that I have read and understood the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐

3. I understand that any personal information collected during the study will be anonymised and remain confidential ☐

4. I agree to take part in the above study *(if appropriate please specify the type of study or particular intervention you are seeking consent for – eg focus group, interview, training programme)* ☐

5. I understand that the interview/focus group will be audio/video recorded and I am happy to proceed ☐

6. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised. ☐

7.

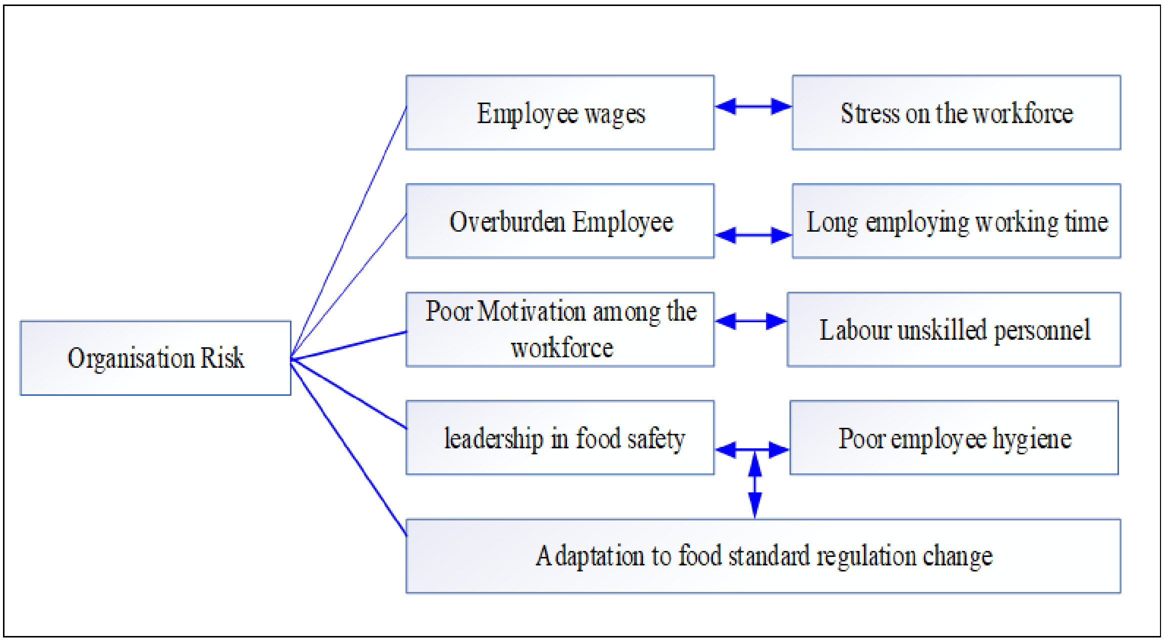
Name of Participant	Date	Signature
Name of Researcher	Date	Signature
Onakoya Rasheed		
PhD Researcher		
Name of Person taking consent	Date	Signature

(if different from the researcher)

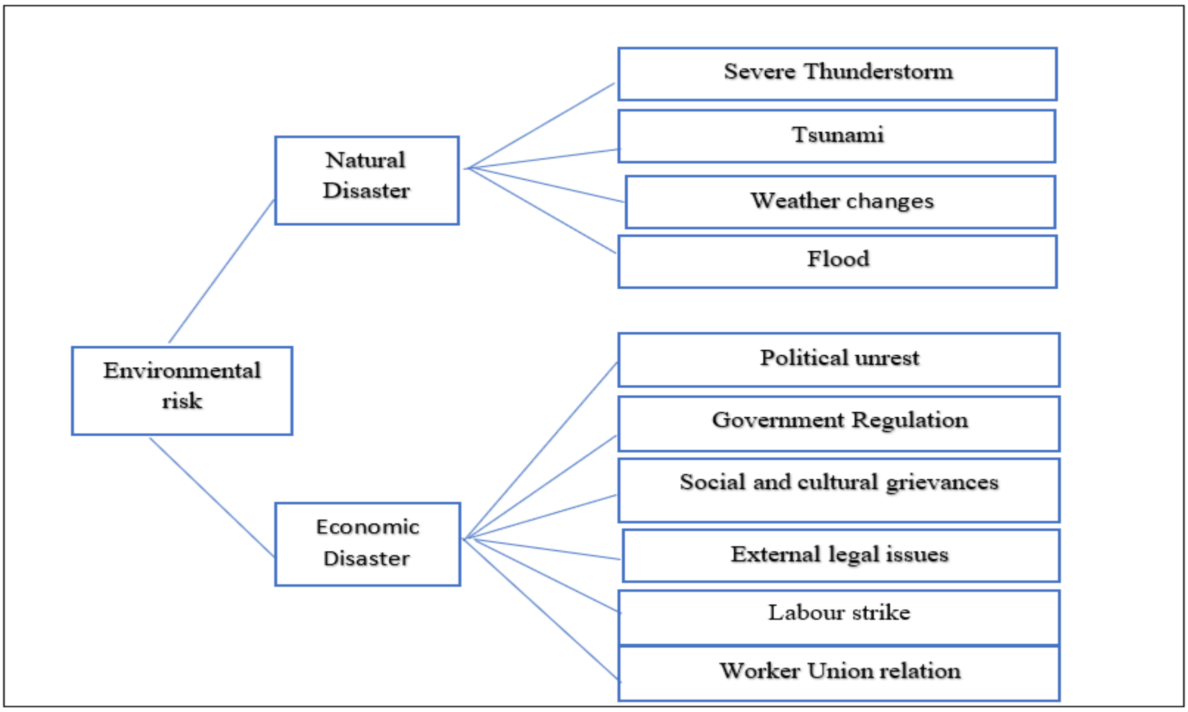
Note: When completed 1 copy for the participant and 1 copy for the researcher

Appendix Nine - Transport and logistic risk hazard classification

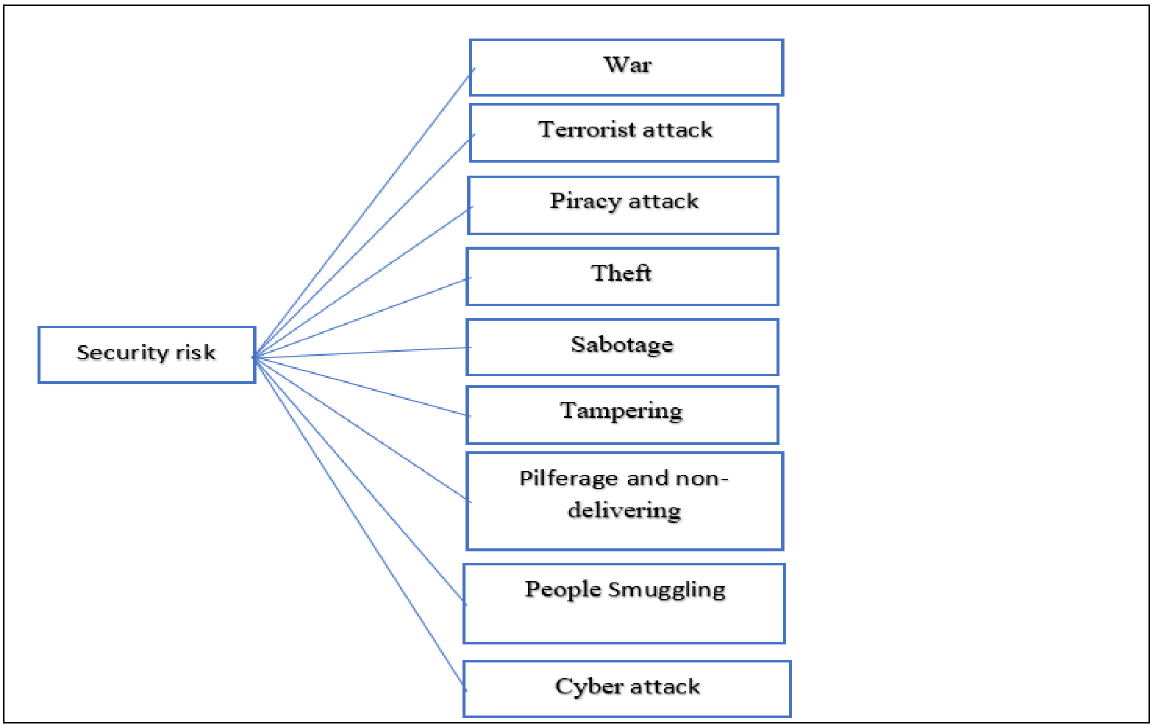
The transport and logistic organization risk hazard source



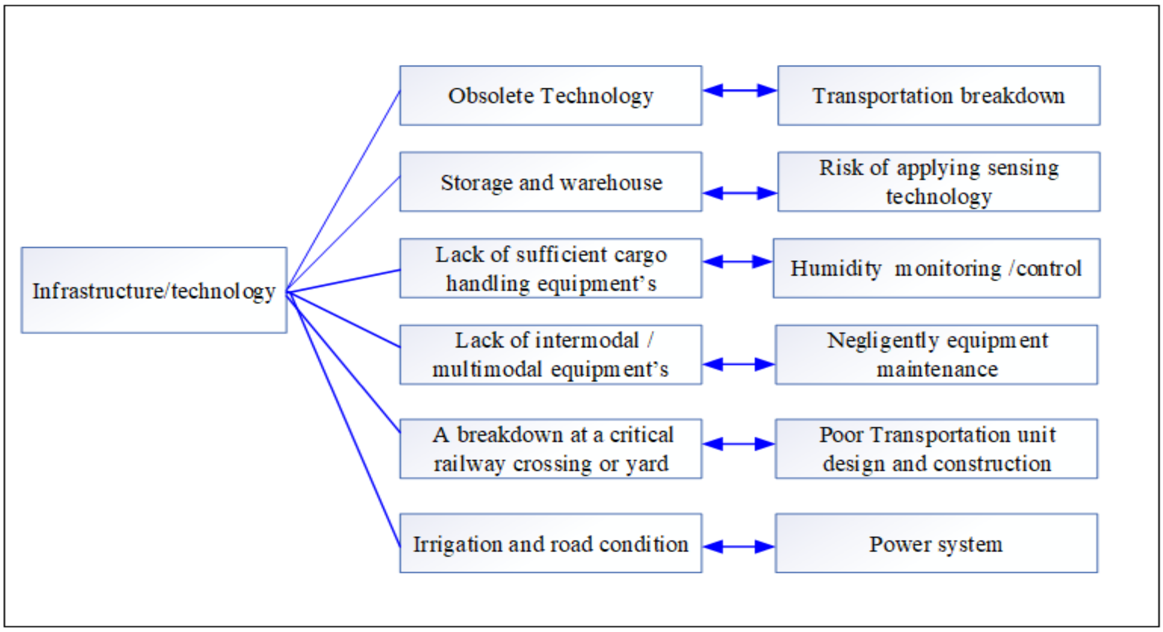
The transport and logistic environmental risk hazard source



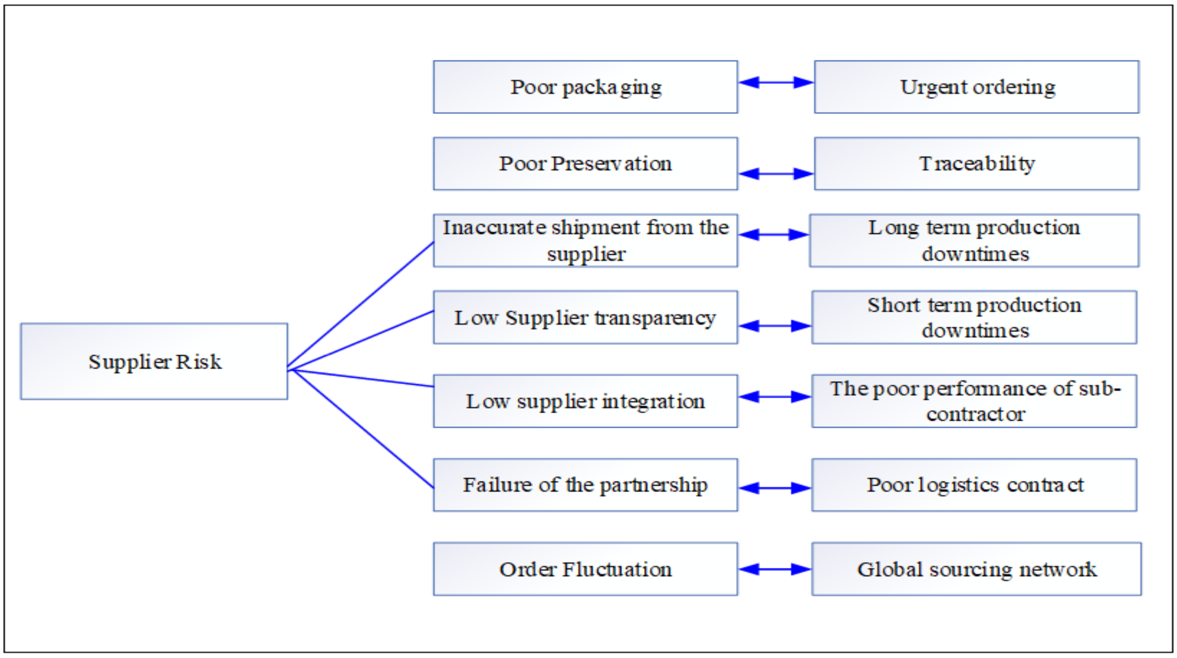
The transport and logistic security risk hazard source



The transport and logistic infrastructure and technology risk hazard source



The transport and logistic supplier risk hazard source


Supplier Risk
Poor packaging
Urgent ordering
Poor Preservation
Traceability
Inaccurate shipment from the supplier
Long term production downtimes
Low Supplier transparency
Short term production downtimes
Low supplier integration
The poor performance of sub-contractor
Failure of the partnership
Poor logistics contract
Order Fluctuation
Global sourcing network

Appendix Ten.

Rule based belief structure

The established L, R, P, C_L FRB with a belief structure for the assessment of AFTL risk factors

Rules	Antecedent Attribute (input)				Risk result (Output)				
No	L	R	P	C	Very Low	Low	Medium	High	Very High
1	Highly Unlikely	Very Low	Highly Unlikely	Very Low	1				
2	Highly Unlikely	Very Low	Highly Unlikely	Low	0.71	0.29			
3	Highly Unlikely	Very Low	Highly Unlikely	Medium	0.71		0.29		
4	Highly Unlikely	Very Low	Highly Unlikely	High	0.71			0.29	
5	Highly Unlikely	Very Low	Highly Unlikely	Very High	0.71				0.29
6	Highly Unlikely	Very Low	Unlikely	Very Low	0.68	0.32			
7	Highly Unlikely	Very Low	Unlikely	Low	0.39	0.61			
8	Highly Unlikely	Very Low	Unlikely	Medium	0.39	0.32	0.29		
9	Highly Unlikely	Very Low	Unlikely	High	0.39	0.32		0.29	
10	Highly Unlikely	Very Low	Unlikely	Very High	0.39	0.32			0.29
11	Highly Unlikely	Very Low	Likely	Very Low	0.68		0.32		
12	Highly Unlikely	Very Low	Likely	Low	0.39	0.29	0.32		
13	Highly Unlikely	Very Low	Likely	Medium	0.39		0.61		
14	Highly Unlikely	Very Low	Likely	High	0.39		0.32	0.29	
15	Highly Unlikely	Very Low	Likely	Very High	0.39		0.32		0.29
16	Highly Unlikely	Very Low	Highly Likely	Very Low	0.68			0.32	
17	Highly Unlikely	Very Low	Highly Likely	Low	0.39	0.29		0.32	
18	Highly Unlikely	Very Low	Highly Likely	Medium	0.39		0.29	0.32	
19	Highly Unlikely	Very Low	Highly Likely	High	0.39			0.61	

20	Highly Unlikely	Very Low	Highly Likely	Very High	0.39			0.32	0.29
21	Highly Unlikely	Very Low	Definite	Very Low	0.68				0.32
22	Highly Unlikely	Very Low	Definite	Low	0.39	0.29			0.32
23	Highly Unlikely	Very Low	Definite	Medium	0.39		0.29		0.32
24	Highly Unlikely	Very Low	Definite	High	0.39			0.29	0.32
25	Highly Unlikely	Very Low	Definite	Very High	0.39				0.61
26	Highly Unlikely	Low	Highly Unlikely	Very Low	0.92	0.08			
27	Highly Unlikely	Low	Highly Unlikely	Low	0.63	0.37			
28	Highly Unlikely	Low	Highly Unlikely	Medium	0.63	0.08	0.29		
29	Highly Unlikely	Low	Highly Unlikely	High	0.63	0.08		0.29	
30	Highly Unlikely	Low	Highly Unlikely	Very High	0.63	0.08			0.29
31	Highly Unlikely	Low	Unlikely	Very Low	0.6	0.4			
32	Highly Unlikely	Low	Unlikely	Low	0.31	0.69			
33	Highly Unlikely	Low	Unlikely	Medium	0.31	0.4	0.29		
34	Highly Unlikely	Low	Unlikely	High	0.31	0.4		0.29	
35	Highly Unlikely	Low	Unlikely	Very High	0.31	0.4			0.29
36	Highly Unlikely	Low	Likely	Very Low	0.6	0.08	0.32		
37	Highly Unlikely	Low	Likely	Low	0.31	0.37	0.32		
38	Highly Unlikely	Low	Likely	Medium	0.31	0.08	0.61		
39	Highly Unlikely	Low	Likely	High	0.31	0.08	0.32	0.29	
40	Highly Unlikely	Low	Likely	Very High	0.31	0.08	0.32		0.29
41	Highly Unlikely	Low	Highly Likely	Very Low	0.6	0.08		0.32	
42	Highly Unlikely	Low	Highly Likely	Low	0.31	0.37		0.32	
43	Highly Unlikely	Low	Highly Likely	Medium	0.31	0.08	0.29	0.32	
44	Highly Unlikely	Low	Highly Likely	High	0.31	0.08		0.61	
45	Highly Unlikely	Low	Highly Likely	Very High	0.31	0.08		0.32	0.29

46	Highly Unlikely	Low	Definite	Very Low	0.6	0.08			0.32
47	Highly Unlikely	Low	Definite	Low	0.31	0.37			0.32
48	Highly Unlikely	Low	Definite	Medium	0.31	0.08	0.29		0.32
49	Highly Unlikely	Low	Definite	High	0.31	0.08		0.29	0.32
50	Highly Unlikely	Low	Definite	Very High	0.31	0.08			0.61
51	Highly Unlikely	Medium	Highly Unlikely	Very Low	0.92		0.08		
52	Highly Unlikely	Medium	Highly Unlikely	Low	0.63	0.29	0.08		
53	Highly Unlikely	Medium	Highly Unlikely	Medium	0.63		0.37		
54	Highly Unlikely	Medium	Highly Unlikely	High	0.63		0.08	0.29	
55	Highly Unlikely	Medium	Highly Unlikely	Very High	0.63		0.08		0.29
56	Highly Unlikely	Medium	Unlikely	Very Low	0.6	0.32	0.08		
57	Highly Unlikely	Medium	Unlikely	Low	0.31	0.61	0.08		
58	Highly Unlikely	Medium	Unlikely	Medium	0.31	0.32	0.37		
59	Highly Unlikely	Medium	Unlikely	High	0.31	0.32	0.08	0.29	
60	Highly Unlikely	Medium	Unlikely	Very High	0.31	0.32	0.08		0.29
61	Highly Unlikely	Medium	likely	Very Low	0.6		0.4		
62	Highly Unlikely	Medium	likely	Low	0.31	0.29	0.4		
63	Highly Unlikely	Medium	likely	Medium	0.31		0.69		
64	Highly Unlikely	Medium	likely	High	0.31		0.4	0.29	
65	Highly Unlikely	Medium	likely	Very High	0.31		0.4		0.29
66	Highly Unlikely	Medium	Highly Likely	Very Low	0.6		0.08	0.32	
67	Highly Unlikely	Medium	Highly Likely	Low	0.31	0.29	0.08	0.32	
68	Highly Unlikely	Medium	Highly Likely	Medium	0.31		0.37	0.32	
69	Highly Unlikely	Medium	Highly Likely	High	0.31		0.08	0.61	
70	Highly Unlikely	Medium	Highly Likely	Very High	0.31		0.08	0.32	0.29
71	Highly Unlikely	Medium	Definite	Very Low	0.6		0.08		0.32

72	Highly Unlikely	Medium	Definite	Low	0.31	0.29	0.08		0.32
73	Highly Unlikely	Medium	Definite	Medium	0.31		0.37		0.32
74	Highly Unlikely	Medium	Definite	High	0.31		0.08	0.29	0.32
75	Highly Unlikely	Medium	Definite	Very High	0.31		0.08		0.61
76	Highly Unlikely	High	Highly Unlikely	Very Low	0.92			0.08	
77	Highly Unlikely	High	Highly Unlikely	Low	0.63	0.29		0.08	
78	Highly Unlikely	High	Highly Unlikely	Medium	0.63		0.29	0.08	
79	Highly Unlikely	High	Highly Unlikely	High	0.63			0.37	
80	Highly Unlikely	High	Highly Unlikely	Very High	0.63			0.08	0.29
81	Highly Unlikely	High	Unlikely	Very Low	0.63	0.32		0.08	
82	Highly Unlikely	High	Unlikely	Low	0.31	0.61		0.08	
83	Highly Unlikely	High	Unlikely	Medium	0.31	0.32	0.29	0.08	
84	Highly Unlikely	High	Unlikely	High	0.31	0.32		0.37	
85	Highly Unlikely	High	Unlikely	Very High	0.31	0.32		0.08	0.29
86	Highly Unlikely	High	Likely	Very Low	0.6		0.32	0.08	
87	Highly Unlikely	High	Likely	Low	0.31	0.29	0.32	0.08	
88	Highly Unlikely	High	Likely	Medium	0.31		0.61	0.08	
89	Highly Unlikely	High	Likely	High	0.31		0.32	0.37	
90	Highly Unlikely	High	Likely	Very High	0.31		0.32	0.08	0.29
91	Highly Unlikely	High	Highly Likely	Very Low	0.6			0.4	
92	Highly Unlikely	High	Highly Likely	Low	0.31	0.29		0.4	
93	Highly Unlikely	High	Highly Likely	Medium	0.31		0.29	0.4	
94	Highly Unlikely	High	Highly Likely	High	0.31			0.69	
95	Highly Unlikely	High	Highly Likely	Very High	0.31			0.4	0.29
96	Highly Unlikely	High	Definite	Very Low	0.6			0.08	0.32
97	Highly Unlikely	High	Definite	Low	0.31	0.29		0.08	0.32

98	Highly Unlikely	High	Definite	Medium	0.31		0.29	0.08	0.32
99	Highly Unlikely	High	Definite	High	0.31			0.37	0.32
100	Highly Unlikely	High	Definite	Very High	0.31			0.08	0.61
101	Highly Unlikely	Very High	Highly Unlikely	Very Low	0.92				0.08
102	Highly Unlikely	Very High	Highly Unlikely	Low	0.63	0.29			0.08
103	Highly Unlikely	Very High	Highly Unlikely	Medium	0.63		0.29		0.08
104	Highly Unlikely	Very High	Highly Unlikely	High	0.63			0.29	0.08
105	Highly Unlikely	Very High	Highly Unlikely	Very High	0.63				0.37
106	Highly Unlikely	Very High	Unlikely	Very Low	0.6	0.32			0.08
107	Highly Unlikely	Very High	Unlikely	Low	0.31	0.61			0.08
108	Highly Unlikely	Very High	Unlikely	Medium	0.31	0.32	0.29		0.08
109	Highly Unlikely	Very High	Unlikely	High	0.31	0.32		0.29	0.08
110	Highly Unlikely	Very High	Unlikely	Very High	0.31	0.32			0.37
111	Highly Unlikely	Very High	Likely	Very Low	0.6		0.32		0.08
112	Highly Unlikely	Very High	Likely	Low	0.31	0.29	0.32		0.08
113	Highly Unlikely	Very High	Likely	Medium	0.31		0.61		0.08
114	Highly Unlikely	Very High	Likely	High	0.31		0.32	0.29	0.08
115	Highly Unlikely	Very High	Likely	Very High	0.31		0.32		0.37
116	Highly Unlikely	Very High	Highly Likely	Very Low	0.6			0.32	0.08
117	Highly Unlikely	Very High	Highly Likely	Low	0.31	0.29		0.32	0.08
118	Highly Unlikely	Very High	Highly Likely	Medium	0.31		0.29	0.32	0.08
119	Highly Unlikely	Very High	Highly Likely	High	0.31			0.61	0.08
120	Highly Unlikely	Very High	Highly Likely	Very High	0.31			0.32	0.37
121	Highly Unlikely	Very High	Definite	Very Low	0.6				0.4
122	Highly Unlikely	Very High	Definite	Low	0.31	0.29			0.4
123	Highly Unlikely	Very High	Definite	Medium	0.31		0.29		0.4

124	Highly Unlikely	Very High	Definite	High	0.31			0.29	0.4
125	Highly Unlikely	Very High	Definite	Very High	0.31				0.69
126	Unlikely	Very Low	Highly unlikely	Very Low	0.69	0.31			
127	Unlikely	Very Low	Highly unlikely	Low	0.4	0.6			
128	Unlikely	Very Low	Highly unlikely	Medium	0.4	0.31	0.29		
129	Unlikely	Very Low	Highly unlikely	High	0.4	0.31		0.29	
130	Unlikely	Very Low	Highly unlikely	Very High	0.4	0.31			0.29
131	Unlikely	Very Low	Unlikely	Very Low	0.37	0.63			
132	Unlikely	Very Low	Unlikely	Low	0.08	0.92			
133	Unlikely	Very Low	Unlikely	Medium	0.08	0.63	0.29		
134	Unlikely	Very Low	Unlikely	High	0.08	0.63		0.29	
135	Unlikely	Very Low	Unlikely	Very High	0.08	0.63			0.29
136	Unlikely	Very Low	Likely	Very Low	0.37	0.31	0.32		
137	Unlikely	Very Low	Likely	Low	0.08	0.6	0.32		
138	Unlikely	Very Low	Likely	Medium	0.08	0.31	0.61		
139	Unlikely	Very Low	Likely	High	0.08	0.31	0.32	0.29	
140	Unlikely	Very Low	Likely	Very High	0.08	0.31	0.32		0.29
141	Unlikely	Very Low	Highly Likely	Very Low	0.37	0.31		0.32	
142	Unlikely	Very Low	Highly Likely	Low	0.08	0.6		0.32	
143	Unlikely	Very Low	Highly Likely	Medium	0.08	0.31	0.29	0.32	
144	Unlikely	Very Low	Highly Likely	High	0.08	0.31		0.61	
145	Unlikely	Very Low	Highly Likely	Very High	0.08	0.31		0.32	0.29
146	Unlikely	Very Low	Definite	Very Low	0.37	0.31			0.32
147	Unlikely	Very Low	Definite	Low	0.08	0.6			0.32
148	Unlikely	Very Low	Definite	Medium	0.08	0.31	0.29		0.32
149	Unlikely	Very Low	Definite	High	0.08	0.31		0.29	0.32
150	Unlikely	Very Low	Definite	Very High	0.08	0.31			0.61
151	Unlikely	Low	Highly Unlikely	Very Low	0.61	0.39			
152	Unlikely	Low	Highly Unlikely	Low	0.32	0.68			
153	Unlikely	Low	Highly Unlikely	Medium	0.32	0.39	0.29		
154	Unlikely	Low	Highly Unlikely	High	0.32	0.39		0.29	

155	Unlikely	Low	Highly Unlikely	Very High	0.32	0.39			0.29
156	Unlikely	Low	Unlikely	Very Low	0.29	0.71			
157	Unlikely	Low	Unlikely	Low		1			
158	Unlikely	Low	Unlikely	Medium		0.71	0.29		
159	Unlikely	Low	Unlikely	High		0.71		0.29	
160	Unlikely	Low	Unlikely	Very High		0.71			0.29
161	Unlikely	Low	likely	Very Low	0.29	0.39	0.32		
162	Unlikely	Low	likely	Low		0.68	0.32		
163	Unlikely	Low	likely	Medium		0.39	0.61		
164	Unlikely	Low	likely	High		0.39	0.32	0.29	
165	Unlikely	Low	likely	Very High		0.39	0.32		0.29
166	Unlikely	Low	Highly Likely	Very Low	0.29	0.39		0.32	
167	Unlikely	Low	Highly Likely	Low		0.68		0.32	
168	Unlikely	Low	Highly Likely	Medium		0.39	0.29	0.32	
169	Unlikely	Low	Highly Likely	High		0.39		0.61	
170	Unlikely	Low	Highly Likely	Very High		0.39		0.32	0.29
171	Unlikely	Low	Definite	Very Low	0.29	0.39			0.32
172	Unlikely	Low	Definite	Low		0.68			0.32
173	Unlikely	Low	Definite	Medium		0.39	0.29		0.32
174	Unlikely	Low	Definite	High		0.39		0.29	0.32
175	Unlikely	Low	Definite	Very High		0.39			0.61
176	Unlikely	Medium	Highly Unlikely	Very Low	0.61	0.31	0.08		
177	Unlikely	Medium	Highly Unlikely	Low	0.32	0.6	0.08		
178	Unlikely	Medium	Highly Unlikely	Medium	0.32	0.31	0.37		
179	Unlikely	Medium	Highly Unlikely	High	0.32	0.31	0.08	0.29	
180	Unlikely	Medium	Highly Unlikely	Very High	0.32	0.31	0.08		0.29
181	Unlikely	Medium	Unlikely	Very Low	0.29	0.63	0.08		
182	Unlikely	Medium	Unlikely	Low		0.92	0.08		
183	Unlikely	Medium	Unlikely	Medium		0.63	0.37		
184	Unlikely	Medium	Unlikely	High		0.63	0.08	0.29	
185	Unlikely	Medium	Unlikely	Very High		0.63	0.08		0.29
186	Unlikely	Medium	Likely	Very Low	0.29	0.31	0.4		
187	Unlikely	Medium	Likely	Low		0.6	0.4		

188	Unlikely	Medium	Likely	Medium		0.31	0.69		
189	Unlikely	Medium	Likely	High		0.31	0.4	0.29	
190	Unlikely	Medium	Likely	Very High		0.31	0.4		0.29
191	Unlikely	Medium	Highly Likely	Very Low	0.29	0.31	0.08	0.32	
192	Unlikely	Medium	Highly Likely	Low		0.6	0.08	0.32	
193	Unlikely	Medium	Highly Likely	Medium		0.31	0.37	0.32	
194	Unlikely	Medium	Highly Likely	High		0.31	0.08	0.61	
195	Unlikely	Medium	Highly Likely	Very High		0.31	0.08	0.32	0.29
196	Unlikely	Medium	Definite	Very Low	0.29	0.31	0.08		0.32
197	Unlikely	Medium	Definite	Low		0.6	0.08		0.32
198	Unlikely	Medium	Definite	Medium		0.31	0.37		0.32
199	Unlikely	Medium	Definite	High		0.31	0.08	0.29	0.32
200	Unlikely	Medium	Definite	Very High		0.31	0.08		0.61
201	Unlikely	High	Highly Unlikely	Very Low	0.61	0.31		0.08	
202	Unlikely	High	Highly Unlikely	Low	0.32	0.6		0.08	
203	Unlikely	High	Highly Unlikely	Medium	0.32	0.31	0.29	0.08	
204	Unlikely	High	Highly Unlikely	High	0.32	0.31		0.37	
205	Unlikely	High	Highly Unlikely	Very High	0.32	0.31		0.08	0.29
206	Unlikely	High	Unlikely	Very Low	0.29	0.63		0.08	
207	Unlikely	High	Unlikely	Low		0.92		0.08	
208	Unlikely	High	Unlikely	Medium		0.63	0.29	0.08	
209	Unlikely	High	Unlikely	High		0.63		0.37	
210	Unlikely	High	Unlikely	Very High		0.63		0.08	0.29
211	Unlikely	High	Likely	Very Low	0.29	0.31	0.32	0.08	
212	Unlikely	High	Likely	Low		0.6	0.32	0.08	
213	Unlikely	High	Likely	Medium		0.31	0.61	0.08	
214	Unlikely	High	Likely	High		0.31	0.32	0.37	
215	Unlikely	High	Likely	Very High		0.31	0.32	0.08	0.29
216	Unlikely	High	Highly Likely	Very Low	0.29	0.31		0.4	
217	Unlikely	High	Highly Likely	Low		0.6		0.4	
218	Unlikely	High	Highly Likely	Medium		0.31	0.29	0.4	
219	Unlikely	High	Highly Likely	High		0.31		0.69	

220	Unlikely	High	Highly Likely	Very High		0.31		0.4	0.29
221	Unlikely	High	Definite	Very Low	0.29	0.31		0.08	0.32
222	Unlikely	High	Definite	Low		0.6		0.08	0.32
223	Unlikely	High	Definite	Medium		0.31	0.29	0.08	0.32
224	Unlikely	High	Definite	High		0.31		0.37	0.32
225	Unlikely	High	Definite	Very High		0.31		0.08	0.61
226	Unlikely	Very High	Highly unlikely	Very Low	0.61	0.31			0.08
227	Unlikely	Very High	Highly unlikely	Low	0.32	0.6			0.08
228	Unlikely	Very High	Highly unlikely	Medium	0.32	0.31	0.29		0.08
229	Unlikely	Very High	Highly unlikely	High	0.32	0.31		0.29	0.08
230	Unlikely	Very High	Highly unlikely	Very High	0.32	0.31			0.37
231	Unlikely	Very High	Unlikely	Very Low	0.29	0.63			0.08
232	Unlikely	Very High	Unlikely	Low		0.92			0.08
233	Unlikely	Very High	Unlikely	Medium		0.63	0.29		0.08
234	Unlikely	Very High	Unlikely	High		0.63		0.29	0.08
235	Unlikely	Very High	Unlikely	Very High		0.63			0.37
236	Unlikely	Very High	Likely	Very Low	0.29	0.31	0.32		0.08
237	Unlikely	Very High	Likely	Low		0.6	0.32		0.08
238	Unlikely	Very High	Likely	Medium		0.31	0.61		0.08
239	Unlikely	Very High	Likely	High		0.31	0.32	0.29	0.08
240	Unlikely	Very High	Likely	Very High		0.31	0.32		0.37
241	Unlikely	Very High	Highly Likely	Very Low	0.29	0.31		0.32	0.08
242	Unlikely	Very High	Highly Likely	Low		0.6		0.32	0.08
243	Unlikely	Very High	Highly Likely	Medium		0.31	0.29	0.32	0.08
244	Unlikely	Very High	Highly Likely	High		0.31		0.61	0.08
245	Unlikely	Very High	Highly Likely	Very High		0.31		0.32	0.37
246	Unlikely	Very High	Definite	Very Low	0.29	0.31			0.4
247	Unlikely	Very High	Definite	Low		0.6			0.4
248	Unlikely	Very High	Definite	Medium		0.31	0.29		0.4
249	Unlikely	Very High	Definite	High		0.31		0.29	0.4
250	Unlikely	Very High	Definite	Very High		0.31			0.69
251	Likely	Very Low	Highly Unlikely	Very Low	0.69		0.31		

252	Likely	Very Low	Highly Unlikely	Low	0.4	0.29	0.31		
253	Likely	Very Low	Highly Unlikely	Medium	0.4		0.6		
254	Likely	Very Low	Highly Unlikely	High	0.4	0.31		0.29	
255	Likely	Very Low	Highly Unlikely	Very High	0.4		0.31		0.29
256	Likely	Very Low	Unlikely	Very Low	0.37	0.32	0.31		
257	Likely	Very Low	Unlikely	Low	0.08	0.61	0.31		
258	Likely	Very Low	Unlikely	Medium	0.08	0.32	0.6		
259	Likely	Very Low	Unlikely	High	0.08	0.32	0.31	0.29	
260	Likely	Very Low	Unlikely	Very High	0.08	0.32	0.31		0.29
261	Likely	Very Low	likely	Very Low	0.37		0.63		
262	Likely	Very Low	likely	Low	0.08	0.29	0.63		
263	Likely	Very Low	likely	Medium	0.08		0.92		
264	Likely	Very Low	likely	High	0.08		0.63	0.29	
265	Likely	Very Low	likely	Very High	0.08		0.63		0.29
266	Likely	Very Low	Highly Likely	Very Low	0.37		0.31	0.32	
267	Likely	Very Low	Highly Likely	Low	0.08	0.29	0.31	0.32	
268	Likely	Very Low	Highly Likely	Medium	0.08		0.6	0.32	
269	Likely	Very Low	Highly Likely	High	0.08		0.31	0.61	
270	Likely	Very Low	Highly Likely	Very High	0.08		0.31	0.32	0.29
271	Likely	Very Low	Definite	Very Low	0.37		0.31		0.32
272	Likely	Very Low	Definite	Low	0.08	0.29	0.31		0.32
273	Likely	Very Low	Definite	Medium	0.08		0.6		0.32
274	Likely	Very Low	Definite	High	0.08		0.31	0.29	0.32
275	Likely	Very Low	Definite	Very High	0.08		0.31		0.61
276	Likely	Low	Highly Unlikely	Very Low	0.61	0.08	0.31		
277	Likely	Low	Highly Unlikely	Low	0.32	0.37	0.31		
278	Likely	Low	Highly Unlikely	Medium	0.32	0.08	0.6		
279	Likely	Low	Highly Unlikely	High	0.32	0.08	0.31	0.29	
280	Likely	Low	Highly Unlikely	Very High	0.32	0.08	0.31		0.29
281	Likely	Low	Unlikely	Very Low	0.29	0.4	0.31		
282	Likely	Low	Unlikely	Low		0.69	0.31		
283	Likely	Low	Unlikely	Medium		0.4	0.6		

284	Likely	Low	Unlikely	High		0.4	0.31	0.29	
285	Likely	Low	Unlikely	Very High		0.4	0.31		0.29
286	Likely	Low	Likely	Very Low	0.29	0.08	0.63		
287	Likely	Low	Likely	Low		0.37	0.63		
288	Likely	Low	Likely	Medium		0.08	0.92		
289	Likely	Low	Likely	High		0.08	0.63	0.29	
290	Likely	Low	Likely	Very High		0.08	0.63		0.29
291	Likely	Low	Highly Likely	Very Low	0.29	0.08	0.31	0.32	
292	Likely	Low	Highly Likely	Low		0.37	0.31	0.32	
293	Likely	Low	Highly Likely	Medium		0.08	0.6	0.32	
294	Likely	Low	Highly Likely	High		0.08	0.31	0.61	
295	Likely	Low	Highly Likely	Very High		0.08	0.31	0.32	0.29
296	Likely	Low	Definite	Very Low	0.29	0.08	0.31		0.32
297	Likely	Low	Definite	Low		0.37	0.31		0.32
298	Likely	Low	Definite	Medium		0.08	0.6		0.32
299	Likely	Low	Definite	High		0.08	0.31	0.29	0.32
300	Likely	Low	Definite	Very High		0.08	0.31		0.61
301	Likely	Medium	Highly Unlikely	Very Low	0.61		0.39		
302	Likely	Medium	Highly Unlikely	Low	0.32	0.29	0.39		
303	Likely	Medium	Highly Unlikely	Medium	0.32		0.68		
304	Likely	Medium	Highly Unlikely	High	0.32		0.39	0.29	
305	Likely	Medium	Highly Unlikely	Very High	0.32		0.39		0.29
306	Likely	Medium	Unlikely	Very Low	0.29	0.32	0.39		
307	Likely	Medium	Unlikely	Low		0.61	0.39		
308	Likely	Medium	Unlikely	Medium		0.32	0.68		
309	Likely	Medium	Unlikely	High		0.32	0.39	0.29	
310	Likely	Medium	Unlikely	Very High		0.32	0.39		0.29
311	Likely	Medium	Likely	Very Low	0.29		0.71		
312	Likely	Medium	Likely	Low		0.29			
313	Likely	Medium	Likely	Medium			1		
314	Likely	Medium	Likely	High			0.71	0.29	
315	Likely	Medium	Likely	Very High			0.71		0.29
316	Likely	Medium	Highly likely	Very Low	0.29		0.39	0.32	

317	Likely	Medium	Highly likely	Low		0.29	0.39	0.32	
318	Likely	Medium	Highly likely	Medium			0.68	0.32	
319	Likely	Medium	Highly likely	High			0.39	0.61	
320	Likely	Medium	Highly likely	Very High			0.39	0.32	0.29
321	Likely	Medium	Definite	Very Low	0.29		0.39		0.32
322	Likely	Medium	Definite	Low		0.29	0.39		0.32
323	Likely	Medium	Definite	Medium			0.68		0.32
324	Likely	Medium	Definite	High			0.39	0.29	0.32
325	Likely	Medium	Definite	Very High			0.39		0.61
326	Likely	High	Highly unlikely	Very Low	0.61		0.31	0.08	
327	Likely	High	Highly unlikely	Low	0.32	0.29	0.31	0.08	
328	Likely	High	Highly unlikely	Medium	0.32		0.6	0.08	
329	Likely	High	Highly unlikely	High	0.32		0.31	0.37	
330	Likely	High	Highly unlikely	Very High	0.32		0.31	0.08	0.29
331	Likely	High	Unlikely	Very Low	0.29	0.32	0.31	0.08	
332	Likely	High	Unlikely	Low		0.61	0.31	0.08	
333	Likely	High	Unlikely	Medium		0.32	0.6	0.08	
334	Likely	High	Unlikely	High		0.32	0.31	0.37	
335	Likely	High	Unlikely	Very High		0.32	0.31	0.08	0.29
336	Likely	High	Likely	Very Low	0.29		0.63	0.08	
337	Likely	High	Likely	Low		0.29	0.63	0.08	
338	Likely	High	Likely	Medium			0.92	0.08	
339	Likely	High	Likely	High			0.63	0.37	
340	Likely	High	Likely	Very High			0.63	0.08	0.29
341	Likely	High	Highly Likely	Very Low	0.29		0.31	0.4	
342	Likely	High	Highly Likely	Low		0.29	0.31	0.4	
343	Likely	High	Highly Likely	Medium			0.6	0.4	
344	Likely	High	Highly Likely	High			0.31	0.69	
345	Likely	High	Highly Likely	Very High			0.31	0.4	0.29
346	Likely	High	Definite	Very Low	0.29		0.31	0.08	0.32
347	Likely	High	Definite	Low		0.29	0.31	0.08	0.32
348	Likely	High	Definite	Medium			0.6	0.08	0.32

349	Likely	High	Definite	High			0.31	0.37	0.32
350	Likely	High	Definite	Very High			0.31	0.08	0.61
351	Likely	Very High	Highly Unlikely	Very Low	0.61		0.31		0.08
352	Likely	Very High	Highly Unlikely	Low	0.32	0.29	0.31		0.08
353	Likely	Very High	Highly Unlikely	Medium	0.32		0.6		0.08
354	Likely	Very High	Highly Unlikely	High	0.32		0.31	0.29	0.08
355	Likely	Very High	Highly Unlikely	Very High	0.32		0.31		0.37
356	Likely	Very High	Unlikely	Very Low	0.29	0.32	0.31		0.08
357	Likely	Very High	Unlikely	Low		0.61	0.31		0.08
358	Likely	Very High	Unlikely	Medium		0.32	0.6		0.08
359	Likely	Very High	Unlikely	High		0.32	0.31	0.29	0.08
360	Likely	Very High	Unlikely	Very High		0.32	0.31		0.37
361	Likely	Very High	likely	Very Low	0.29		0.63		0.08
362	Likely	Very High	likely	Low		0.29	0.63		0.08
363	Likely	Very High	likely	Medium			0.92		0.08
364	Likely	Very High	likely	High			0.63	0.29	0.08
365	Likely	Very High	likely	Very High			0.63		0.37
366	Likely	Very High	Highly Likely	Very Low	0.29		0.31	0.32	0.08
367	Likely	Very High	Highly Likely	Low		0.29	0.31	0.32	0.08
368	Likely	Very High	Highly Likely	Medium			0.6	0.32	0.08
369	Likely	Very High	Highly Likely	High			0.31	0.61	0.08
370	Likely	Very High	Highly Likely	Very High			0.31	0.32	0.37
371	Likely	Very High	Definite	Very Low	0.29		0.31		0.4
372	Likely	Very High	Definite	Low		0.29	0.31		0.4
373	Likely	Very High	Definite	Medium			0.6		0.4
374	Likely	Very High	Definite	High			0.31	0.29	0.4
375	Likely	Very High	Definite	Very High			0.31		0.69
376	Highly likely	Very low	Highly Unlikely	Very Low	0.69			0.31	
377	Highly likely	Very low	Highly Unlikely	Low	0.4	0.29		0.31	
378	Highly likely	Very low	Highly Unlikely	Medium	0.4		0.29	0.31	
379	Highly likely	Very low	Highly Unlikely	High	0.4			0.6	

380	Highly likely	Very low	Highly Unlikely	Very High	0.4			0.31	0.29
381	Highly likely	Very low	Unlikely	Very Low	0.37	0.32		0.31	
382	Highly likely	Very low	Unlikely	Low	0.08	0.61		0.31	
383	Highly likely	Very low	Unlikely	Medium	0.08	0.32	0.29	0.31	
384	Highly likely	Very low	Unlikely	High	0.08	0.32		0.6	
385	Highly likely	Very low	Unlikely	Very High	0.08	0.32		0.31	0.29
386	Highly likely	Very low	Likely	Very Low	0.37		0.32	0.31	
387	Highly likely	Very low	Likely	Low	0.08	0.29	0.32	0.31	
388	Highly likely	Very low	Likely	Medium	0.08		0.61	0.31	
389	Highly likely	Very low	Likely	High	0.08		0.32	0.6	
390	Highly likely	Very low	Likely	Very High	0.08		0.32	0.31	0.29
391	Highly likely	Very low	Highly Likely	Very Low	0.37			0.63	
392	Highly likely	Very low	Highly Likely	Low	0.08	0.29		0.63	
393	Highly likely	Very low	Highly Likely	Medium	0.08		0.29	0.63	
394	Highly likely	Very low	Highly Likely	High	0.08			0.92	
395	Highly likely	Very low	Highly Likely	Very High	0.08			0.63	0.29
396	Highly likely	Very low	Definite	Very Low	0.37			0.31	0.32
397	Highly likely	Very low	Definite	Low	0.08	0.29		0.31	0.32
398	Highly likely	Very low	Definite	Medium	0.08		0.29	0.31	0.32
399	Highly likely	Very low	Definite	High	0.08			0.6	0.32
400	Highly likely	Very low	Definite	Very High	0.08			0.31	0.61
401	Highly likely	Low	Highly Unlikely	Very Low	0.61	0.08		0.31	
402	Highly likely	Low	Highly Unlikely	Low	0.32	0.37		0.31	
403	Highly likely	Low	Highly Unlikely	Medium	0.32	0.08	0.29	0.31	
404	Highly likely	Low	Highly Unlikely	High	0.32	0.08		0.6	
405	Highly likely	Low	Highly Unlikely	Very High	0.32	0.08		0.31	0.29
406	Highly likely	Low	Unlikely	Very Low	0.29	0.4		0.31	
407	Highly likely	Low	Unlikely	Low		0.69		0.31	
408	Highly likely	Low	Unlikely	Medium		0.4	0.29	0.31	
409	Highly likely	Low	Unlikely	High		0.4		0.6	
410	Highly likely	Low	Unlikely	Very High		0.4		0.31	0.29
411	Highly likely	Low	Likely	Very Low	0.29	0.08	0.32	0.31	
412	Highly likely	Low	Likely	Low		0.37	0.32	0.31	

413	Highly likely	Low	Likely	Medium		0.08	0.61	0.31	
414	Highly likely	Low	Likely	High		0.08	0.32	0.6	
415	Highly likely	Low	Likely	Very High		0.08	0.32	0.31	0.29
416	Highly likely	Low	Highly Likely	Very Low	0.29	0.08		0.63	
417	Highly likely	Low	Highly Likely	Low		0.37		0.63	
418	Highly likely	Low	Highly Likely	Medium		0.08	0.29	0.63	
419	Highly likely	Low	Highly Likely	High		0.08		0.92	
420	Highly likely	Low	Highly Likely	Very High		0.08		0.63	0.29
421	Highly likely	Low	Definite	Very Low	0.29	0.08		0.31	0.32
422	Highly likely	Low	Definite	Low		0.37	0.31		0.32
423	Highly likely	Low	Definite	Medium		0.08	0.29	0.31	0.32
424	Highly likely	Low	Definite	High		0.08		0.6	0.32
425	Highly likely	Low	Definite	Very High		0.08		0.31	0.61
426	Highly likely	Medium	Highly unlikely	Very Low	0.61		0.08	0.31	
427	Highly likely	Medium	Highly unlikely	Low	0.32	0.29	0.08	0.31	
428	Highly likely	Medium	Highly unlikely	Medium	0.32		0.37	0.31	
429	Highly likely	Medium	Highly unlikely	High	0.32		0.08	0.6	
430	Highly likely	Medium	Highly unlikely	Very High	0.32		0.08	0.31	0.29
431	Highly likely	Medium	Unlikely	Very Low	0.29	0.32	0.08	0.31	
432	Highly likely	Medium	Unlikely	Low		0.61	0.08	0.31	
433	Highly likely	Medium	Unlikely	Medium		0.32	0.37	0.31	
434	Highly likely	Medium	Unlikely	High		0.32	0.08	0.6	
435	Highly likely	Medium	Unlikely	Very High		0.32	0.08	0.31	0.29
436	Highly likely	Medium	Likely	Very Low	0.29		0.4	0.31	
437	Highly likely	Medium	Likely	Low		0.29	0.4	0.31	
438	Highly likely	Medium	Likely	Medium			0.69	0.31	
439	Highly likely	Medium	Likely	High			0.4	0.6	
440	Highly likely	Medium	Likely	Very High			0.4	0.31	0.29
441	Highly likely	Medium	Highly likely	Very Low	0.29		0.08	0.63	
442	Highly likely	Medium	Highly likely	Low		0.29	0.08	0.63	
443	Highly likely	Medium	Highly likely	Medium			0.37	0.63	
444	Highly likely	Medium	Highly likely	High			0.08	0.92	

445	Highly likely	Medium	Highly likely	Very High			0.08	0.63	0.29
446	Highly likely	Medium	Definite	Very Low	0.29		0.08	0.31	0.32
447	Highly likely	Medium	Definite	Low		0.29	0.08	0.31	0.32
448	Highly likely	Medium	Definite	Medium			0.37	0.31	0.32
449	Highly likely	Medium	Definite	High			0.08	0.6	0.32
450	Highly likely	Medium	Definite	Very High			0.08	0.31	0.61
451	Highly likely	High	Highly Unlikely	Very Low	0.61			0.39	
452	Highly likely	High	Highly Unlikely	Low	0.32	0.29		0.39	
453	Highly likely	High	Highly Unlikely	Medium	0.32		0.29	0.39	
454	Highly likely	High	Highly Unlikely	High	0.32			0.68	
455	Highly likely	High	Highly Unlikely	Very High	0.32			0.39	0.29
456	Highly likely	High	Unlikely	Very Low	0.29	0.32		0.39	
457	Highly likely	High	Unlikely	Low		0.61		0.39	
458	Highly likely	High	Unlikely	Medium		0.32	0.29	0.39	
459	Highly likely	High	Unlikely	High		0.32		0.68	
460	Highly likely	High	Unlikely	Very High		0.32		0.39	0.29
461	Highly likely	High	likely	Very Low	0.29		0.32	0.39	
462	Highly likely	High	likely	Low		0.29	0.32	0.39	
463	Highly likely	High	likely	Medium			0.61	0.39	
464	Highly likely	High	likely	High			0.32	0.68	
465	Highly likely	High	likely	Very High			0.32	0.39	0.29
466	Highly likely	High	Highly Likely	Very Low	0.29			0.71	
467	Highly likely	High	Highly Likely	Low		0.29		0.71	
468	Highly likely	High	Highly Likely	Medium			0.29	0.71	
469	Highly likely	High	Highly Likely	High				1	
470	Highly likely	High	Highly Likely	Very High				0.71	0.29
471	Highly likely	High	Definite	Very Low	0.29			0.39	0.32
472	Highly likely	High	Definite	Low		0.29		0.39	0.32
473	Highly likely	High	Definite	Medium			0.29	0.39	0.32
474	Highly likely	High	Definite	High				0.68	0.32
475	Highly likely	High	Definite	Very High				0.39	0.61
476	Highly likely	Very High	Highly Unlikely	Very Low	0.61			0.31	0.08

477	Highly likely	Very High	Highly Unlikely	Low	0.32	0.29		0.31	0.08
478	Highly likely	Very High	Highly Unlikely	Medium	0.32		0.29	0.31	0.08
479	Highly likely	Very High	Highly Unlikely	High	0.32			0.6	0.08
480	Highly likely	Very High	Highly Unlikely	Very High	0.32			0.31	0.37
481	Highly likely	Very High	Unlikely	Very Low	0.29	0.32		0.31	0.08
482	Highly likely	Very High	Unlikely	Low		0.61		0.31	0.08
483	Highly likely	Very High	Unlikely	Medium		0.32	0.29	0.31	0.08
484	Highly likely	Very High	Unlikely	High		0.32		0.6	0.08
485	Highly likely	Very High	Unlikely	Very High		0.32		0.31	0.37
486	Highly likely	Very High	Likely	Very Low	0.29		0.32	0.31	0.08
487	Highly likely	Very High	Likely	Low		0.29	0.32	0.31	0.08
488	Highly likely	Very High	Likely	Medium			0.61	0.31	0.08
489	Highly likely	Very High	Likely	High			0.32	0.6	0.08
490	Highly likely	Very High	Likely	Very High			0.32	0.31	0.37
491	Highly likely	Very High	Highly Likely	Very Low	0.29			0.63	0.08
492	Highly likely	Very High	Highly Likely	Low		0.29		0.63	0.08
493	Highly likely	Very High	Highly Likely	Medium			0.29	0.63	0.08
494	Highly likely	Very High	Highly Likely	High				0.92	0.08
495	Highly likely	Very High	Highly Likely	Very High				0.63	0.37
496	Highly likely	Very High	Definite	Very Low	0.29			0.31	0.4
497	Highly likely	Very High	Definite	Low		0.29		0.31	0.4
498	Highly likely	Very High	Definite	Medium			0.29	0.31	0.4
499	Highly likely	Very High	Definite	High				0.6	0.4
500	Highly likely	Very High	Definite	Very High				0.31	0.69
501	Definite	Very Low	Highly unlikely	Very Low	0.69				0.31
502	Definite	Very Low	Highly unlikely	Low	0.4	0.29			0.31
503	Definite	Very Low	Highly unlikely	Medium	0.4		0.29		0.31
504	Definite	Very Low	Highly unlikely	High	0.4			0.29	0.31
505	Definite	Very Low	Highly unlikely	Very High	0.4				0.6
506	Definite	Very Low	Unlikely	Very Low	0.37	0.32			0.31
507	Definite	Very Low	Unlikely	Low	0.08	0.61			0.31
508	Definite	Very Low	Unlikely	Medium	0.08	0.32	0.29		0.31

509	Definite	Very Low	Unlikely	High	0.08	0.32		0.29	0.31
510	Definite	Very Low	Unlikely	Very High	0.08	0.32			0.6
511	Definite	Very Low	Likely	Very Low	0.37		0.32		0.31
512	Definite	Very Low	Likely	Low	0.08	0.29	0.32		0.31
513	Definite	Very Low	Likely	Medium	0.08		0.61		0.31
514	Definite	Very Low	Likely	High	0.08		0.32	0.29	0.31
515	Definite	Very Low	Likely	Very High	0.08		0.32		0.6
516	Definite	Very Low	Highly Likely	Very Low	0.37			0.32	0.31
517	Definite	Very Low	Highly Likely	Low	0.08	0.29		0.32	0.31
518	Definite	Very Low	Highly Likely	Medium	0.08		0.29	0.32	0.31
519	Definite	Very Low	Highly Likely	High	0.08			0.61	0.31
520	Definite	Very Low	Highly Likely	Very High	0.08			0.32	0.6
521	Definite	Very Low	Definite	Very Low	0.37				0.63
522	Definite	Very Low	Definite	Low	0.08	0.29			0.63
523	Definite	Very Low	Definite	Medium	0.08		0.29		0.63
524	Definite	Very Low	Definite	High	0.08			0.29	0.63
525	Definite	Very Low	Definite	Very High	0.08				0.92
526	Definite	Low	Highly Unlikely	Very Low	0.61	0.08			0.31
527	Definite	Low	Highly Unlikely	Low	0.32	0.37			0.31
528	Definite	Low	Highly Unlikely	Medium	0.32	0.08	0.29		0.31
529	Definite	Low	Highly Unlikely	High	0.32	0.08		0.29	0.31
530	Definite	Low	Highly Unlikely	Very High	0.32	0.08			0.6
531	Definite	Low	Unlikely	Very Low	0.29	0.4			0.31
532	Definite	Low	Unlikely	Low		0.69			0.31
533	Definite	Low	Unlikely	Medium		0.4	0.29		0.31
534	Definite	Low	Unlikely	High		0.4		0.29	0.31
535	Definite	Low	Unlikely	Very High		0.4			0.6
536	Definite	Low	Likely	Very Low	0.29	0.08	0.32		0.31
537	Definite	Low	Likely	Low		0.37	0.32		0.31
538	Definite	Low	Likely	Medium		0.08	0.61		0.31
539	Definite	Low	Likely	High		0.08	0.32	0.29	0.31
540	Definite	Low	Likely	Very High		0.08	0.32		0.6
541	Definite	Low	Highly Likely	Very Low	0.29	0.08		0.32	0.31

542	Definite	Low	Highly Likely	Low		0.37		0.32	0.31
543	Definite	Low	Highly Likely	Medium		0.08	0.29	0.32	0.31
544	Definite	Low	Highly Likely	High		0.08		0.61	0.31
545	Definite	Low	Highly Likely	Very High		0.08		0.32	0.6
546	Definite	Low	Definite	Very Low	0.29	0.08			0.63
547	Definite	Low	Definite	Low		0.37			0.63
548	Definite	Low	Definite	Medium		0.08	0.29		0.63
549	Definite	Low	Definite	High		0.08		0.29	0.63
550	Definite	Low	Definite	Very High		0.08			0.92
551	Definite	Medium	Highly Unlikely	Very Low	0.61		0.08		0.31
552	Definite	Medium	Highly Unlikely	Low	0.32	0.29	0.08		0.31
553	Definite	Medium	Highly Unlikely	Medium	0.32		0.37		0.31
554	Definite	Medium	Highly Unlikely	High	0.32		0.08	0.29	0.31
555	Definite	Medium	Highly Unlikely	Very High	0.32		0.08		0.6
556	Definite	Medium	Unlikely	Very Low	0.29	0.32	0.08		0.31
557	Definite	Medium	Unlikely	Low		0.61	0.08		0.31
558	Definite	Medium	Unlikely	Medium		0.32	0.37		0.31
559	Definite	Medium	Unlikely	High		0.32	0.08	0.29	0.31
560	Definite	Medium	Unlikely	Very High		0.32	0.08		0.6
561	Definite	Medium	likely	Very Low	0.29		0.4		0.31
562	Definite	Medium	likely	Low		0.29	0.4		0.31
563	Definite	Medium	likely	Medium			0.69		0.31
564	Definite	Medium	likely	High			0.4	0.29	0.31
565	Definite	Medium	likely	Very High			0.4		0.6
566	Definite	Medium	Highly Likely	Very Low	0.29		0.08	0.32	0.31
567	Definite	Medium	Highly Likely	Low		0.29	0.08	0.32	0.31
568	Definite	Medium	Highly Likely	Medium			0.37	0.32	0.31
569	Definite	Medium	Highly Likely	High			0.08	0.61	0.31
570	Definite	Medium	Highly Likely	Very High			0.08	0.32	0.6
571	Definite	Medium	Definite	Very Low	0.29		0.08		0.63
572	Definite	Medium	Definite	Low		0.29	0.08		0.63
573	Definite	Medium	Definite	Medium			0.37		0.63

574	Definite	Medium	Definite	High			0.08	0.29	0.63
575	Definite	Medium	Definite	Very High			0.08		0.92
576	Definite	High	Highly Unlikely	Very Low	0.61			0.08	0.31
577	Definite	High	Highly Unlikely	Low	0.32	0.29		0.08	0.31
578	Definite	High	Highly Unlikely	Medium	0.32		0.29	0.08	0.31
579	Definite	High	Highly Unlikely	High	0.32			0.37	0.31
580	Definite	High	Highly Unlikely	Very High	0.32			0.08	0.6
581	Definite	High	Unlikely	Very Low	0.29	0.32		0.08	0.31
582	Definite	High	Unlikely	Low		0.61		0.08	0.31
583	Definite	High	Unlikely	Medium		0.32	0.29	0.08	0.31
584	Definite	High	Unlikely	High		0.32		0.37	0.31
585	Definite	High	Unlikely	Very High		0.32		0.08	0.6
586	Definite	High	Likely	Very Low	0.29		0.32	0.08	0.31
587	Definite	High	Likely	Low		0.29	0.32	0.08	0.31
588	Definite	High	Likely	Medium			0.61	0.08	0.31
589	Definite	High	Likely	High			0.32	0.37	0.31
590	Definite	High	Likely	Very High			0.32	0.08	0.6
591	Definite	High	Highly Likely	Very Low	0.29			0.4	0.31
592	Definite	High	Highly Likely	Low		0.29		0.4	0.31
593	Definite	High	Highly Likely	Medium			0.29	0.4	0.31
594	Definite	High	Highly Likely	High				0.69	0.31
595	Definite	High	Highly Likely	Very High				0.4	0.6
596	Definite	High	Definite	Very Low	0.29			0.08	0.63
597	Definite	High	Definite	Low		0.29		0.08	0.63
598	Definite	High	Definite	Medium			0.29	0.08	0.63
599	Definite	High	Definite	High				0.37	0.63
600	Definite	High	Definite	Very High				0.08	0.92
601	Definite	Very High	Highly unlikely	Very Low	0.61				0.39
602	Definite	Very High	Highly unlikely	Low	0.32	0.29			0.39
603	Definite	Very High	Highly unlikely	Medium	0.32		0.29		0.39
604	Definite	Very High	Highly unlikely	High	0.32			0.29	0.39

605	Definite	Very High	Highly unlikely	Very High	0.32				0.68
606	Definite	Very High	Unlikely	Very Low	0.29	0.32			0.39
607	Definite	Very High	Unlikely	Low		0.61			0.39
608	Definite	Very High	Unlikely	Medium		0.32	0.29		0.39
609	Definite	Very High	Unlikely	High		0.32		0.29	0.39
610	Definite	Very High	Unlikely	Very High		0.32			0.68
611	Definite	Very High	Likely	Very Low	0.29		0.32		0.39
612	Definite	Very High	Likely	Low		0.29	0.32		0.39
613	Definite	Very High	Likely	Medium			0.61		0.39
614	Definite	Very High	Likely	High			0.32	0.29	0.39
615	Definite	Very High	Likely	Very High			0.32		0.68
616	Definite	Very High	Highly Likely	Very Low	0.29			0.32	0.39
617	Definite	Very High	Highly Likely	Low		0.29		0.32	0.39
618	Definite	Very High	Highly Likely	Medium			0.29	0.32	0.39
619	Definite	Very High	Highly Likely	High				0.61	0.39
620	Definite	Very High	Highly Likely	Very High				0.32	0.68
621	Definite	Very High	Definite	Very Low	0.29				0.71
622	Definite	Very High	Definite	Low		0.29			0.71
623	Definite	Very High	Definite	Medium			0.29		0.71
624	Definite	Very High	Definite	High				0.29	0.71
625	Definite	Very High	Definite	Very High					1

The established C_T, CQV, and C_Q FRB with a belief structure for the assessment of AFTL risk factors

Rules	**Antecedent Attribute (input)**			**Risk result (output)**				
No	**CT**	**CQV**	**CQ**	**Very low**	**Low**	**Medium**	**High**	**Very high**
1	Very low	Very low	Very low	1				
2	Very low	Very low	Low	0.41	0.59			
3	Very low	Very low	Medium	0.41		0.59		
4	Very low	Very low	High	0.41			0.59	
5	Very low	Very low	Very high	0.41				0.59
6	Very low	Low	Very low	0.86	0.14			
7	Very low	Low	low	0.27	0.73			
8	Very low	Low	Medium	0.27	0.14	0.59		
9	Very low	Low	High	0.27	0.14		0.59	
10	Very low	Low	Very high	0.27	0.14			0.59
11	Very low	Medium	Very low	0.86		0.14		
12	Very low	Medium	low	0.27	0.59	0.14		

13	Very low	Medium	Medium	0.27		0.73		
14	Very low	Medium	High	0.27		0.14	0.59	
15	Very low	Medium	Very high	0.27		0.14		0.59
16	Very low	High	Very low	0.86				
17	Very low	High	low	0.27	0.59		0.14	
18	Very low	High	Medium	0.27		0.59	0.14	
19	Very low	High	High	0.27			0.73	
20	Very low	High	Very high	0.27			0.14	0.59
21	Very low	Very high	Very low	0.86				0.14
22	Very low	Very high	low	0.27	0.59			0.14
23	Very low	Very high	Medium	0.27		0.59		0.14
24	Very low	Very high	High	0.27			0.59	0.14
25	Very low	Very high	Very high	0.27				0.73
26	Low	Very low	Very low	0.73	0.27			
27	Low	Very low	Low	0.14	0.86			
28	Low	Very low	Medium	0.14	0.27	0.59		
29	Low	Very low	High	0.14	0.27		0.59	
30	Low	Very low	Very high	0.14	0.27			0.59
31	Low	Low	Very low	0.59	0.41			
32	Low	low	low		1			
33	Low	low	Medium		0.41	0.59		
34	Low	low	High		0.41		0.59	
35	Low	low	Very high		0.41			0.59
36	Low	Medium	Very low	0.59	0.27	0.14		
37	Low	Medium	Low		0.86	0.14		
38	Low	Medium	Medium		0.27	0.73		
39	Low	Medium	High		0.27	0.14	0.59	
40	Low	Medium	Very high		0.27	0.14		0.59
41	Low	High	Very Low	0.59	0.27		0.14	
42	Low	High	Low		0.86		0.14	
43	Low	High	Medium		0.27	0.59	0.14	
44	Low	High	High		0.27		0.73	
45	Low	High	Very High		0.27		0.14	0.59
46	Low	Very High	Very Low	0.59	0.27			0.14
47	Low	Very High	Low		0.86			0.14
48	Low	Very High	Medium		0.27	0.59		0.14
49	Low	Very High	High		0.27		0.59	0.14
50	Low	Very High	Very High		0.27			0.73
51	Medium	Very low	Very low	0.73		0.27		
52	Medium	Very low	Low	0.14	0.59	0.27		
53	Medium	Very low	Medium	0.14		0.86		
54	Medium	Very low	High	0.14		0.27	0.59	
55	Medium	Very low	Very high	0.14		0.27		0.59
56	Medium	Low	Very low	0.59	0.14	0.27		
57	Medium	Low	Low		0.73	0.27		
58	Medium	Low	Medium		0.14	0.86		
59	Medium	Low	High		0.14	0.27	0.59	
60	Medium	Low	Very high		0.14	0.27		0.59
61	Medium	Medium	Very low	0.59		0.41		
62	Medium	Medium	Low		0.59	0.41		
63	Medium	Medium	Medium			1		
64	Medium	Medium	High			0.41	0.59	

65	Medium	Medium	Very high			0.41		0.59
66	Medium	High	Very low	0.59		0.27	0.14	
67	Medium	High	Low		0.59	0.27	0.14	
68	Medium	High	Medium			0.86	0.14	
69	Medium	High	High			0.27	0.73	
70	Medium	High	Very high			0.27	0.14	0.59
71	Medium	Very high	Very low	0.59		0.27		0.14
72	Medium	Very high	Low		0.59	0.27		0.14
73	Medium	Very high	Medium			0.86		0.14
74	Medium	Very high	High			0.27	0.59	0.14
75	Medium	Very high	Very high			0.27		0.73
76	High	Very Low	Very low	0.73			0.27	
77	High	Very Low	low	0.14	0.59		0.27	
78	High	Very Low	Medium	0.14		0.59	0.27	
79	High	Very Low	High	0.14			0.86	
80	High	Very Low	Very high	0.14			0.27	0.59
81	High	Low	Very low	0.59	0.14		0.27	
82	High	Low	Low		0.73		0.27	
83	High	Low	Medium		0.14	0.59	0.27	
84	High	Low	High		0.14		0.86	
85	High	Low	Very high		0.14		0.27	0.59
86	High	Medium	Very Low	0.59		0.14	0.27	
87	High	Medium	Low		0.59	0.14	0.27	
88	High	Medium	Medium			0.73	0.27	
89	High	Medium	High			0.14	0.86	
90	High	Medium	Very High			0.14	0.27	0.59
91	High	High	Very low	0.59			0.41	
92	High	High	Low		0.59		0.41	
93	High	High	Medium			0.59	0.41	
94	High	High	High				1	
95	High	High	Very high				0.41	0.59
96	High	Very high	Very Low	0.59			0.27	0.14
97	High	Very high	Low		0.59		0.27	0.14
98	High	Very high	Medium			0.59	0.27	0.14
99	High	Very high	High				0.86	0.14
100	High	Very high	Very high				0.27	0.73
101	Very High	Very low	Very low	0.73				0.27
102	Very High	Very low	Low	0.14	0.59			0.27
103	Very High	Very low	Medium	0.14		0.59		0.27
104	Very High	Very low	High	0.14			0.59	0.27
105	Very High	Very low	Very high	0.14				0.86
106	Very High	Low	Very Low	0.59	0.14			0.27
107	Very High	Low	Low		0.73			0.27
108	Very High	Low	Medium		0.14	0.59		0.27
109	Very High	Low	High		0.14		0.59	0.27
110	Very High	Low	Very High		0.14			0.86
111	Very High	Medium	Very Low	0.59		0.14		0.27
112	Very High	Medium	Low		0.59	0.14		0.27
113	Very High	Medium	Medium			0.73		0.27
114	Very High	Medium	High			0.14	0.59	0.27
115	Very High	Medium	Very High			0.14		0.86
116	Very High	High	Very Low	0.59			0.14	0.27

117	Very High	High	Low		0.59		0.14	0.27
118	Very High	High	Medium			0.59	0.14	0.27
119	Very High	High	High				0.73	0.27
120	Very High	High	Very High				0.14	0.86
121	Very High	Very high	Very low	0.59				0.41
122	Very High	Very high	Low		0.59			0.41
123	Very High	Very high	Medium			0.59		0.41
124	Very High	Very high	High				0.59	0.41
125	Very High	Very high	Very high					1

Appendix Eleven: Vegetable handling companies' assessment

Value of the quantitative index of vegetable handling companies.

Case company	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
Vegetable case_Company 1	29.23	99	0.003	75	100	100	99	85	100	0	99
Vegetable case _Company 2	25.71	99	0.003	83	100	100	99	85	100	0	99
Vegetable case _Company 3	30.00	83	0.133	50	100	90	83	60	100	0	83
Vegetable case_Company 4	200	92	0.0025	40	100	100	92	80	100	0.0275	92
Vegetable case _Company 5	100	97	0	100	30	100	97	80	100	0	29

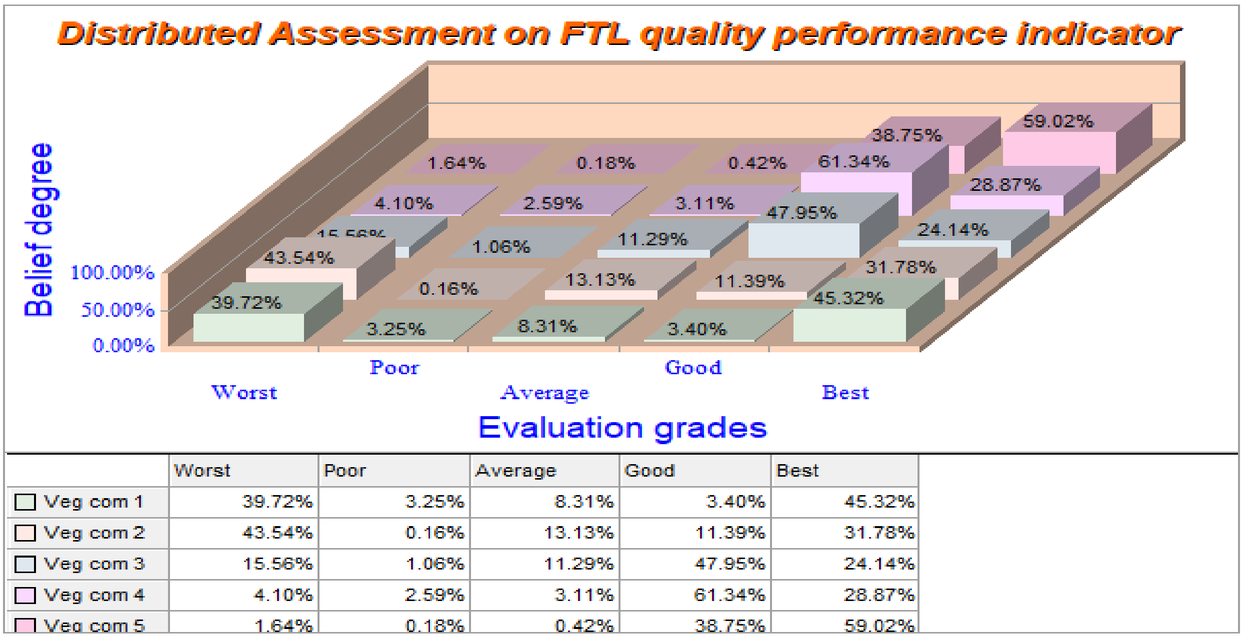
Belief degree of the quantitative CVI's vegetable case companies

	e_{12}	e_{14}	e_{19}	e_{21}	e_{22}	e_{23}	e_{24}	e_{33}	e_{41}	e_{43}	e_{47}
Vegetable Case_Company 1	{ (H_1 0 ($H_3$0)((H_5 0.7	{ (H_1 0 ($H_3$0)((H_5 0.8	{ (H_1 ($H_3$0)((H_5 0)	{ (H_1 0 ($H_2$0), (($H_4$0,95	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0) ($H_3$0)((H_5 0.8	{ (H_1 0 ($H_3$0)((H_5 0.4	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 0.
Vegetable Case_Company 2	{ (H_1 0 ($H_3$0)((H_5 0.7	{ (H_1 0 ($H_3$0)((H_5 0.8	{ (H_1 ($H_3$0)((H_5 0)	{ (H_1 0 ($H_3$0)((H_5 0.2	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0) ($H_3$0)((H_5 0.8	{ (H_1 0 ($H_3$0)((H_5 0.4	{ (H_1 ($H_3$0)((H_5 1)	{{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 0.
Vegetable Case_Company 3	{ ($H_1$0) ($H_3$0)(, (H_5 0.	{ (H_1 0 ($H_3$0.28 (H_5 0)}	{ (H_1 (H_2 0. ($H_4$0)(	{ (H_1 0 ($H_3$0.89 (H_5 0)}	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 0.	{ (H_1 0) ($H_3$0.28 (H_5 0)}	{ (H_1 0 ($H_3$0.60 (H_5 0)]	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 0.
Vegetable Case_Company 4	{ (H_1 0 ($H_3$0.67 (H_5 0)}	{ (H_1 0 ($H_3$0.28 (H_5 0)}	{ (H_1 ($H_3$0)((H_5 0)	{ (H_1 0 ($H_3$0.47 (H_5 0)}	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0) ($H_3$0.28 (H_5 0)}	{{ (H_1 ($H_3$0)((H_5 0.2	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 ($H_3$0)((H_5 0.
Vegetable Case_Company 5	{ (H_1 0 (H_2 0), ($H_4$0.87	{ (H_1 0 ($H_3$0)((H_5 0.5	{ (H_1 ($H_3$0)((H_5 0)	{ (H_1 0 ($H_3$0)((H_5 1)}	{ (H_1 0 (H_2 0. ($H_4$0),	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0) ($H_3$0)((H_5 0.5	{{ (H_1 ($H_3$0)((H_5 0.2	{ (H_1 ($H_3$0)((H_5 1)	{ (H_1 0 ($H_3$0)((H_5 1)	{ (H_1 (H_2 0. ($H_4$0)(

Value of the qualitative index of vegetable handling companies.

Qualitative CVI's		Belief of degree
$S(e_1)$	$S(e_{111})$	{ (H_1, 0), (H_2, 0), (H_3, 0.20), (H_4, 0.60), (H_5, 0.20)}
	$S(e_{112})$	{ (H_1, 0.20), (H_2, 0), (H_3, 0.20), (H_4, 0.60), (H_5, 0)}
	$S(e_{113})$	{ (H_1, 0.40), (H_2, 0), (H_3, 0), (H_4, 0.60), (H_5, 0)}
	$S(e_{114})$	{ (H_1, 0.20), (H_2, 0), (H_3, 0), (H_4, 0.40), (H_5, 0.40)}
$S(e_{13})$		{ (H_1, 0), (H_2, 0), (H_3, 0.0), (H_4, 0.60), (H_5, 0.40)}
$S(e_{15})$		{ (H_1, 0), (H_2, 0), (H_3, 0.0), (H_4, 0.60), (H_5, 0.40)}
$S(e_{16})$		{ (H_1, 0), (H_2, 0), (H_3, 0.40), (H_4, 0.40), (H_5, 0.20)}
$S(e_{17})$		{ (H_1, 0), (H_2, 0), (H_3, 0.20), (H_4, 0.40), (H_5, 0.40)}
$S(e_{18})$	$S(e_{181})$	{ (H_1, 0), (H_2, 0.20), (H_3, 0.40), (H_4, 0.60), (H_5, 0)}
	$S(e_{182})$	{ (H_1, 0), (H_2, 0), (H_3, 0.0), (H_4, 0.80), (H_5, 0.20)}
	$S(e_{183})$	{ (H_1, 0), (H_2, 0), (H_3, 0.0), (H_4, 0.80), (H_5, 0.20)}
$S(e_{31})$		{ (H_1, 0), (H_2, 0), (H_3, 0.60), (H_4, 0.40), (H_5, 0)}
$S(e_{32})$	$S(e_{321})$	{ (H_1, 0.20), (H_2, 0), (H_3, 0.20), (H_4, 0.60), (H_5, 0)}
	$S(e_{322})$	{ (H_1, 0.20), (H_2, 0), (H_3, 0), (H_4, 0.60), (H_5, 0.20)}

$S(e_{323})$	$\{ (H_1, 0.40), (H_2, 0), (H_3, 0), (H_4, 0.60), (H_5, 0)\}$
$S(e_{324})$	$\{ (H_1, 0.60), (H_2, 0), (H_3, 0), (H_4, 0.20), (H_5, 0.20)\}$
$S(e_{325})$	$\{ (H_1, 0.60), (H_2, 0), (H_3, 0), (H_4, 0.40), (H_5, 0)\}$
$S(e_{42})$	$\{ (H_1, 0), (H_2, 0), (H_3, 0), (H_4, 0.80), (H_5, 0.20)\}$
$S(e_{44})$	$\{ (H_1, 0), (H_2, 0), (H_3, 0), (H_4, 0.80), (H_5, 0.20)\}$
$S(e_{45})$	$\{ (H_1, 0), (H_2, 0), (H_3, 0), (H_4, 0.40), (H_5, 0.60)\}$
$S(e_{46})$	$\{ (H_1, 0), (H_2, 0), (H_3, 0.40), (H_4, 0.40), (H_5, 0.20)\}$



Most influencing attributes on the quality performance of the company handling vegetable products.

Appendix 12: Fuzzy TOPSIS computation

Aggregated fuzzy decision matrix for the alternatives.

	V1			V2			V3			V4			V5			V6			V7			V8			V9			V10			V11		
S1	1	7.889	9	1	7.444	9	3	8.429	9	3	8.429	9	3	8.250	9	5	8.667	9	7	9	9	5	8.143	9	1	7.250	9	1	7.500	9	3	7.667	9
S2	5	8.750	9	5	8.714	9	7	9.000	9	7	9.000	9	7	8.333	9	7	8.667	9	7	8.000	9	5	7.500	9	3	8.500	9	7	7.750	9	1	8.000	9
S3	3	8.500	9	3	8.429	9	7	9.000	9	5	8.333	9	3	7.889	9	7	7.750	9	7	8.500	9	3	7.500	9	1	7.667	9	7	7.444	9	1	8.000	9
S4	5	8.250	9	1	8.000	9	5	8.667	9	7	8.500	9	1	6.778	9	7	9.000	9	7	9.000	9	5	8.429	9	3	8.111	9	1	7.500	9	1	8.000	9
S5	5	8.750	9	1	8.000	9	5	8.500	9	5	8.250	9	5	8.500	9	7	8.667	9	7	9.000	9	7	8.714	9	3	8.111	9	1	7.750	9	1	8.000	9
S6	3	8.500	9	1	8.000	9	7	9.000	9	7	9.000	9	5	8.250	9	5	8.333	9	7	8.500	9	5	8.429	9	3	8.111	9	1	7.750	9	1	8.000	9
S7	3	8.500	9	1	7.889	9	3	8.429	9	7	8.250	9	3	8.000	9	7	8.143	9	7	8.500	9	5	8.429	9	3	8.111	9	1	7.750	9	1	7.444	9
S8	5	8.500	9	1	8.250	9	1	7.667	9	7	8.000	9	7	8.750	9	7	8.000	9	7	8.500	9	7	7.500	9	3	8.111	9	1	7.750	9	1	8.000	9
S9	5	8.000	9	1	6.778	9	5	8.667	9	3	6.778	9	5	7.667	9	5	7.667	9	7	9.000	9	7	8.714	9	3	8.500	9	1	7.750	9	1	8.000	9
S10	3	7.444	9	1	6.800	9	3	8.000	9	1	7.286	9	3	7.500	9	5	8.333	9	5	8.429	9	5	7.500	9	1	7.667	9	3	8.250	9	3	7.889	9
S11	5	8.750	9	7	9.000	9	3	8.429	9	3	7.750	9	3	7.444	9	7	8.667	9	7	9.000	9	5	8.250	9	3	7.750	9	1	7.250	9	1	7.222	9

	V12			V13			V14			V15			V16			V17			V18			V19			V20			V21			V22		
S1	3	8.000	9	7	9.000	9	7	7.667	9	3	7.500	9	3	7.250	9	1	7.286	9	3	7.250	9	3	7.750	9	3	7.667	9	3	7.444	9	1	7.444	9
S2	7	9.000	9	3	8.429	9	7	9.000	9	3	8.429	9	3	8.250	9	1	7.500	9	1	7.750	9	3	8.500	9	3	8.333	9	3	8.250	9	3	8.500	9

S3	7	8.500	9	7	9.000	9	7	9.000	9	3	8.429	9	3	7.667	9	1	7.857	9	1	7.750	9	3	8.429	9	3	8.200	9	3	8.250	9	3	7.889	9
S4	7	8.714	9	3	8.429	9	7	8.714	9	3	8.429	9	3	8.250	9	3	8.000	9	1	7.750	9	3	8.000	9	3	8.200	9	3	8.250	9	3	8.250	9
S5	7	8.714	9	7	8.500	9	7	8.250	9	3	8.000	9	7	7.750	9	3	8.000	9	1	7.500	9	3	8.111	9	3	7.857	9	3	7.889	9	3	7.889	9
S6	7	8.250	9	1	8.250	9	5	8.429	9	3	8.429	9	1	7.500	9	3	7.667	9	3	7.500	9	3	7.444	9	3	7.857	9	3	8.250	9	3	7.889	9
S7	7	8.714	9	7	9.000	9	7	8.714	9	3	8.429	9	1	7.750	9	3	8.500	9	1	7.500	9	3	8.250	9	3	8.333	9	3	8.250	9	3	8.250	9
S8	7	9.000	9	7	9.000	9	7	8.500	9	3	8.429	9	3	7.750	9	3	8.500	9	3	8.000	9	3	8.250	9	3	7.750	9	3	8.250	9	3	8.250	9
S9	1	8.250	9	1	8.714	9	5	7.750	9	3	8.429	9	3	8.000	9	3	8.000	9	3	8.000	9	3	8.000	9	3	8.143	9	3	7.889	9	3	7.222	9
S10	5	8.000	9	7	8.429	9	5	8.143	9	3	7.750	9	3	7.444	9	3	7.250	9	3	7.750	9	3	7.250	9	3	8.200	9	3	7.444	9	3	7.500	9
S11	3	8.000	9	3	8.429	9	3	8.429	9	3	7.500	9	1	7.000	9	3	7.250	9	3	7.750	9	1	6.111	9	3	7.250	9	3	7.222	9	3	7.000	9

W	0.028			0.031			0.029			0.028			0.028			0.028			0.027			0.027			0.027			0.061			0.064		
	V1			V2			V3			V4			V5			V6			V7			V8			V9			V10			V11		
S1	0.11	0.127	1	0.1	0.134	1	0.1	0.12	0.3	0.1	0.1186	0.3	0.11	0.121	0.3	0.6	0.577	1	0.6	0.556	0.7	0.3	0.368	0.6	0.1	0.138	1	0.1	0.13	1	0.1	0.13	0
S2	0.11	0.114	0.2	0.1	0.115	0.2	0.1	0.11	0.1	0.1	0.1111	0.1	0.11	0.12	0.1	0.6	0.577	1	0.6	0.625	0.7	0.3	0.4	0.6	0.1	0.118	0	0.1	0.13	0.14	0.1	0.125	1
S3	0.11	0.118	0.3	0.1	0.119	0.33	0.1	0.11	0.1	0.1	0.12	0.2	0.11	0.127	0.3	0.6	0.645	1	0.6	0.588	0.7	0.3	0.4	1	0.1	0.13	1	0.1	0.13	0.14	0.1	0.125	1
S4	0.11	0.121	0.2	0.1	0.125	1	0.1	0.12	0.2	0.1	0.1176	0.1	0.11	0.148	1	0.6	0.556	1	0.6	0.556	0.7	0.3	0.356	0.6	0.1	0.123	0	0.1	0.13	1	0.1	0.125	1
S5	0.11	0.114	0.2	0.1	0.125	1	0.1	0.12	0.2	0.1	0.1212	0.2	0.11	0.118	0.2	0.6	0.577	1	0.6	0.556	0.7	0.3	0.344	0.4	0.1	0.123	0	0.1	0.13	1	0.1	0.125	1
S6	0.11	0.118	0.3	0.1	0.125	1	0.1	0.11	0.1	0.1	0.1111	0.1	0.11	0.121	0.2	0.6	0.6	1	0.6	0.588	0.7	0.3	0.356	0.6	0.1	0.123	0	0.1	0.13	1	0.1	0.125	1
S7	0.11	0.118	0.3	0.1	0.127	1	0.1	0.12	0.3	0.1	0.1212	0.1	0.11	0.125	0.3	0.6	0.614	1	0.6	0.588	0.7	0.3	0.356	0.6	0.1	0.123	0	0.1	0.13	1	0.1	0.134	1
S8	0.11	0.118	0.2	0.1	0.121	1	0.1	0.13	1	0.1	0.125	0.1	0.11	0.114	0.1	0.6	0.625	1	0.6	0.588	0.7	0.3	0.4	0.4	0.1	0.123	0	0.1	0.13	1	0.1	0.125	1
S9	0.11	0.125	0.2	0.1	0.148	1	0.1	0.12	0.2	0.1	0.1475	0.3	0.11	0.13	0.2	0.6	0.652	1	0.6	0.556	0.7	0.3	0.344	0.4	0.1	0.118	0	0.1	0.13	1	0.1	0.125	1
S10	0.11	0.134	0.3	0.1	0.147	1	0.1	0.13	0.3	0.1	0.1373	1	0.11	0.133	0.3	0.6	0.6	1	0.6	0.593	1	0.3	0.4	0.6	0.1	0.13	1	0.1	0.12	0.33	0.1	0.127	0
S11	0.11	0.114	0.2	0.1	0.111	0.14	0.1	0.12	0.3	0.1	0.129	0.3	0.11	0.134	0.3	0.6	0.577	1	0.6	0.556	0.7	0.3	0.364	0.6	0.1	0.129	0	0.1	0.14	1	0.1	0.138	1

Normalised fuzzy decision matrix for the alternatives

W	0.064			0.063			0.05			0.201			0.036			0.036			0.036			0.029			0.035			0.036			0.035		
	V12			V13			V14			V15			V16			V17			V18			V19			V20			V21			V22		
S1	0.11	0.125	0.3	0.1	0.111	0.14	0.3	0.39	0.4	0.3	0.4	1	0.11	0.138	0.3	0.1	0.137	1	0.1	0.138	0.3	0.1	0.129	0.3	0.3	0.391	1	0.3	0.4	1	0.1	0.134	1
S2	0.11	0.111	0.1	0.1	0.119	0.33	0.3	0.33	0.4	0.3	0.3559	1	0.11	0.121	0.3	0.1	0.133	1	0.1	0.129	1	0.1	0.118	0.3	0.3	0.36	1	0.3	0.36	1	0.1	0.118	0
S3	0.11	0.118	0.1	0.1	0.111	0.14	0.3	0.33	0.4	0.3	0.3559	1	0.11	0.13	0.3	0.1	0.127	1	0.1	0.129	1	0.1	0.119	0.3	0.3	0.366	1	0.3	0.36	1	0.1	0.127	0
S4	0.11	0.115	0.1	0.1	0.119	0.33	0.3	0.34	0.4	0.3	0.3559	1	0.11	0.121	0.3	0.1	0.125	0	0.1	0.129	1	0.1	0.125	0.3	0.3	0.366	1	0.3	0.36	1	0.1	0.121	0
S5	0.11	0.115	0.1	0.1	0.118	0.14	0.3	0.36	0.4	0.3	0.375	1	0.11	0.129	0.1	0.1	0.125	0	0.1	0.133	1	0.1	0.123	0.3	0.3	0.382	1	0.3	0.38	1	0.1	0.127	0
S6	0.11	0.121	0.1	0.1	0.121	1	0.3	0.36	0.6	0.3	0.3559	1	0.11	0.133	1	0.1	0.13	0	0.1	0.133	0.3	0.1	0.134	0.3	0.3	0.382	1	0.3	0.36	1	0.1	0.127	0
S7	0.11	0.115	0.1	0.1	0.111	0.14	0.3	0.34	0.4	0.3	0.3559	1	0.11	0.129	1	0.1	0.118	0	0.1	0.133	1	0.1	0.121	0.3	0.3	0.36	1	0.3	0.36	1	0.1	0.121	0
S8	0.11	0.111	0.1	0.1	0.111	0.14	0.3	0.35	0.4	0.3	0.3559	1	0.11	0.129	0.3	0.1	0.118	0	0.1	0.125	0.3	0.1	0.121	0.3	0.3	0.387	1	0.3	0.36	1	0.1	0.121	0
S9	0.11	0.121	1	0.1	0.115	1	0.3	0.39	0.6	0.3	0.3559	1	0.11	0.125	0.3	0.1	0.125	0	0.1	0.125	0.3	0.1	0.125	0.3	0.3	0.368	1	0.3	0.38	1	0.1	0.138	0
S10	0.11	0.125	0.2	0.1	0.119	0.14	0.3	0.37	0.6	0.3	0.3871	1	0.11	0.134	0.3	0.1	0.138	0	0.1	0.129	0.3	0.1	0.138	0.3	0.3	0.366	1	0.3	0.4	1	0.1	0.133	0
S11	0.11	0.125	0.3	0.1	0.119	0.33	0.3	0.36	1	0.3	0.4	1	0.11	0.143	1	0.1	0.138	0	0.1	0.129	0.3	0.1	0.164	1	0.3	0.414	1	0.3	0.42	1	0.1	0.143	0

Weighted normalized fuzzy decision matrix

Weight	0.028			0.031			0.029			0.028		
	V1			V2			V3			V4		
S1	0.003	0.004	0.028	0.003	0.004	0.031	0.003	0.003	0.0097	0.0031	0.003	0.009
S2	0.003	0.003	0.006	0.003	0.004	0.006	0.003	0.003	0.0041	0.0031	0.003	0.004
S3	0.003	0.003	0.009	0.003	0.004	0.01	0.003	0.003	0.0041	0.0031	0.003	0.006
S4	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.003	0.0058	0.0031	0.003	0.004
S5	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.003	0.0058	0.0031	0.003	0.006
S6	0.003	0.003	0.009	0.003	0.004	0.031	0.003	0.003	0.0041	0.0031	0.003	0.004
S7	0.003	0.003	0.009	0.003	0.004	0.031	0.003	0.003	0.0097	0.0031	0.003	0.004
S8	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.004	0.029	0.0031	0.004	0.004
S9	0.003	0.004	0.006	0.003	0.005	0.031	0.003	0.004	0.0058	0.0031	0.004	0.009
S10	0.003	0.004	0.009	0.003	0.005	0.031	0.003	0.004	0.0097	0.0031	0.004	0.028
S11	0.003	0.003	0.006	0.003	0.003	0.004	0.003	0.003	0.0097	0.0031	0.004	0.009

Weight	0.028			0.028			0.027			0.027		
	V5			V6			V7			V8		
S1	0.003	0.003	0.009	0.016	0.016	0.028	0.015	0.015	0.019	0.009	0.01	0.016
S2	0.003	0.003	0.004	0.016	0.016	0.02	0.015	0.017	0.019	0.009	0.011	0.016
S3	0.003	0.004	0.009	0.016	0.018	0.02	0.015	0.016	0.019	0.009	0.011	0.027
S4	0.003	0.004	0.028	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.01	0.016
S5	0.003	0.003	0.006	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.009	0.012
S6	0.003	0.003	0.006	0.016	0.017	0.028	0.015	0.016	0.019	0.009	0.01	0.016
S7	0.003	0.004	0.009	0.016	0.017	0.02	0.015	0.016	0.019	0.009	0.01	0.016
S8	0.003	0.003	0.004	0.016	0.018	0.02	0.015	0.016	0.019	0.009	0.011	0.012
S9	0.003	0.004	0.006	0.016	0.017	0.028	0.015	0.016	0.019	0.009	0.011	0.012
S10	0.003	0.004	0.009	0.016	0.017	0.028	0.015	0.016	0.027	0.009	0.011	0.016
S11	0.003	0.004	0.009	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.01	0.016

Weight	0.027			0.061			0.064			0.064			0.063			0.05			0.201		
	V9			V10			V11			V12			V13			V14			V15		
S1	0.003	0.004	0.027	0.007	0.008	0.061	0.007	0.008	0.0213	0.0071	0.008	0.021	0.007	0.007	0.009	0.017	0.02	0.021	0.067	0.08	0.201
S2	0.003	0.003	0.009	0.007	0.008	0.009	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.021	0.017	0.017	0.021	0.067	0.072	0.201
S3	0.003	0.004	0.027	0.007	0.008	0.009	0.007	0.008	0.064	0.0071	0.008	0.009	0.007	0.007	0.009	0.017	0.017	0.021	0.067	0.072	0.201
S4	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.021	0.017	0.017	0.021	0.067	0.072	0.201
S5	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.018	0.021	0.067	0.075	0.201
S6	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.008	0.009	0.007	0.008	0.063	0.017	0.018	0.03	0.067	0.072	0.201
S7	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.009	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.017	0.021	0.067	0.072	0.201
S8	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.018	0.021	0.067	0.072	0.201
S9	0.003	0.004	0.009	0.007	0.007	0.061	0.007	0.008	0.064	0.0071	0.008	0.064	0.007	0.007	0.063	0.017	0.018	0.03	0.067	0.078	0.201
S10	0.003	0.004	0.027	0.007	0.007	0.02	0.007	0.008	0.0213	0.0071	0.008	0.013	0.007	0.007	0.009	0.017	0.018	0.03	0.067	0.078	0.201
S11	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.009	0.064	0.0071	0.008	0.021	0.007	0.007	0.021	0.017	0.018	0.05	0.067	0.08	0.201

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Weight	0.036			0.036			0.036			0.029			0.035			0.036			0.035		
	V16			V17			V18			V19			V20			V21			V22		
S1	0.004	0.005	0.012	0.004	0.005	0.036	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.014	0.035	0.012	0.015	0.036	0.004	0.005	0.035
S2	0.004	0.004	0.012	0.004	0.005	0.036	0.004	0.005	0.036	0.0032	0.003	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S3	0.004	0.005	0.012	0.004	0.005	0.036	0.004	0.005	0.036	0.0032	0.003	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S4	0.004	0.004	0.012	0.004	0.005	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S5	0.004	0.005	0.005	0.004	0.005	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.014	0.036	0.004	0.004	0.012
S6	0.004	0.005	0.036	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S7	0.004	0.005	0.036	0.004	0.004	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S8	0.004	0.005	0.012	0.004	0.004	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.014	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S9	0.004	0.005	0.012	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.015	0.036	0.004	0.005	0.012
S10	0.004	0.005	0.012	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.015	0.036	0.004	0.005	0.012
S11	0.004	0.005	0.036	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.005	0.029	0.012	0.014	0.035	0.012	0.015	0.036	0.004	0.005	0.012

FNIS and FPIS of the criteria

Weight	0.028			0.031			0.029			0.028			0.028			0.028			0.027			0.027		
	V1			V2			V3			V4			V5			V6			V7			V8		
S1	0.003	0.004	0.028	0.003	0.004	0.031	0.003	0.003	0.0097	0.0031	0.003	0.009	0.003	0.003	0.009	0.016	0.016	0.028	0.015	0.015	0.019	0.009	0.01	0.016
S2	0.003	0.003	0.006	0.003	0.004	0.006	0.003	0.003	0.0041	0.0031	0.003	0.004	0.003	0.003	0.004	0.016	0.016	0.02	0.015	0.017	0.019	0.009	0.011	0.016
S3	0.003	0.003	0.009	0.003	0.004	0.01	0.003	0.003	0.0041	0.0031	0.003	0.006	0.003	0.004	0.009	0.016	0.018	0.02	0.015	0.016	0.019	0.009	0.011	0.027
S4	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.003	0.0058	0.0031	0.003	0.004	0.003	0.004	0.028	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.01	0.016
S5	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.003	0.0058	0.0031	0.003	0.006	0.003	0.003	0.006	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.009	0.012
S6	0.003	0.003	0.009	0.003	0.004	0.031	0.003	0.003	0.0041	0.0031	0.003	0.004	0.003	0.003	0.006	0.016	0.017	0.028	0.015	0.016	0.019	0.009	0.01	0.016
S7	0.003	0.003	0.009	0.003	0.004	0.031	0.003	0.003	0.0097	0.0031	0.003	0.004	0.003	0.004	0.009	0.016	0.017	0.02	0.015	0.016	0.019	0.009	0.01	0.016
S8	0.003	0.003	0.006	0.003	0.004	0.031	0.003	0.004	0.029	0.0031	0.004	0.004	0.003	0.003	0.004	0.016	0.018	0.02	0.015	0.016	0.019	0.009	0.011	0.012
S9	0.003	0.004	0.006	0.003	0.005	0.031	0.003	0.004	0.0058	0.0031	0.004	0.009	0.003	0.004	0.006	0.016	0.017	0.028	0.015	0.016	0.019	0.009	0.011	0.012
S10	0.003	0.004	0.009	0.003	0.005	0.031	0.003	0.004	0.0097	0.0031	0.004	0.028	0.003	0.004	0.009	0.016	0.017	0.028	0.015	0.016	0.027	0.009	0.011	0.016
S11	0.003	0.003	0.006	0.003	0.003	0.004	0.003	0.003	0.0097	0.0031	0.004	0.009	0.003	0.004	0.009	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.01	0.016
(FPIS) A*	0.003	0.004	0.009	0.003	0.005	0.031	0.003	0.004	0.029	0.0031	0.004	0.028	0.003	0.004	0.028	0.016	0.017	0.028	0.015	0.016	0.027	0.009	0.011	0.027
(FNIS) A~	0.003	0.003	0.006	0.003	0.003	0.004	0.003	0.004	0.0097	0.0031	0.003	0.004	0.003	0.003	0.006	0.016	0.016	0.02	0.015	0.015	0.019	0.009	0.009	0.012

Weight	0.027			0.061			0.064			0.064			0.063			0.05			0.201		
	V9			V10			V11			V12			V13			V14			V15		
S1	0.003	0.004	0.027	0.007	0.008	0.061	0.007	0.008	0.0213	0.0071	0.008	0.021	0.007	0.007	0.009	0.017	0.02	0.021	0.067	0.08	0.201
S2	0.003	0.003	0.009	0.007	0.008	0.009	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.021	0.017	0.017	0.021	0.067	0.072	0.201
S3	0.003	0.004	0.027	0.007	0.008	0.009	0.007	0.008	0.064	0.0071	0.008	0.009	0.007	0.007	0.009	0.017	0.017	0.021	0.067	0.072	0.201
S4	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.021	0.017	0.017	0.021	0.067	0.072	0.201
S5	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.018	0.021	0.067	0.075	0.201
S6	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.008	0.009	0.007	0.008	0.063	0.017	0.018	0.03	0.067	0.072	0.201
S7	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.009	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.017	0.021	0.067	0.072	0.201
S8	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.008	0.064	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.018	0.021	0.067	0.072	0.201
S9	0.003	0.004	0.009	0.007	0.007	0.061	0.007	0.008	0.064	0.0071	0.008	0.064	0.007	0.007	0.063	0.017	0.018	0.03	0.067	0.078	0.201
S10	0.003	0.004	0.027	0.007	0.007	0.02	0.007	0.008	0.0213	0.0071	0.008	0.013	0.007	0.007	0.009	0.017	0.018	0.03	0.067	0.078	0.201
S11	0.003	0.003	0.009	0.007	0.008	0.061	0.007	0.009	0.064	0.0071	0.008	0.021	0.007	0.007	0.021	0.017	0.018	0.05	0.067	0.08	0.201
(FPIS) A*	0.003	0.004	0.027	0.007	0.008	0.061	0.007	0.009	0.064	0.0071	0.008	0.064	0.007	0.008	0.063	0.017	0.018	0.05	0.067	0.08	0.201
(FNIS) A~	0.003	0.003	0.009	0.007	0.007	0.02	0.007	0.008	0.0213	0.0071	0.007	0.009	0.007	0.007	0.009	0.017	0.017	0.021	0.067	0.072	0.201

Weight	0.036			0.036			0.036			0.029			0.035			0.036			0.035		
	V16			V17			V18			V19			V20			V21			V22		
S1	0.004	0.005	0.012	0.004	0.005	0.036	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.014	0.035	0.012	0.015	0.036	0.004	0.005	0.035
S2	0.004	0.004	0.012	0.004	0.005	0.036	0.004	0.005	0.036	0.0032	0.003	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S3	0.004	0.005	0.012	0.004	0.005	0.036	0.004	0.005	0.036	0.0032	0.003	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S4	0.004	0.004	0.012	0.004	0.005	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S5	0.004	0.005	0.005	0.004	0.005	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.014	0.036	0.004	0.004	0.012
S6	0.004	0.005	0.036	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S7	0.004	0.005	0.036	0.004	0.004	0.012	0.004	0.005	0.036	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S8	0.004	0.005	0.012	0.004	0.004	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.014	0.035	0.012	0.013	0.036	0.004	0.004	0.012
S9	0.004	0.005	0.012	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.015	0.036	0.004	0.005	0.012
S10	0.004	0.005	0.012	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.004	0.01	0.012	0.013	0.035	0.012	0.015	0.036	0.004	0.005	0.012
S11	0.004	0.005	0.036	0.004	0.005	0.012	0.004	0.005	0.012	0.0032	0.005	0.029	0.012	0.014	0.035	0.012	0.015	0.036	0.004	0.005	0.012
(FPIS) A*	0.004	0.005	0.036	0.004	0.005	0.036	0.004	0.005	0.036	0.0032	0.005	0.029	0.012	0.014	0.035	0.012	0.015	0.036	0.004	0.005	0.035
(FNIS) A~	0.004	0.004	0.012	0.004	0.004	0.012	0.004	0.005	0.012	0.0032	0.003	0.01	0.012	0.013	0.035	0.012	0.013	0.036	0.004	0.004	0.012

Distance of the alternate from FPIS

Quality indicators	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	di*
S1	0.0108	0.0002	0.0112	0.0108	0.0108	0.0004	0.0045	0.0063	0.0001	0.0002	0.0246	0.0246	0.0325	0.0449	0.1211	0.0046	0.0002	0.0139	0.0112	0.0005	0.0000	0.0000	0.3332
S2	0.0022	0.0143	0.0144	0.0139	0.0144	0.0046	0.0045	0.0062	0.0104	0.0302	0.0003	0.0317	0.0272	0.0407	0.1212	0.0046	0.0001	0.0000	0.0112	0.0011	0.0008	0.0135	0.3675
S3	0.0003	0.0119	0.0144	0.0129	0.0144	0.0047	0.0045	0.0000	0.0000	0.0302	0.0003	0.0317	0.0325	0.0407	0.1212	0.0046	0.0000	0.0000	0.0112	0.0010	0.0008	0.0135	0.3507
S4	0.0022	0.0004	0.0134	0.0139	0.0134	0.0047	0.0045	0.0063	0.0104	0.0002	0.0003	0.0317	0.0272	0.0415	0.1212	0.0046	0.0139	0.0000	0.0112	0.0010	0.0008	0.0135	0.336
S5	0.0022	0.0004	0.0134	0.0129	0.0134	0.0046	0.0045	0.0089	0.0104	0.0003	0.0003	0.0317	0.0324	0.0429	0.1211	0.0007	0.0139	0.0001	0.0112	0.0006	0.0005	0.0135	0.34
S6	0.0003	0.0004	0.0144	0.0139	0.0144	0.0000	0.0045	0.0063	0.0104	0.0003	0.0003	0.0317	0.0088	0.0527	0.1212	0.0185	0.0139	0.0139	0.0112	0.0006	0.0008	0.0135	0.3517
S7	0.0003	0.0004	0.0112	0.0139	0.0112	0.0046	0.0045	0.0063	0.0104	0.0003	0.0000	0.0317	0.0325	0.0415	0.1212	0.0185	0.0139	0.0001	0.0112	0.0011	0.0008	0.0135	0.3487
S8	0.0022	0.0005	0.0000	0.0139	0.0000	0.0046	0.0045	0.0089	0.0104	0.0003	0.0003	0.0317	0.0325	0.0421	0.1212	0.0046	0.0139	0.0139	0.0112	0.0005	0.0008	0.0135	0.3313
S9	0.0022	0.0000	0.0134	0.0108	0.0134	0.0000	0.0045	0.0089	0.0104	0.0006	0.0003	0.0000	0.0088	0.0534	0.1211	0.0046	0.0139	0.0139	0.0112	0.0010	0.0000	0.0135	0.3056
S10	0.0000	0.0000	0.0112	0.0000	0.0112	0.0000	0.0000	0.0062	0.0000	0.0235	0.0246	0.0296	0.0324	0.0534	0.1211	0.0046	0.0139	0.0139	0.0112	0.0010	0.0000	0.0135	0.3712
S11	0.0022	0.0154	0.0112	0.0108	0.0112	0.0046	0.0045	0.0063	0.0104	0.0000	0.0002	0.0246	0.0272	0.0880	0.1211	0.0185	0.0139	0.0139	0.0000	0.0000	0.0003	0.0135	0.3974

Distance of the alternate from FNIS

Quality indicators	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	di-
S1	0.0129	0.0153	0.0001	0.0031	0.0022	0.0046	0.0000	0.0027	0.0104	0.0235	0.0001	0.0070	0.0020	0.0537	0.1194	0.0003	0.0139	0.0002	0.0002	0.0005	0.0008	0.0135	0.2865
S2	0.0000	0.0010	0.0032	0.0001	0.0009	0.0000	0.0011	0.0028	0.0000	0.0067	0.0246	0.0001	0.0043	0.0502	0.1195	0.0000	0.0139	0.0139	0.0000	0.0001	0.0000	0.0002	0.2426
S3	0.0022	0.0034	0.0032	0.0009	0.0022	0.0011	0.0005	0.0089	0.0104	0.0067	0.0246	0.0001	0.0020	0.0502	0.1195	0.0002	0.0139	0.0139	0.0000	0.0000	0.0000	0.0000	0.2639
S4	0.0001	0.0153	0.0022	0.0000	0.0129	0.0003	0.0000	0.0027	0.0001	0.0235	0.0246	0.0000	0.0043	0.0509	0.1195	0.0000	0.0002	0.0139	0.0001	0.0000	0.0000	0.0001	0.2707
S5	0.0000	0.0153	0.0022	0.0009	0.0001	0.0000	0.0000	0.0000	0.0001	0.0235	0.0246	0.0000	0.0019	0.0520	0.1194	0.0040	0.0002	0.0139	0.0001	0.0003	0.0003	0.0000	0.2588
S6	0.0022	0.0153	0.0032	0.0001	0.0000	0.0046	0.0005	0.0027	0.0001	0.0235	0.0246	0.0002	0.0226	0.0652	0.1195	0.0139	0.0003	0.0001	0.0003	0.0003	0.0000	0.0000	0.2991
S7	0.0022	0.0153	0.0001	0.0001	0.0022	0.0006	0.0005	0.0027	0.0001	0.0235	0.0246	0.0000	0.0020	0.0509	0.1195	0.0139	0.0000	0.0139	0.0001	0.0001	0.0000	0.0001	0.2721
S8	0.0001	0.0153	0.0112	0.0001	0.0009	0.0008	0.0005	0.0009	0.0001	0.0235	0.0246	0.0001	0.0020	0.0514	0.1195	0.0002	0.0000	0.0001	0.0001	0.0004	0.0000	0.0001	0.2518
S9	0.0003	0.0154	0.0022	0.0031	0.0002	0.0046	0.0006	0.0009	0.0002	0.0235	0.0246	0.0317	0.0226	0.0658	0.1194	0.0003	0.0004	0.0000	0.0003	0.0000	0.0008	0.0001	0.317
S10	0.0022	0.0154	0.0000	0.0139	0.0022	0.0046	0.0045	0.0028	0.0104	0.0000	0.0000	0.0021	0.0019	0.0658	0.1194	0.0003	0.0004	0.0000	0.0003	0.0000	0.0008	0.0001	0.2471
S11	0.0000	0.0000	0.0001	0.0031	0.0022	0.0000	0.0000	0.0027	0.0002	0.0235	0.0246	0.0070	0.0043	0.1032	0.1194	0.0139	0.0004	0.0000	0.0112	0.0010	0.0011	0.0003	0.318