University of Bedfordshire

Title: Reducing edible food waste in the UK food manufacturing supply chain through collaboration

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Reducing edible food waste in the UK food manufacturing supply chain through collaboration.

Submitted by

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Author's Declaration

I hereby declare that this thesis is my own unaided original piece of work. It is not been submitted before for any degree or examination in any other university.

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Date: 09/06/2017.

Abstract

The aim of this study is to examine the relationship between food manufacturing supply chain (FMSC) collaboration, collaborative effectiveness and edible food waste (EF) waste reduction; and also identify the key dimensions of collaboration and collaborative effectiveness in the context of the FMSC. A conceptual framework was built based on thorough relevant literature review and theory. Then all items of the conceptual framework were revised by academics and practitioners. The model was empirically tested with survey data using 122 responses from food manufacturing firms, using PLS-SEM. The findings indicated that the structural paths support hypotheses that FMSC collaboration has a positive effect related to collaborative effectiveness, and collaborative effectiveness has a strong contribution in EF waste (over-production of EF waste, processing of EF waste and storage of EF waste) reduction. However, the direct impact of FMSC collaboration on EF waste (over-production of EF waste, processing of EF waste and storage of EF waste) reduction is insignificant. A mediation analysis showed that the relationship between FMSC collaboration and EF waste is fully mediated by collaborative effectiveness. This research brought relational view theory for the concept of FMSC collaboration and collaborative effectiveness into the FMSC context, which has not previously been done, and developed and validated those constructs and relationships. The UK FMSC members would benefit from applying all dimensions of FMSC collaboration in this study to their supply chain operation to achieve greater collaborative effectiveness, and that will lead to reducing EF waste.

Keywords: - FMSC collaboration, collaborative effectiveness, EF waste reduction

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I dedicate this research to my parents, Jagdishbhai Shah and Kusumben Shah, and I am sure my research will earn the highest pride in their life.

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List of Abbreviation

Abbreviation	Full term
FMSC	Food manufacturing supply chain.
FMSC collaboration or FMSCC	Food manufacturing supply chain collaboration
EF waste	Edible food waste
RV	Relational view
JDF	Joint demand forecast
RFID	Using Radio-frequency identification (RFID) technology
SPD	Smart packaging design
JTP	Joint training programme
KI	Knowledge integration
OPEFW	Over-production edible food waste
PEFW	Processing edible food waste
SEFW	Storage edible food waste
PLS-SEM	partial least squares structural equation modelling

1 CHAPTER ONE: INTRODUCTION

This chapter delineates the research background, research objective rationale of thesis, and an overview of research methodology. The final section provides the structure summary of the whole thesis.

1.1 Research background

The global population now exceeds seven billion and by 2050 the world's population will reach 9 billion; so, food demand will increase up to 50 percent by that time and a huge amount of resources will be needed to feed this enormous number of people (Mishra and Singh, 2016, Bond et al., 2013). Edible food (EF) waste is much higher at the immediate post-harvest stages (agricultural stage) in developing countries, e.g. India; while in affluent countries or developed countries (the UK, USA), the pre-consumer stage means the factory in-gate to the point of purchase by consumers accounts for the highest amount of EF waste (Parfitt et al., 2010).

Estimation shows that a third of food produced is wasted at the pre-consumer stage in the UK Food manufacturing supply chain (FMSC), which never reaches our plates. Recently, the unprecedented scale of EF waste in the UK FMSC has drawn significant attention because EF waste's direct negative impacts on the UK environment, society and economics are becoming more apparent, recently (Papargyropoulou et al., 2014). EF waste means "wholesome edible material intended for human consumption, arising at any point in the FMSC that is instead discarded, lost or degraded", as defined by Parfitt et al. (2010). While the European Commission (FUSIONS, n.d.) has defined EF waste generated specifically at the UK pre-consumer stage, as "food appropriate for human consumption being discarded, whether or not after it is kept beyond its expiry date or left to spoil. Often this is because food has spoiled but it can be for other reasons such as oversupply due to markets".

Mishra and Singh (2016) and Gadde and Amani (2016) stated that EF waste is generated at one end of the FMSC but its root cause is linked to other segments of the FMSC; therefore the stakeholders of the FMSC, including food manufacturing and retailer, have the onus of EF waste. EF waste arises at the pre-consumer stage in the UK FMSC for a variety of different reasons.

Due to lack of coordination of supply chain operational and logistic related activities in the UK FMSC, UK FMSC members (FMSC partners; However, both terms are used interchangeably in this thesis) face various challenges and complexity in their supply chain operation and logistic (Mena et al., 2011, Eksoz et al., 2014, Kumar and Nigmatullin, 2011, Kummu et al., 2012). While, FMSC's operational and logistic challenges relate mainly to unexpected events, poor forecasting (Kumar and Nigmatullin, 2011), seasonality, promotion, typical short shelf-life of product (Eksoz et al., 2014), constant changes in consumer demand, poorly trained workers (Kumar and Nigmatullin, 2011), cold chain integrity (temperature maintenance), cross-contamination and poor coordination between members (Mena et al., 2014). Meanwhile, the operational and logistic complexity of the FMSC refers to poor information structure (Eksoz et al., 2014), poor communication, over- stocking, poor management structure (Eksoz et al., 2014, Mena et al., 2011), poor visibility, lack of internal integration, uncertainty in demand (Mena et al., 2011) and lack of data availability (Eksoz et al., 2014). For those reasons, a high proportion of EF is being wasted at the pre-consumer stage in the UK FMSC (Mena et al., 2014).

Despite different approaches taken by WRAP (Waste & Resources Action Programme – a UK government funding charity) with UK food manufacturing, retailer and wholesalers for EF waste reduction and also redistribution efforts across the sector, still, there is not any significant achievement in reducing EF waste in the UK FMSC. On the basis of a European Commission report Gadde and Amani (2016) estimated that until 2020, EF waste will increase by 26 percent in the UK FMSC; therefore, it is necessary to take strong measures to reduce EF waste. Gadde and Amani (2016) found that a FMSC is a network of organisations and involved in a number of processes and activities which make FMSCs very complex; therefore they are harder to manage than other supply chains. Therefore, Gadde and Amani (2016) advocated a holistic approach is needed among the FMSC members which will efficiently and effectively manage the complex FMSC. Garnett (2011) also stated that collaboration among the FMSC members is the more holistic approach to address EF waste. This is supported by Bosona and Gebresenbet (2011) who stated that for managing complexity and challenges of the FMSC, a highly collaborative approach has become a necessity, that aligns the supply chain operational and logistic activities among the FMSC members for reducing EF waste (Garnett, 2011). Collaboration in the FMSC is required, where FMSC members can build an esprit de corps between FMSC members in order to unite efforts to achieve EF waste reduction (Stank et al., 2001), but this is still in its infancy in the UK FMSC (Arshinder et al., 2008).

The question of reducing EF waste through FMSC collaboration is still a subject of debate (Papargyropoulou et al., 2014, Mena et al., 2011, Kouwenhoven et al., 2012). Previous studies on collaboration in the FMSC including Rota et al. (2012), Nair and Lau (2012), Ali et al. (2016), Göbel et al. (2015) and Ramanathan (2012) have not shown clear results of FMSC collaboration impact on collaborative effectiveness and reduction of EF waste. This inconclusiveness highlights that the impact of FMSC collaboration on collaborative effectiveness and EF waste reduction is uncertain. However, the literature on the key dimension of FMSC collaboration, and also if FMSC collaboration has a positive impact on collaborative effectiveness and EF waste reduction is still limited (Arshinder et al., 2008, Herbert et al., 2011) Therefore, FMSC managers may struggle to implement collaboration in the FMSC (Piboonrungroj, 2012). Such ambiguity means that insights into to what extent FMSC collaboration works are currently needed (Piboonrungroj, 2012, Quinn, 2012).

1.2 Research focus

This study focuses on EF waste reduction in the intermediate stage (FMSC stage), which is vertically linked to downstream partners; that means interface between the food manufacturing and retailer stages. While the other two stages of primary producer (agricultural stage EF waste) and end stage (household stage EF waste) are excluded in this research. This research has focused on the impact of FMSC collaboration on EF food waste reduction, and also collaborative effectiveness. The study also investigated the impact of collaborative effectiveness on EF waste reduction and also identified the FMSC collaboration and collaborative effectiveness dimension through a rigorous literature review and theory, and generated the conceptual framework. This will assist FMSC managers in drawing conclusions on the need for collaboration in FMSC operations and logistic to reduce EF waste.

1.3 Research gaps

EF waste occurs at different points in the FMSC. Previous research has suggested various approaches including Six Sigma by Nabhani and Shokri (2009), the values chain framework suggested by Kouwenhoven et al. (2012), analytical method by Darlington et al. (2009) and the waste hierarchy model by Papargyropoulou et al. (2014) to reduce EF waste at the small and medium enterprises (SMEs), agricultural, retailer and processor stages. While Nair and Lau (2012) have focused on postharvest fruit and vegetable waste reduction, on the other hand, Göbel et al. (2015) identified the causes of EF waste and proposed that FMSC partners need to share responsibility and work together to reduce this waste through qualitative information along the FMSC.

Whereas Mena et al. (2011), Whitehead et al. (2013), Kummu et al. (2012) and Parfitt et al. (2010) have conducted research to identify EF waste across the multi-tier FMSC network and mentioned that the greatest amount of EF waste is generated interface between the food manufacturing and retailer stages at the FMSC. However, Mena et al. (2011) and Mena et al. (2014) strongly pointed out that a number of studies measure the causes of EF waste; where there is, notably, not much research concerning the reduction of EF waste at the FMSC (interface between the food manufacturing and retailers stages) specifically in the UK. It is supported through the Dorward (2012) statement that little attention has been paid to reduce EF waste in the UK FMSC stage until now, and there are still many low hanging fruits to be plucked.

On the other hand, in relation to collaboration in the FMSC, past literature has looked into various aspects: Ali et al. (2016) has focused on halal food chain collaboration for integrity, Chen (2017) conducted a study on food traceability system collaboration for integrity, Ramanathan (2012) conducted research on grocery supply chain collaboration for promotional forecast accuracy, Rota et al. (2013) focused on agri-food supply chain collaboration for sustainable relationship, and Touboulic and Walker (2014) focused on collaboration between large buyers and small suppliers in the food manufacture supply chain for sustainability. Naspetti et al. (2011) focused on organic FMSC collaboration (FMSC collaboration) to improve organic FMSC performance in terms of quality and safety, and Eksoz et al. (2014) proposed the conceptual framework of collaborative forecasting for specific food product categories, particularly in manufacturers and retailers' dyadic relationship. Where, in the context of the agri-food industry, Matopoulos et al. (2007) concentrated on supply chain collaboration for establishing and maintaining supply chain relationships between the grower and processor interface. However, most of the collaborative studies conducted research on different stages of FMSC collaboration for different outcomes. However, there is a scarcity of studies of collaboration, specifically which focus on FMSC collaboration which will help to reduce EF waste in the UK FMSC**.**

However, as per above, few studies have conceptualised collaboration at different stages of the FMSC; indeed, there is a lack of empirical evidence for reducing EF waste through FMSC collaboration and also more importantly, the conceptual framework of FMSC collaboration has not been clearly established to date. Even though, collaborative effectiveness is not thoroughly acknowledged in the previous FMSC collaborative literature.

1.4 Research aims

The aim of the research is to investigate the key collaborative dimensions of FMSC collaboration and measure their impact on collaborative effectiveness and EF waste reduction; and also determine the dimension of collaborative effectiveness in terms of the FMSC context. This work will address the above discussed research gap and advance understanding of FMSC collaboration.

1.5 Research questions

As described in the research background and research gap sections, this study aims to investigate the key dimensions of FMSC collaboration and collaborative effectiveness, and examine the relationships between FMSC collaboration, collaborative effectiveness and EF waste reduction. Therefore, to fulfil the aims of the study the following research questions have been investigated:

- **Research question 1:** What are the key dimensions of FMSC collaboration?
- **Research question 2:** What are the key dimensions of collaborative effectiveness (in the context of FMSC), and EF waste reduction?
- **Research question 3:** To what extent is FMSC collaboration influencing collaborative effectiveness?
- **Research question 4:** To what extent is FMSC collaboration affecting EF waste reduction?
- **Research question 5**: To what extent is collaborative effectiveness affecting the EF waste reduction?

1.6 Research objectives

More specifically this research is carried out with the following objectives:

- To identify key dimension of FMSC collaboration.
- To identify key dimensions of collaborative effectiveness (in the context of FMSC), and EF waste reduction.

- To empirically examine the impact of FMSC collaboration on collaborative effectiveness and EF waste reduction.
- To understand / analyse the impact of collaborative effectiveness on EF waste reduction.
- To develop and empirically test the conceptual framework.

1.7 Research methodology

The research aims to investigate and validate the multi-dimensional construct of FMSC collaboration and collaborative effectiveness and examine whether FMSC collaboration has an impact on collaborative effectiveness and EF waste, or not. This study is a descriptive study and examines the causal relationship between the FMSC collaboration, collaborative effectiveness and EF waste (over-production of EF waste, processing of EF waste and storage of EF waste) through using a sample from one sector in a particular country, which has not yet been examined in the FMSC context. This study is conducted under the positivist paradigm and deductive reasoning approach. A quantitative method is used for this study. Measurement scales are explored and chosen based on rigorous literature review, then discussed with academic and industry experts to identify any ambiguity. Then the study used a survey strategy as the main data collection strategy to obtain the data from food manufacturing companies, and then tested the research hypotheses. There is no representative directory listing available UK food manufacturing companies, which lead to using convenience sampling for this study. Qualtrics software was used to collect the data from potential respondents. To conduct a statistical examination, a Structured Equation Modelling (SEM) was carried out to test the hypotheses about relationships between the variables. Smart PLS-SEM version 3 software was used in this study. The repeated indicator approach was used on the basis of previous studies, including Peng and Lai (2012), Sarstedt et al. (2014) and Han et al. (2017), to evaluate reflective and formative measurement indicators.

1.8 Rationale of the thesis

As per New (1997), p-21 "The research agenda in supply chain management must not be driven by industrial interests alone". As per Mentzer (2008) and Dess and Markoczy (2008) observation, the gaps between scholarly research (academic rigour) and practice in business (practical relevance) have been significant for decades, because many researchers considered the supply chain as a new discipline and need to prove that they are scholarly; therefore the primary aim of their research study is to make an academic contribution (Piboonrungroj, 2012, Mentzer, 2008). Furthermore, Mentzer (2008) advised that research study must be applicable to real word situations and problems as well; and therefore, supply chain scholars need to aim for both rigour and relevance in their research (Piboonrungroj, 2012). To do this, the research agenda of this thesis is significant for academic interest, and also FMSC professionals, managers and operational decision makers as well. However, the supply chain is a very practical discipline, so the aim of supply chain scholars and educators is that their contributed knowledge (outcomes of the research) should not only make an academic contribution but also excel in making an impact on supply chain practitioners (Piboonrungroj, 2012, Mentzer, 2008). This will lead to the extinction of the ''gap'' between scholarly research and practice. As per Fawcett et al. (2011), in today's environment, it is a necessity that FMSC research must be useful to both academic and business communities; so this research provides advance knowledge that is relevant to both the academic and practical interests.

1.8.1 Academic interest

In addressing the identified research gaps, there are a number of academic benefits expected to emerge from this research. First, this research will contribute to the knowledge on FMSC collaboration, and proposes that FMSC collaboration is reducing EF waste in the FMSC. However, a few studies examined the collaboration in the FMSC for a number of reason; but specifically, empirical research that examined the relationship between the EF waste reduction and FMSC collaboration is absent in the previous literatures. This research therefore will add to the existing literature about FMSC collaboration and EF waste reduction and will contribute to the knowledge on this highly important relationship (FMSC collaboration positively associated with EF waste reduction) from the specific interface stage (between the food manufacturing and retailers stages), which is limited in the academic research (Mena et al., 2011). This is the first study addressing this relationship and hence the first contribution in this area for academics.

To the author's best knowledge, the study represents one of the first multi-dimensional construct models to provide preliminary insights into the antecedents to, and the consequences of, FMSC collaboration. Another envisaged significant contribution of this study will be the identification of the key dimensions of FMSC collaboration and collaborative effectiveness, which was missing from previous academic literatures in the context of FMSC collaboration (Piboonrungroj, 2012).

1.8.2 Practical interest

On the basis of survey analysis, the Grocery Manufacturers Association found that only 20% of FMSC collaborative companies have achieved positive results of collaboration (specifically in terms of forming sustainable relationships and new product development) (G.M.A, 2010). However, in reality, most of the FMSC companies faced critical challenges to improve their FMSC operational and logistic performances or even failed to align their operational and logistic activities with their the downstream partners (Piboonrungroj, 2012, Cooke, 2011, Kotzab et al., 2006, Matopoulos et al., 2007). This problem could be a result of failure to identify the key FMSC collaborative measures (elements) which help to align operational and logistic activities with the downstream partners of FMSC (Matopoulos et al., 2007). Therefore, collaborative failure can lead to a breach of the collaborative agreements and damage the FMSC collaborative relationship in the long term (Piboonrungroj, 2012).

Considering the above perceived challenges, this research identifies key measures of FMSC collaboration, which can help managers to define specific action to be taken for improving shared FMSC operational and logistic activities that help to reduce EF waste. These measures can serve as a powerful toolkit for managers to form effective collaboration in the FMSC, and it also helps the FMSC firms to minimize the chance of collaboration failure through using the key FMSC collaborative measures of this research. On other hand, this research suggests concrete and important insights for managers regarding the reduction of EF waste through FMSC collaboration that will have a significant impact on the overall performance (financial and operational performance) of all the downstream FMSC entities as well. In general it is hoped that the findings of this research will provide useful practical guidelines and recommendations for FMSC entities, and mostly to FMSC managers and consultants.

1.9 Structure of the thesis

The structure of this thesis is organised into seven chapters.

Chapter 1 introduces the research background, research focus, research gaps, research method, rationale of the thesis and structure of the thesis.

Chapter 2 starts with an overview of the FMSC, classification of the FMSC, amount of EF waste arising in the UK by sector, specifying special characteristics of the FMSC, types of food waste, justification for importance of reducing EF waste and causes of EF waste. This chapter also outlines the theoretical background, conceptual model development, background of the FMSC collaboration; discusses the previous relevant literature associated with FMSC collaboration, collaborative effectiveness and EF waste; then in each discussion part the research hypotheses are developed based on previous relevant literature and theory.

Chapter 3 is the research methodology chapter, which includes research design, research philosophy, research approach, research strategy, questionnaire design and scale development, sampling method, validity, reliability, data analysis, limitation of research methodology and ethical consideration.

Chapter 4 is the data analysis chapter, which consists of two main sections: Descriptive statistics and Statistical analysis. The descriptive statistics section is the results of the research findings including response rate, overall demographic details of the sample and descriptive statistics for the main questions. Statistical analysis presents the statistical analysis of the model specification to evaluate the measurement model and the structural model to ensure validity, reliability and path coefficients.

Chapter 5 is the finding and discussion chapter, where research findings and discussion of each hypothesis is discussed.

Chapter 6 illustrates the contribution to theories, theoretical implication, managerial Implication, environmental implication, social implication, economic implication, limitation and future research and finally conclusion.

Chapter 7 is reference chapter, where all references of this study is mentioned here.

1.10 Summary

This chapter has provided an overview of the contents of this thesis by including research background, research focus, research questions, research gaps and research methodology. The next chapter discusses overviews of the FMSC and EF waste.

2 CHAPTER TWO: LITERATURE REVIEW

This chapter focuses on the literature review for both theoretical and empirical studies. First, an overview of the Food Supply chain is given and its classifications and the amount of edible food waste is also discussed. Second, the food manufacturing supply chain is defined, and its classification, contribution, and special characteristics are explained. Here, causes of edible food waste at FMSC and its justification to reduce edible food waste is very clearly described. Third, 2.3 provides a theoretical framework on which this research is based. Fourth 2.4 the conceptual model development and hypothesis derivation is dedicated to exploring the main constructs of this study; where this study defines food manufacturing supply chain collaboration (FMSC collaboration), collaborative effectiveness (CE) and edible food waste (EF waste); and investigates the main activities and key dimensions of FMSC collaboration, collaborative effectiveness and EF waste. Here, the background of the evolution of FMSC collaboration practice is also reviewed.

2.1 An overview of the food supply chain (FSC) and its food waste

FSC is the lifeline of human existence on the planet (Dani, 2015). Nowadays, it is not only a key segment of the business world but also of importance in the service sector, public sector and not-for-profit organizations (Mangan et al., 2016). Rather than being focused on nutritional and quality management perspectives, this study address only EF waste which has the highly impacts on the UK businesses, environment and livelihoods of today.

2.1.1 Definition of FSC

A few authors have defined the FSC in their context. FSC means "a network of organisations, including from upstream to downstream (farm to retailer), that work together in sequence of / the different processes and activities to deliver food products to the market and fulfil end consumer" (Maloni and Brown, 2006, Mangan et al., 2016).

2.1.2 Classification or structure of the FSC

FSC is sub-divided into three different stages (Ball et al., 2001, Bourlakis and Weightman, 2008, Tsolakis et al., 2014) and a number of sectors play different roles or are involved in each stage of FSC, as follows:

- **Primary producers:-** This stage includes the agricultural supply chain, fisheries supply chain and livestock (animal products) supply chains.
- **Intermediate stage:-** this stage includes the **food manufacture supply chain (FMSC).**
- **End stage:-** This stage includes wholesalers supply chain, caterers supply chain, retailer supply chain and consumers or household.

At each stage of FSC, the food is passed through a number of processes, operations and entities for turning food from a raw material state into an edible state. Jones (2002) has referred to these three stages as the complete lifecycle of food because food moves from production to consumption to landfill.

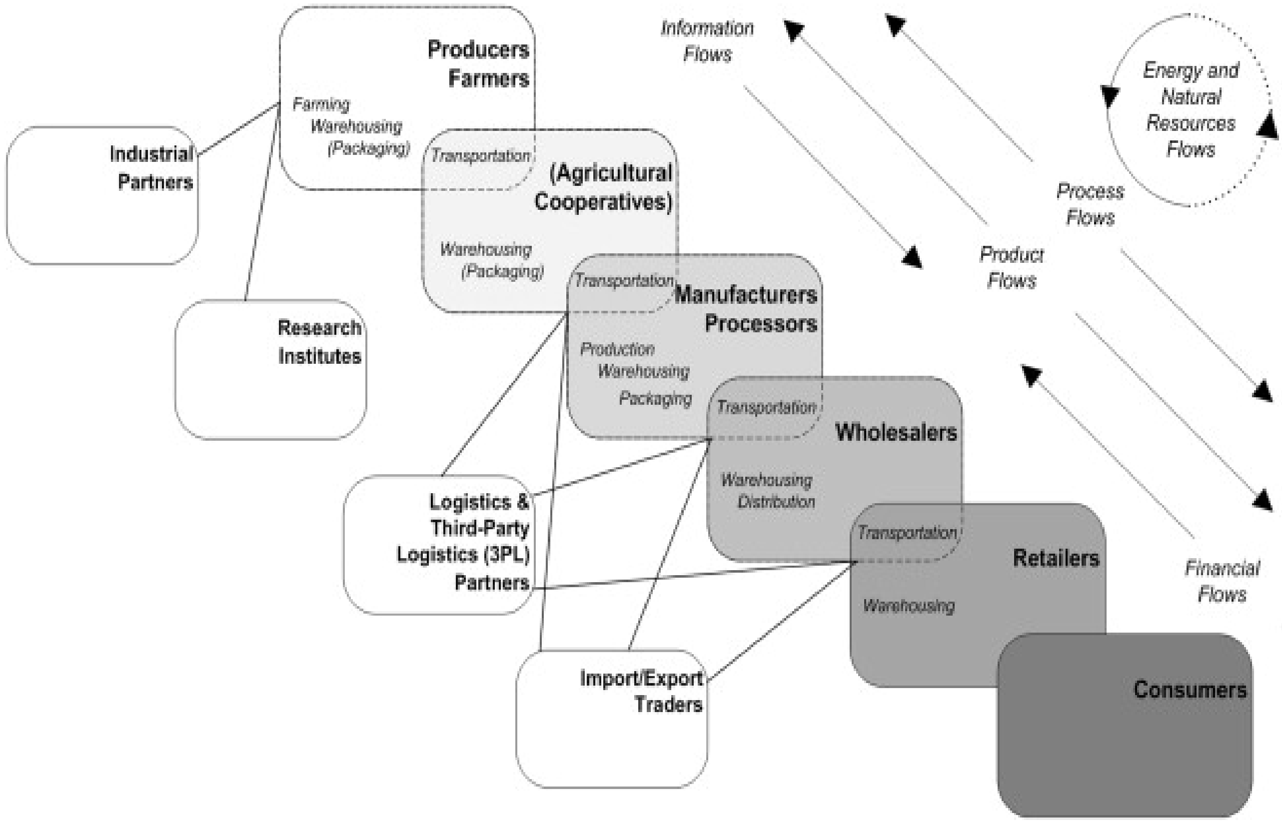

Figure 1: Structure of the UK FSC, source (Tsolakis et al., 2014)

2.1.3 Food losses and food waste along the entire FSC

As per Papargyropoulou et al. (2014) and Gustavsson et al. (2011) food is lost or wasted throughout the food supply chain (FSC), from primary producer (agricultural production) stage to the end stage (final household consumption); and Bond et al. (2013) clearly classified that food loss is incurred during early phases of the food supply chain, and food waste generated at the latter phases of the FSC. Moreover, Parfitt et al. (2010) page- 3065) mentioned that "food waste and food lost relate to specific point of arising, often framed in relation to specific environmental factors, and also defined in different legal jurisdictions".

2.1.3.1 Food losses

Food waste at the primary producer stage is likely to be referred to as 'food losses or spoilage', and not considered as 'food waste'. It is also known as 'post-harvest losses' (Parfitt et al., 2010, Papargyropoulou et al., 2014). Food losses are defined by Parfitt et al. (2010) as "the degradation in food quantity or quality, which makes it unfit for human consumption". The reasons for food losses at the primary producer stage mostly relate to a lack of infrastructure investment, poor harvesting technique, poor transport technique, disease, contamination and natural drying out of food (Papargyropoulou et al., 2014).

2.1.3.2 Food waste

Food waste is most readily defined at two stages of FSC: the intermediate stage and the end stage (Parfitt et al., 2010). The Waste & Resources Action Programme (WRAP), Parfitt et al. (2010), Beretta et al. (2013), and Whitehead et al. (2013) have classified food waste into two categories:

- Avoidable or Edible food (EF) waste, such as cooked food.
- Unavoidable OR Bio Food Waste, means "waste arising during food preparation, that is not, and has not been, edible under normal circumstances" (Parfitt et al., 2010, Beretta et al., 2013), such as vegetable peeling, bone.

Moreover, Bond et al. (2013) referred to food waste as EF products which are intended for the purposes of human consumption, but have instead been discarded, lost, degraded or consumed by pests, and this does not include the inedible or undesirable portions of foodstuffs (unavoidable OR bio Food Waste) (Bond et al., 2013) that are highly wasted at the interface between the stages (the intermediate stage and the end stage), reported by (Mena et al., 2011).

2.1.4 The global food supply chain: food losses and waste

Previous studies (Bond et al., 2013, Gustavsson et al., 2011, Papargyropoulou et al., 2014) have looked at food losses and waste across the FSC (all three stages) in developing and developed countries. Such studies estimated that there are 1.3 billion tonnes of edible parts of food wasted annually; this equals one-third of global food (Bond et al., 2013) or nearly 40% of food (Kummu et al., 2012) being lost and wasted before and after it reaches the consumer across the global food supply chain; albeit through very different channels of food supply chain. Bond et al. (2013) and Parfitt et al. (2010) have differentiated food losses and waste according to economic development as follows:

2.1.4.1 Low income countries

According to Gustavsson et al. (2011), Bond et al. (2013) and Parfitt et al. (2010), low-income countries (including Afghanistan, sub-Saharan Africa) are facing the highest amount of food losses at their agricultural stages because those countries are dominated by smallholder farmers (smallholders have limited access to information or trade with non-local food markets), inefficient agriculture infrastructure (including technical limitations in harvesting techniques, storage and cooling facilities), and they also face considerable challenges from harsh climates.

2.1.4.2 Transition countries

These are characterised by increased population, increased urbanisation, rising incomes and a dietary shift more inclusive of meat, fish and dairy; especially Brazil and China (Bond et al., 2013). Due to both infrastructural inadequacies and consumption excesses, the proportion of food lost and waste are a similar amount in those transition countries.

2.1.4.3 High-income countries

These are also known as industrialised countries, such the UK and the US. With better resource efficiency, food losses are less at the primary stage of FSC. However, a greater amount of EF wastage occurs at the factory stage (Parfitt et al., 2010), due to lack of coordination and insufficient purchase planning, as observed by Gustavsson et al. (2011).

Overall, on a per-capita basis, Kummu et al. (2012) and Gustavsson et al. (2011) estimated that 95-115kg of food waste is produced per person annually in the industrialised world, such as Europe and North America. Developing countries produce only 6-11 kg per person annually, but, conversely, those developing countries lose around 40% to 50% of all root crops, grain, fruits and vegetables at the primary stages (Bond et al., 2013).

Food losses arising in the agriculture, fisheries and livestock supply chain have not been an area of focus for this research because food losses are not considered under the EF waste norms through the Food and Agriculture Organization of the United Nations (FAO), as mentioned by Jan et al. (2013)**.** On the other hand, there is also very little statistical data related to how much quantity of food is lost at the primary producer stage in the UK.

2.1.5 Amount of EF waste arising in the two stages of UK FSC

DEFRA (the UK's Department for Environment, Food & Rural Affairs) and WRAP (Waste & Resources Action Programme) have estimated the amount of all types of waste, such as avoidable waste, unavoidable waste, mixed waste and packing waste, generated by two stages of the UK FSC (the intermediate stage and the end stage) (WRAP(1), n.d.), (DEFRA, 2015). This study has considered only EF waste (avoidable waste) and excluded the other types of waste which are not part of the research for this study. Figure 2 represents the EF waste statistics in the two stages (the intermediate stage and the end stage) of the UK FSC.

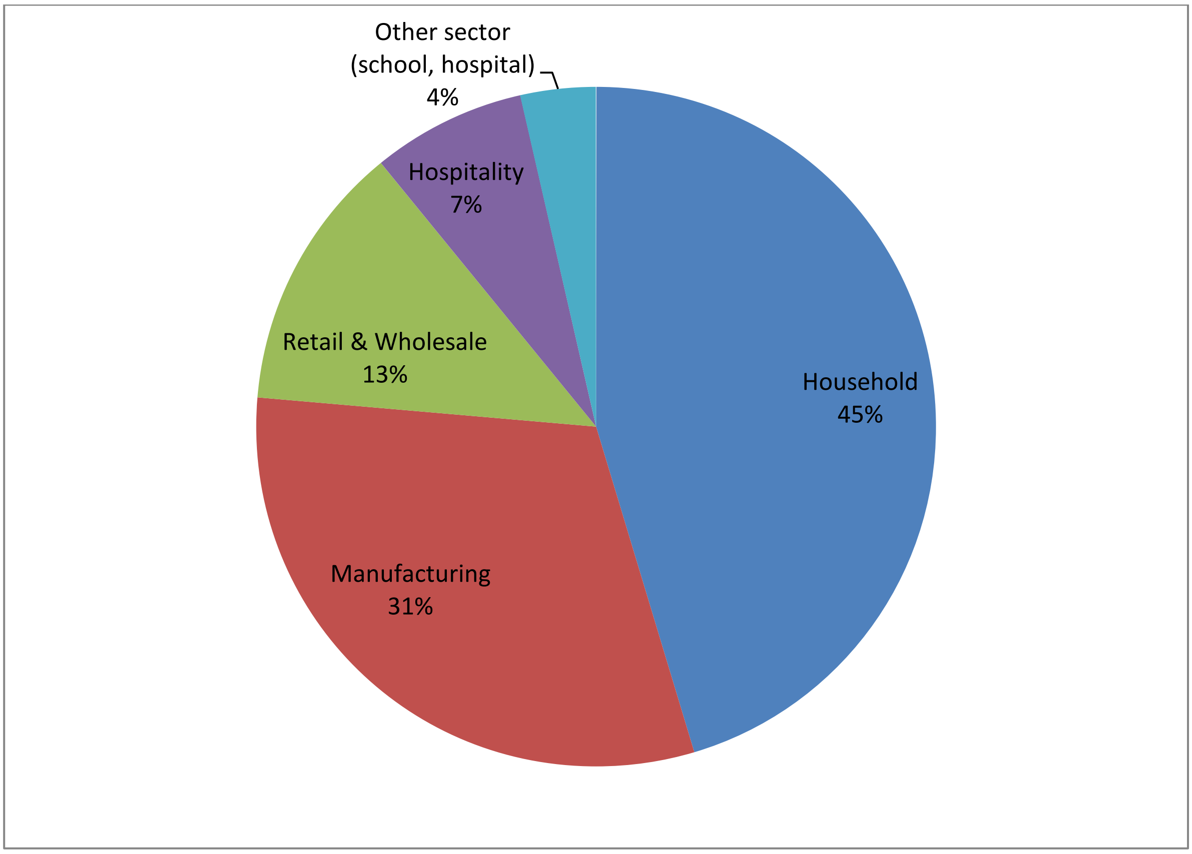

Figure 2: Amount of EF waste arising in the ***two stages of supply chain in the UK FSC.***

Source:-(WRAP(1), n.d.) , (DEFRA, 2015)

As per Figure 2, the largest source of EF waste is generated at the UK consumer level (the end stage of UK FSC), which means the UK household level, where some 4.3 Mt of EF is wasted per year, representing 45% of the total UK EF waste. The UK FMSC (the intermediate stage of UK FSC) contributed the second largest proportion of EF waste in their supply chain and logistics operation, wasting 3.9 Mt, which was 31% of the total UK EF waste generated. Meanwhile, 1.6 Mt (13%) of EF waste was generated by the UK retailers supply chain and wholesalers supply chain, with hospitality (caterers) supply chain and other sectors (schools, hospitals) generating 0.92 Mt (7%) and 0.45 Mt (4%), respectively.

On the other hand, recently, Priestley (2016) and Parry (2016) reported that EF waste at the consumer stage (household EF waste or end stage of UK FSC) had been reduced by an impressive 21% between 2007 and 2013 (despite an increasing number of households in the UK in the same period), saving UK consumers nearly £13 billion over the five-year period. This large reduction of EF waste is enough to fill the whole of Wembley stadium (Parry, 2016). Retailer supply chain, wholesaler supply chain and caterer supply chain are donating their surplus food to charities; this initiative is showing good progress in the reduction of EF waste in their supply chain operations (BRC, 2015).

A total of 31% of EF waste is generated by the FMSC (the intermediate stage of UK FSC); specifically, when it is linked vertically with downstream partners. Indeed, the reduction of EF waste in the FMSC has significant importance because EF has passed through multiple activities such as processing, packaging, storage and distribution. If EF waste is generated at this stage, that means it has wasted value-adding activities, accumulating cost and embedded energy (Mena et al., 2011). It has a highly negative impact on the UK economy because reduction of EF waste could save the UK FMSC £300 million a year (DEFRA, 2015, Whitehead et al., 2013). As per Mena et al. (2011)'s investigation, the UK FMSC produced over a third of all industrial and commercial waste in their supply chain. Food waste generated at this stage is known as 'pre-consumer waste' (Dorward, 2012).

Actually, the FMSC had increased attention on environmental preservation and focused on other types of waste reduction in the supply chain operation, such as packaging waste, energy waste, processing water waste, landfill waste and pollution during transportation and cooking processing, which contribute greatly to Green House Gas (GHG) emissions in the UK environment (Papargyropoulou et al., 2014, Garnett, 2011, FDF, n.d.). Furthermore, the latest report of the Food and Drink Federation (FDF) showed that the FMSC had achieved 20% absolute reduction of GHG emissions in their supply chain operation (FDF, n.d.) through reduction of other types of waste (GHG emission-related waste). Still, there is not any notable achievement in the EF waste reduction in the UK FMSC (Mena et al., 2011, Mena et al., 2014). Therefore, this research is focused only on EF waste reduction at the FMSC stage (the intermediate stage of UK FSC) in the UK; where higher amounts of EF waste were generated between the FMSC and their downstream partners.

2.2 UK food manufacturing supply chain (FMSC)

2.2.1 Definition of FMSC

The FMSC is defined by Dani (2015) as: "it transforms the raw food products supplied by the primary producers into the product that meet consumer requirement", which is called as food processing. FMSC adds incremental value to a raw state of a food product into ready-to-eat meals through processing, therefore the FMSC is also known as the 'value-added FMSC' (Dani, 2015, Stevenson and Pirog, 2013).

2.2.2 Contribution in the UK economy or the values of the UK FMSC

It is traditionally a low margin FMSC industry. UK FMSC is the second largest and fastest growing manufacturing supply chain industry in the UK (Bourlakis and Weightman, 2008). UK FMSC has the fourth largest turnover in the EU. It makes the major contribution to the UK economy. Its net worth is £96 billion. It accounts for 19% of total UK manufacturing supply chain by turnover, Gross Value Added and employment (Rhodes, 2015). It is equivalent to 2.6% of GDP (Ball et al., 2001). It is a highly competitive sector, which has introduced more than 1500 new food products into the market in each quarter (Livesey, 2010). It is a one of UK's biggest exporters. It exports two-thirds of food products to the EU, and £7.5 billion worth of food was exported to non-EU countries in 2016 (Denney, 2016, DEFRA, 2017). There are the more than 8000 FMSC companies in the UK, where 70% of these companies are categorised as a SME (FDF(2), n.d., Denney, 2016). FMSC either prepares food in a ready-to-eat format or creates other food products demanded by consumers, such as pureeing, milling of grain, bakery and confectionery (Dani, 2015). It plays a vital role in the food supply chain, being the vertical integration link between the primary producer and the end stage of the food supply chain.

2.2.3 Classification of UK FMSC

UK FMSC comprises a variety of sectors and processes. UK FMSC is classified by the different types of manufacturing activities, where the activities deal with different types of food products: meat, fish, fruit and vegetables, fats and oils, milk products, grain mill products, animal feeds and other food products (Prosser, 2009). Each group also consists of many sub-divisions as well, which were classified by Prosser (2009). Under the UK's current Standard Industrial Classification (2007), FMSC is classified as follows:

Group 10.1: Processing and preserving of meat and production of meat products.

Group 10.2: Processing and preserving of fish, crustaceans and molluscs.

Group 10.3: Processing and preserving of fruit and vegetables.

Group 10.4: Manufacture of vegetable and animal oils and fats.

Group 10.5: Manufacture of dairy products.

Group 10.6: Manufacture of grain mill products, starches and starch products.

Group 10.7: Manufacture of bakery and farinaceous products.

Group 10.8: Manufacture of other food products.

Group 10.9: Manufacture of prepared animal feeds.

2.2.4 Specifying special characteristics of the FMSC

FMSC has specific inherent characteristics which differ from other supply chains, which make their supply chain even more specific and identify it uniquely. FMSC structure is a fragmented and decentralised structure and more vertically integrated among FMSC members (Bourlakis and Weightman, 2008). van der Vorst (2000), Van der Vorst and Beulens (2002) and Vlajic et al. (2008) have distinguished specific inherent characteristics of FMSC from other supply chain as summarised in the following sub-sections.

2.2.4.1 Product characteristics

van der Vorst (2000), Van der Vorst and Beulens (2002)and Vlajic et al. (2008) have described characteristic of product of FMSC.

- It is a shelf life constraints food product.
- Quality decay of products. It means food item has perfect nutritional quality, but with cosmetic defects.
- There is high requirements regarded product freshness and food safety.
- Increasing product variety, packaging size and receipts (Chabada et al., 2012).
- There is the firm based variability of quality and quantity of food product, such as use different types of quality of raw material.
- Food product is highly depended on seasonality and event based.

2.2.4.2 Demand characteristics

Demand characteristics of FMSC are characterised by van der Vorst (2000) and Vlajic et al. (2008).

- Highly volatile demand characteristic.
- There is the mostly seen as high fluctuations in predictable demand.
- There is the high uncertainty may take the form of high variability in consumer demand due to seasonal patterns, weather condition and changing consumer preferences.
- Fluctuations in information lead time and time needed for order generation.
- Lack of up-to-date of input data, such as stock level data.

2.2.4.3 Process characteristics

Food manufacturing processing was very uniquely described by van der Vorst (2000), Van der Vorst and Beulens (2002)and Vlajic et al. (2008).

- Long production throughput times (longer manufacturing lead time) due to waiting for the results of quality tests, alternative installations, product-dependent cleaning, processing times, chilling and packaging.
- Many products have time consuming process and relatively long cycle time due to fermentation and slow cooking (Darlington et al., 2009).
- High volume production systems and capital-intensive machinery, automated process.
- "Fluctuations in process outcomes and production times mainly due to variable process yield, perishable end products and scrap-rates" (Jongen, 2005, van der Vorst, 2000).
- Necessity of precautions against cross-contamination, e.g. beef cannot be produced with agricultural inputs.
- Production adapted to high volume, low variety (Chabada et al., 2012).
- "There is the basic requirement of traceability work for quality evaluation, and also environmental requirements and product responsibility" such as metal detection and the weight of ingredients must fall within a specified limit (Jongen, 2005, van der Vorst, 2000).
- "Packaging the food item in a protective cover to protect the food item from hazards" (Dani, 2015).

2.2.4.4 Supply characteristics

Supply characteristic was described by van der Vorst (2000), Van der Vorst and Beulens (2002)and Vlajic et al. (2008).

- "Complex networks due to multiple interactions within the network itself and influence of external factors" (Vlajic et al., 2008).

- Specific requirements for logistic processes, such as perishability of products led to a need for air-conditioned transportation and restricted storage time.
- Longer distribution leads times.
- Frequent deliveries.

2.2.4.5 Regulations

Regulation of FMSC mentioned by van der Vorst (2000) and Vlajic et al. (2008).

- "Legislations concerning food production distribution, trade, quality of products" (Vlajic et al., 2008).
- Specific standards and legislation concerning food preservation.

2.2.5 Causes of EF waste at UK FMSC

Determination of causes of EF waste can help to find solutions to reduce it and consequently prioritise initiatives for action. As per previous studies, Parfitt et al. (2010), Kummu et al. (2012) and the High Level Panel of Experts on Food Security and Nutrition (Timmermans et al., 2014), this study has concluded that each stage of FMSC has its own unique causes for generation of EF waste in the supply chain operation. When looking for specific causes of EF waste in a vertically linked FMSC with downstream partners on the basis of the studies by Mena et al. (2011), Buzby and Hyman (2012), Timmermans et al. (2014), Kumar and Nigmatullin (2011) and Derqui et al. (2016), this study has classified causes of EF waste into two categories, as in the following sub-sections.

2.2.5.1 External causes

- Industry trends (Mena et al., 2011, Kumar and Nigmatullin, 2011):- It is a widely responsible for EF waste. Uncertainty in demand, competition changes and product out of season (seasonality) are the industry trend factors that generate EF waste (Mena et al., 2011).

- Natural constraints (Mena et al., 2011, Kumar and Nigmatullin, 2011):- This means causes associated with inherent characteristics of food products such as shelf-life constraints, weather fluctuation, and also related processes such as longer lead times for imported food products (Mena et al., 2011).
- Structure of supply chain (Kumar and Nigmatullin, 2011):- This means causes of EF waste related to 'how different FMSC members are organised or coordinate their activities together along the supply chain (Timmermans et al., 2014). Organisational inefficiencies of supply chain operators, lack of information sharing, difficulties in forecasting, poor ordering, inefficient promotional planning, lack of technology, suboptimal packaging and poor integration are the causes of EF waste, which are mostly related to poorly coordinated activities among the FMSC members (Mena et al., 2011, Kumar and Nigmatullin, 2011, Canali et al., 2014).

2.2.5.2 Internal causes

- Internal management structure (Mena et al., 2011):- Lack of waste management responsibility, highly focused on production output performance measurement, lack of technology, hired temporary labour, poor forecasting and other targeted priorities are the internal management practices associated with causes of EF waste (Mena et al., 2011, Kumar and Nigmatullin, 2011).

However, there is related no evidence to show which causes of EF waste are the most significant in terms of overall volumes of EF waste (Canali et al., 2014).

2.2.6 Justification for importance of reducing EF waste at FMSC

Reducing the EF waste is an important ethical dimension to sustain limited resources such as water and to feed 1 in 6 families in the UK that have gone without food themselves (Priestley, 2016). It is also important for reducing EF waste's negative impacts and costs of the treatment of waste. A report from WRAP is one of the first country-level assessments of EF waste impact, specifically, on the environmental, economic and social perspectives (Venkat, 2011)

2.2.6.1 Economic impacts

EF waste is costing UK food manufacturing around £5.2 billion, which includes the labour cost, energy cost, waste cost, disposal cost, packaging cost, profit loss and other associated costs. If half of EF waste reduces, UK food manufacturing will save more than £80 million of its disposal cost (Whitehead et al., 2013).

2.2.6.2 Environmental impacts

There are not only other types of food manufacturing waste impacts on the environment, but also EF waste is having a damaging effect on the UK environment, such as it being one of the causes responsible for climate change. As per Papargyropoulou et al. (2014)'s analysis, EF affects the environment once it has become waste and second, before it becomes waste. First, once it becomes waste this means it is related to disposal of EF waste in landfill, where it emits carbon dioxide and methane as part of its natural decomposition process. Another environmental impact is from embedded carbon from the previous lifecycle stage of EF before it became waste (Papargyropoulou et al., 2014); it means EF production's associated activities also emit the carbon dioxide, such as processing, storage and refrigeration. There are 25,000 tonnes of CO2 is released from 3.9 million tonnes of EF waste, which is equal to the emission of 1 in 5 cars on UK roads (Whitehead et al., 2013, Papargyropoulou et al., 2014). This study also used the carbon pollution calculator to measure the impact of 25,000 tonnes of CO2 on the UK environment. According to the greenhouse gas equivalencies calculator, 25,000 tonnes of CO2 is equal to the carbon sequestered by 2.5 million trees or carbon emissions by 40,000 cars or 20,000 home energy uses for the year (EPA, 2014) (CI, 2008).

2.2.6.3 Social impact

EF waste has a direct and negative impact on livelihood. UK food manufacturing companies pass their landfill taxes and disposal costs to consumers in higher prices (Venkat, 2011). WRAP has calculated that EF waste costs each UK household nearly £200 per year (Whitehead et al., 2013). Reduction in EF waste can bring down the food price in order to support 2 million malnourished people in the UK who struggle to get enough food (Priestley, 2016).

2.3 Theoretical background

2.3.1 Theoretical paradigms

In general, theory aims to explain certain phenomena. Stock (1997) defined theory as "Systematically organized knowledge applicable in a relatively wide variety of circumstances, especially a system of assumptions, accepted principles and rules of procedure devised to analyse, predict, or otherwise explain the nature or behaviour of a specified set of phenomena".

The aim of the study is to investigate the impact of FMSC collaboration, especially on collaborative effectiveness and EF waste reduction; and also empirically test the effectiveness of collaboration impacts on EF waste. The theme of this research is relatively new and interdisciplinary in the FMSC context.

In past literature on collaboration, there are a number of theories applied to collaboration which have been adopted from different disciplines, e.g., marketing, organization behaviour, because much supply chain research has borrowed theories from other established disciplines (Stock, 1997). There is no consensus on any theory that can completely explain or offer a comprehensive model of collaboration (Piboonrungroj, 2012, Gray and Wood, 1991).

Kembro et al. (2014) and Soosay and Hyland (2015) explored which theories have been used in collaboration. According to their analysis, resource-based view (RBV), transaction cost theory (TCT), relational view (RV), extended resource-based view (ERBV), resource dependency theory (Eisenhardt and Martin) and dynamic capability (DC) view theory are the most widely used in collaborative research. This study excluded RBV, TCT, ERBV and DC theories due to their irrelevance in explaining collaborative effectiveness and collaboration in the FMSC (Waters and Rinsler, 2014). This study uses RV theory to draw the theoretical framework where FMSC collaboration and collaborative effectiveness are the central concepts.

The above excluded theories tend to stem from a one-sided and organization-focused approach, because those theories focused on sustaining competitiveness of individual firms (Soosay and Hyland, 2015). When examined, the past collaborative literature including Cao and Zhang (2012), Piboonrungroj (2012) and Zacharia et al. (2009), focused on mitigating the probability of a firm's opportunistic behaviour (through trust, commitment), and by owning scarce resources and assets (such as incentive alignment, resources sharing) in a unique way to achieve competitive advantage in terms of business synergy, process efficiency, innovation and flexibility, over competing firms. This is because the embeddedness of partnering firms' relational assets and the causal ambiguity are difficult for their competitors to imitate (Cao and Zhang, 2011).

Moreover, Waters and Rinsler (2014) stated that RDT (resource dependence theory) and RV give much attention to external resources and collaboration; where RDT has limitations in explaining supply chain collaboration because RDT focuses on gaining control over vital resources to reduce their dependency and increase another's dependency on them; so, in a such way RDT improves a firm's efficiency and effectiveness rather than collaborative effectiveness (Cao and Zhang, 2012). On the other hand, RV focuses on fair investment of relation-specific assets, and development and governance of routines for collaboration. Furthermore, in RV practice, FMSC members' collaborative process is collective, even though they have their own separate goals, where FMSC members come together in coordinating their activities to solve 'messy problems' which cannot be resolved in any other way (Dyer and Singh, 1998).

This study views from the dyadic collaboration perspective in the FMSC, therefore the RV is best suited for a dyadic relationship and is easy to explain (Dyer and Singh, 1998). Collaboration is meant to achieve mutual benefits and win-win outcomes for all parties. Previous research just focuses on the firm's perspective-related competitiveness, rather than considering matters as a whole or the collaborative firm's perspective advantage (Soosay and Hyland, 2015).

Miguel et al. (2014) test the relationship between the relational resources from the RV and the economic value creation based on a survey with 67 buyers and 99 suppliers in the food and beverage industries. A result was verified that relational resources of RV generated have positive impact on relational rent and the value created by collaborative firms.

Moreover, as per Kembro et al. (2014)'s finding, more than 80 percent of the theoretical perspective units of analysis in collaboration heavily focused on the level of dyadic relationship, specifically, two-echelon downstream collaboration. Daft (2012) has noted that to achieve collaborative effectiveness in more than two-echelon collaboration is not easy because each collaborative member may want different things from their collaborative partners. It is difficult for organisations to simultaneously satisfy the demands of all groups that lead to conflict in a collaborative relationship, and it probably does not meet collaborative effectiveness (Daft, 2012). Therefore, multiple echelon collaboration can be challenging, so this study conducts two-echelon downstream vertical collaboration, which is highly prevalent in previous collaborative literature.

2.3.2 Relational view theory (RV)

Dyer and Singh (1998) to explain relational rent in different echelons of a supply chain network. It is the complement of RBV where critical resources of a firm may span firm boundaries, so firms can earn internal and as well as relational rents (Cao and Zhang, 2011).

Under the RV, collaborative FMSC members allocate more value to each other in terms of providing undistorted information for demand forecast, integrating knowledge, providing skills through joint training programmes and nuanced information about utility functions; these help in enhancing the collaborative FMSC member's ability to deal with unexpected changes in the environment, which can generate the relational rent. A relational rent means “supernormal profit jointly generated in an exchange of relationship that cannot be generated by either firm in isolation and can only be created through the joint contribution of the collaborative partners” (Cao and Zhang, 2012). This is called collaborative effectiveness. The RV emphasizes common benefit or collaborative advantage which can be extracted only from shared resources among the collaborative partners (Lavie, 2006), while RBV focuses on firm competitive advantage (Cao and Zhang, 2012). RBV has been incapable of explaining how firms gain collaborative effectiveness in collaborative relationships with alliance partners (Lavie, 2006).

Under the RV, the joint efforts of FMSC partners are in terms of relation-specific assets, sharing knowledge, combining complementary resources and using effective governance mechanisms to generate collaborative effectiveness (Turkmen, 2013). In the RV, rather than formal contracting efforts, informal contracts between the firms are more effective in generating collaborative effectiveness through self-enforcing mechanisms (Turkmen, 2013). The RV not only concentrates on joint activities between the alliances partners, but also indicates how effectiveness can be generated through the exchange of relationship or through joint activities (Turkmen, 2013). From the RV perspective, a collaborative firm gains a greater level of advantage through a greater level of relational-specific investment with an alliance partner. This is supported by Tanskanen and Aminoff (2015) who say that collaborative firms put effort into the relationship through forms of relation-specific assets; and they also have better access to resources and exchange services on a frequent basis that leads to generating collaborative advantage.

Dyer and Singh (1998) mentioned relation-specific assets, Inter-firm-knowledge sharing routines and complementary resources and capabilities; where collaborative firms combine their operational and logistic activities with each other. Joint demand forecasting, RFID, smart packaging design, knowledge integration and inter-organizational learning through joint training programmes are efficiently coordinated with operational and logistic activities, such as joint planning, and operating and executing supply chain decisions. These help in jointly solving the problem, communicating efficiently and effectively and accumulating specialised information through know-how, which significantly improves a co-operative firm’s performance.

On the basis of descriptive findings, Turkmen (2013) stated that due to inter-firm linkages with local operators, knowledge integration enables firms to operate more effectively. When alliance partners succeed in transferring tacit, sticky and codified knowledge, they are more likely to achieve collaborative effectiveness. Through inter-firm-knowledge sharing routines, Dyer and Singh (1998) mentioned that alliance partners get to know each other well enough to know who knows what and where critical expertise resides within each other. Previous collaborative studies have shown that collaborative effectiveness generated through knowledge sharing and joint training are achieved by lower total value chain costs, greater demand visibility, fewer product defects and faster product development cycles (Turkmen, 2013, Zacharia et al., 2009, Cao and Zhang, 2012, Kohli and Jensen, 2010).

Eikelenboom (2017) specifies the necessity of complementary resource endowments including RFID, packaging and employees' training, which means that the resources of "collaborative partners collectively generate greater rents (both relational and spill-over internal rent) than they would have generated when each FMSC member individually employs its own resources".

However, relational-specific assets facilitate coordinating inter-firm activities, thereby enhancing performance; but this does not come without threats. However, increased transaction costs may risk opportunistic behaviour on the part of their collaborators (Turkmen, 2013, Kude et al., 2008). But, as per the finding of Dyer (1997), "transaction costs do not necessarily increase with an increase in relation-specific investments". Firms should emphasise the value of relational-specific assets instead of transaction costs, which helps to reduce opportunistic behaviour (Kude et al., 2008). Furthermore, if collaborative firms have effective governance mechanisms including longer payback period during which to earn a return on the investments, costs of safeguarding and a greater volume and scope of exchange activities can simultaneously lower transaction costs, thereby reducing opportunistic behaviour and obtaining collaborative effectiveness (Dyer, 1997). As network partners make symmetric investments dedicated to the relationship and maximize the joint transaction through complementary coordinated actions, this has substantial positive impact on partnership performance, and hence reduces opportunism in practice (Gurcaylilar-Yenidogan et al., 2013).

Turkmen (2013) points out that power is also an inherent risk in an exchange relationship. Maloni and Benton (2000) examined different sources of power such as coercive and non-coercive power, and their subsequent effects on inter-firm collaboration. Coercive power may lead to dissension and under-performance (Benton and Maloni, 2005), while non-coercive power may enhance the level of trust and also create a long-term relationship among the supply chain members (Saosaovaphak et al., 2009). Benton and Maloni (2005) advised that power holders must be judicious in their use of their power to reap more benefits (in terms of collaborative effectiveness) of inter-firm collaboration.

2.4 Conceptual model development and Hypothesis Derivation

Many of the previous studies are devoted to conceptualised collaboration in the supply chain (Barratt, 2004, Holweg et al., 2005). However, research in FMSC collaboration has not consistently supported any of the collaborative models; therefore, this may be the reason that clear structure which represents collaboration in FMSC is lacking (Kumar and Nath Banerjee, 2012). Based on a number of theoretical and empirical bases, this study uses a hierarchical construct or multi-dimensional construct model, which allows more theoretical parsimony, provides holistic representations of complex phenomena and reduces model complexity (Edwards, 2001). FMSC collaboration, collaborative effectiveness and EF waste reduction (overproduction, processing and storage of EF waste) are latent constructs which cannot be measured directly. Therefore, the observed variables of each latent construct are built to measure those constructs; and also those observed variables are measured by multiple indicators or items. Here, operationalizing of all the constructs is to further develop scientific knowledge of the phenomenon and promote the successful application of FMSC collaboration in practice (Min and Mentzer, 2004). In particular, FMSC collaboration and collaborative effectiveness have not been directly identified in the supply chain collaborative literature, so this study has adopted many items from general supply chain management literature and FMSC management literature, and modified them after discussion with food industry experts and academic experts to make sure the variables reflect what they are intended to measure to ensure content validity.

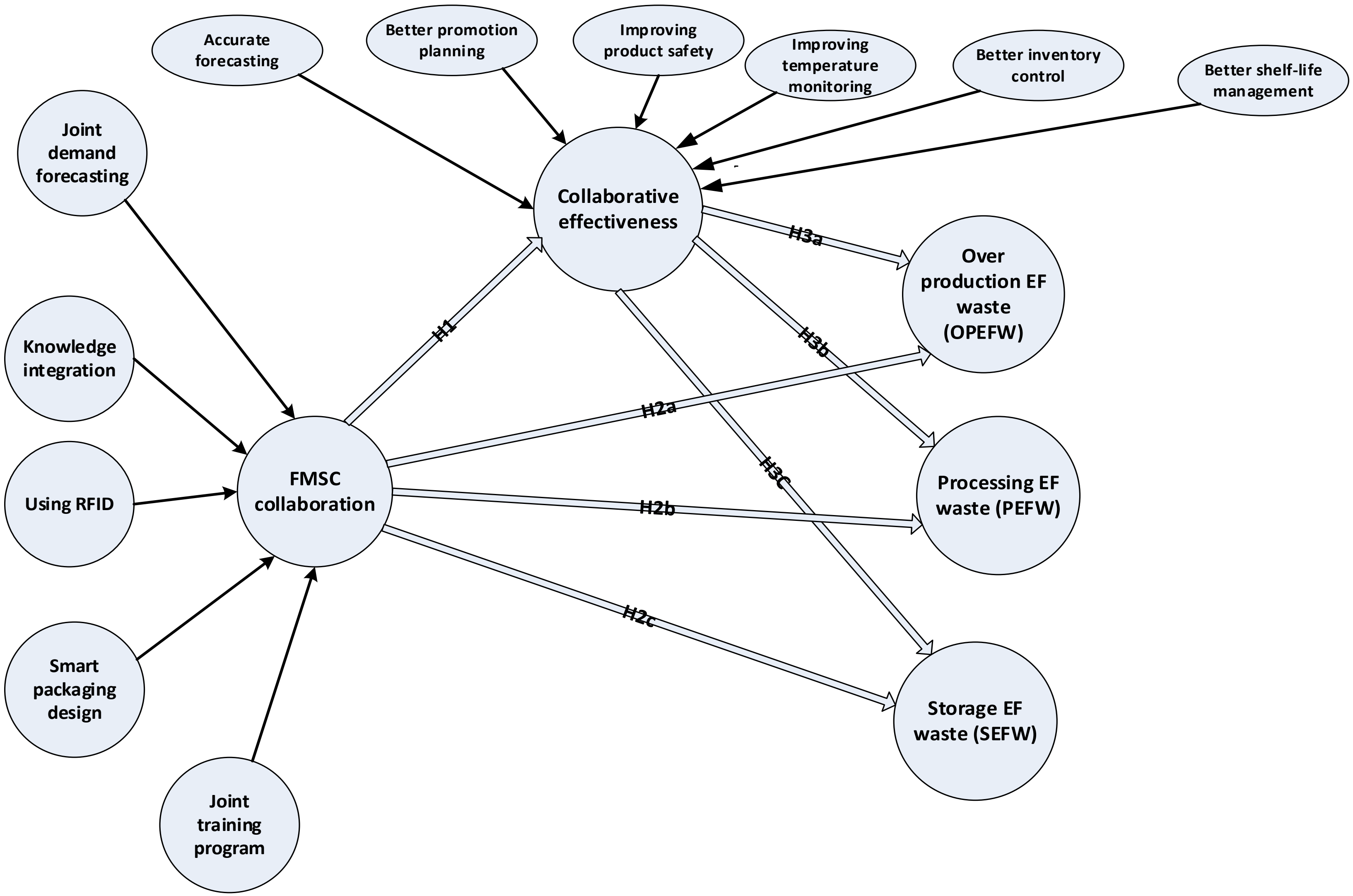

Figure 3: Conceptual Framework

Despite the fact that many efforts had focused on conceptualising the concepts, phenomenon and measurements of FMSC collaboration, no extant measurements exist in the FMSC context. Previous models also considered only FMSC's macro factors, such as focus on buyer and supplier relationship, rather than considering micro factors such as specific inherent characteristics of FMSC (Matopoulos et al., 2007). To conceptualise FMSC collaboration, this study considers past collaborative studies that have provided some theoretical and operational bases, FMSC industry micro factors suggested by Matopoulos et al. (2007), Holweg et al. (2005) and Leeuw and Fransoo (2009), supply chain management literature and FMSC management literature; and has identified five dimensions which explain the latent construct (FMSC collaboration). The five dimensions are joint demand forecasting (Kurtulus et al., 2012, Eksoz et al., 2014, Rajaguru and Matanda, 2013, Singhry et al., 2015), knowledge integration (Haddad and Bozdogan, 2009, Cao and Zhang, 2011, Crook et al., 2008, Teo and Bhattacherjee, 2014), using RFID (Nash, 2010, Angerhofer and Angelides, 2006, Hudnurkar et al., 2014, Lee et al., 2011, Crook et al., 2008, Chen, 2015, Tsai et al., 2010), smart packaging design (Farmer, 2013, Verghese et al., 2013, Mahalik and Nambiar, 2010) and joint training programmes (Shinbaum et al., 2016, Arendt et al., 2011, Jayakumar and Sulthan, 2014, Murphy et al., 2011, Patel et al., 2012, Kim et al., 2013, Kumar and Rahman, 2015). Table 1 shows definitions of sub-components of FMSC collaboration. Here, this study only considers theory, FMSC management literature and supply chain collaboration literature to measure collaborative effectiveness (Cao and Zhang, 2012). It is measured by six items: accurate forecasting (Mena et al., 2011, Mena et al., 2014), better promotional planning (Mena et al., 2011, Mena et al., 2014, Williams et al., 2014.), improving product safety (Mena et al., 2011, Mena et al., 2014, Verghese et al., 2013, WRAP(2), n.d.), improving temperature monitoring (Mena et al., 2011, Mena et al., 2014, George, 2000), better inventory control (Mena et al., 2011, Mena et al., 2014, Verghese et al., 2013), and better shelf-life management (Mena et al., 2011, Betz et al., 2015, Verghese et al., 2013). For EF waste, this study considers previous food waste related literature which measured the several types of FMSC waste. Here, this study thoroughly synthesises prior studies to measure EF waste into three dimensions: processing EF waste (Mena et al., 2014, Darlington et al., 2009, Beretta et al., 2013), over-production of EF waste (Mena et al., 2014, Darlington et al., 2009, Beretta et al., 2013, Chabada et al., 2012), and storage of EF waste (Mena et al., 2011, Mena et al., 2014, Darlington et al., 2009, Parfitt et al., 2010)

Table 1: Constructs Definitions

construct	Definition	References.
Joint demand forecast	"Joint demand forecast means food manufacture and their downstream partners are combining their forecast -related information to form a single, more accurate forecast that has support of the entire FMSC"	Kurtulus et al. (2012), Eksoz et al. (2014)
Using Radio-frequency identification (RFID) technology	"A technology that enables large amounts of information to be stored on chips (tags/transponders) that can be read at a distance by readers, without requiring line of sight scanning".	Nash (2010)
Smart packaging design	"An extra function beyond the traditional function of storing, protecting and information about the food product; where the extra function is the incorporation of mechanical, chemical, electrical and electronic forces or a combination of these, within or on the package".	Farmer (2013), Mahalik and Nambiar (2010)
Joint training programme	"To ensure that all employees (including temporary workers) are adequately trained, instructed and supervised in food safety principles and practices, commensurate with their activities".	Shinbaum et al. (2016).
Knowledge integration	"It is the process of transferring knowledge, both tacit and explicit, across organizational boundaries, sharing it with individuals and teams at the recipient site, and applying the resultant knowledge to solve problems".	Haddad and Bozdogan (2009)
Collaborative effectiveness	"A supernormal profit jointly generated in an exchange relationship that cannot be obtain by either firm in isolation and can only obtain through the joint contribution of the collaborative partners"	Cao and Zhang (2012)
Over-production EF waste	"It can be indicated from planning based on forecasting and production planning based on optimal batch-sizes".	Chabada et al. (2012)
Processing EF waste	"It is generated in the different operational process of the FMSC".	Mena et al. (2014)
Storage EF waste	"The amount of EF product is wasted in the multiple storage point at the food manufacturer, such as EF product is waiting for order to arrive".	Chabada et al. (2012)

2.4.1 Background of the evolution of food manufacturing supply chain collaboration (FMSC collaboration) practices

Barratt (2004) admitted that actually collaboration in FMSC is not new concept and the concept of FMSC collaboration has only really evolved over the past two decades in many different forms. Since the early 1990s, many collaborative-based initiatives and programmes have been developed, such as Vendor-managed Inventory (VMI), and continuous replenishment programmes (CR) (Barratt and Oliveira, 2001). Due to the insufficient visibility of VMI and CR programmes, in the mid-1990s, collaborative planning forecasting and replenishment (CPFR) emerged as the most advanced form of collaboration. Following the emergence of CPFR, it was widely adopted by many companies as a pilot test, such as Wal-Mart, and improved in-stock availability and reduced the lead times were reported (Barratt and Oliveira, 2001).

To the contrary, McCarthy and Golicic (2002) criticized the CPFR process model on the basis of a case study of three companies and stated that several barriers exist to adopting CPFR; their finding revealed that collaborative practice (that developed by the companies themselves) did not require substantial investment in human and technology resources, which the CPFR process model does (Småros, 2007). As per product characteristics, Jain et al. (2008) assumed that CPFR may useful in fashionable product and short product lifecycles, such as the grocery sector. In contrast, a study by Småros (2007) on four collaborative projects in the grocery sector indicated that collaboration on the basis of the CPFR model style is not feasible in the grocery industry. Barratt and Oliveira (2001) reported that the CPFR model is engaging the supplier and retailer into sharing the forecast information, which can substantially reduce inventory, but Danese and Kalchschmidt (2011a) argued that in many cases the CPFR model did not improve forecast accuracy.

On the other hand, instead of CPFR, Demeter et al. (2007) found that focus on collaboration between the supplier and retailer should be more useful for suppliers to get on-time and accurate demand forecasts from retailer that can more efficiently manage the inventory level. Despite successful piloting project of CPFR and consistently updated CPFR guidelines by voluntary inter-industry commerce standards, the adoption rate of CPFR was significantly lower than expected, especially in Europe and the UK (Demeter et al., 2007), due to so many steps to implementation of such a process and that it takes a number of years to improve supply chain performance. Many of the companies that adopted CPFR style collaboration, did not succeed in making the collaboration a successful one (Vanpoucke and Vereecke, n.d.), because the customer's lack of forecasting processes and resources are the most important obstacles, as claimed by Demeter et al. (2007).

2.4.2 FMSC collaboration

In the past decade, collaboration in the FMSC was used as a purely academic or theoretical concept; nowadays, collaboration in the FMSC is becoming a widely adopted practice (Wiengarten et al., 2010). According to Matopoulos et al. (2007), today collaboration among the various stakeholders in the FMSC has become a necessity rather than an option, due to recent major issues of food recalls, food safety and traceability (Dani, 2015). FMSC collaboration is defined as when "two or more independent FMSC companies work jointly to plan and execute FMSC operation towards common goals and mutual benefits" (Aggarwal and Srivastava, 2016, Cao and Zhang, 2011). Matopoulos et al. (2007) add that "FMSC members become involved and actively work together in co-ordinating activities which span the boundaries of their organisation".

Collaboration in general has a rich literature dealing with several different aspects in the supply chain process. However, there seems to be a trend in the collaborative literature that the more recent research on collaboration practice in the supply chain has shown mixed results, as evaluated by Wiengarten et al. (2010). Cao and Zhang (2011) have thoroughly assessed the previous literature, including that of Sanders (2007) and Stank et al. (2001), and found that collaboration directly generates spill-over internal rents. This means collaboration generates private benefits which directly improve the logistical service performance of a firm without focusing on the joint value creation process or relational benefits or common benefits (collaborative effectiveness). Another study, by Vereecke and Muylle (2006), empirically tested the relationship between collaboration and performance improvement and found weak empirical support for a positive relationship between collaboration and logistical performance improvement. Conversely, Seo (2014) and Piboonrungroj (2012) confirmed that collaboration could not directly generate spill-over internal rents without explicitly considering collaborative effectiveness (common benefits), meaning the supply chain operational and logistical performance are not improved by the direct impact of collaboration. They proved this through a survey and interviews with supply chain managers. Moreover, Lavie (2006) mentions that when collaboration is formed, each FMSC company endows the subset of resources - such as forecast information, knowledge, and training - to their collaborative FMSC partners, which leads to gains: first, collaborative effectiveness or common benefits (such as accurate forecasting, reduced uncertainty and improved product safety) through the shared resources of both FMSC firms, and then collaborative effectiveness, which helps to generate spill-over internal rents or private benefits (in terms of reduced spillage, improved forecast planning and improving the employee's skills). Because collaboration is a function of the extract value of all combined and shared resources among the collaborative partners, rather the firms' focuses to fully control the resources of partnering firms to create value (Cao and Zhang, 2011). Supporting this, Ataseven and Nair (2017) have critically examined the empirical findings in various collaboration studies and concluded that collaboration enables FMSC firms to attain relational benefits or collaborative effectiveness through streamlining FMSC processes, and also by coordinating logistical activities with business partners which may indirectly lead to improving organisations' operations efficiencies.

Sheu et al. (2006) suggest that collaboration can deliver some powerful advantages to the FMSC partners, and the collaboration process is worthwhile, with coordination efforts and relation-specific investments which are the realisation of collaborative effectiveness over time (Jap, 1999) and lead to reductions in a firm's logistical related costs, operational flexibility to cope with high demand uncertainties and enhanced profit performance (Sheu et al., 2006). Barratt (2004) has reported that collaboration is a complex structure and difficult for company to implement, conducting and measuring collaborative initiatives. On the other hand, Stank et al. (2001) have mentioned that collaboration is a simple process of decision-making, with joint ownership of decisions and collective responsibility for outcomes between the interdependent firms across many tiers in the FMSC. Moreover, Wiengarten et al. (2010) answered the findings of Barratt (2004) that to simplify the complex nature of the collaboration, researchers have to conceptualise the collaboration as the multidimensional concept, which should be reflected in the measurements items also. However, Wiengarten et al. (2010) page-465) found that many collaborative studies, such as those of Flynn et al. (2010) and Mishra and Shah (2009), have "conceptualised the collaboration as supplier, internal and customer collaboration to where firms collaborate multi-dimensionally". Where, it has been often operationalized and measured differently, such as supplier collaboration, customer collaboration and cross-functional collaboration; which can be make complex structure of collaboration and also may be difficult or costly to implement, as confirmed by Leuschner et al. (2013) through meta-analysis. Mishra and Shah (2009) also investigated supplier collaboration, customer collaboration and cross-functional collaboration considered as individual dimensions and the authors conceptualised each dimension in a multi-dimensional construct to examine their direct relationship with performance effects separately, and surprisingly showed the inconsistent and ambiguous results.

Furthermore, Ali et al. (2016) pointed out that, to ensure the higher integrity or higher traceability of the FMSC, firms require deeper compromise and coordination to meet food integrity through sharing perceptual information, shared goal establishment and communication. On the other hand, Hingley et al. (2006) and Maglaras et al. (2015) examined the buyer-supplier collaboration and relations from a power-dependency or power-imbalanced perspective in the Greek FMSC. They focused on managing financial goal incompatibility, informational asymmetry, negotiation pressures and behavioural uncertainty through a sustainable collaboration relationship. However, Schoenherr and Swink (2012) argued that the above studies focused on the most significant determinants of commercial practices to gain a proportionate share of commercial benefits, rather to focus on collaborative effectiveness and EF waste reduction. Matopoulos et al. (2007) viewed collaboration as a holistic concept, which is going beyond the normal commercial relationship. On the other hand, Rota et al. (2013) and Touboulic and Walker (2014) observed that intangible elements of collaboration, such as information sharing, risk and reward sharing, and leveraging resources, have a great impact in achieving sustainable collaborative relationships among the FMSC members. Under sustainable collaborative relationships, FMSC members cultivate trust and commitment, make a plan jointly to attain each other's long term success and come to a clear understanding of each partner's roles (Kim and Lee, 2010). On the other hand, according to Banchuen et al. (2015) sustainable collaborative relationships within businesses are less concerned with day-to-day operational level interactions. They are more willing to focus on overall cost awareness and market-responsive supply approach to respond quickly to customers' needs and to achieve a high level of market performance that leads to competitive advantage (not collaborative effectiveness). While, on contrary, Holweg et al. (2005) and Mena et al. (2011) argue that perishable EF has a limited shelf-life and high demand variability that needs day-to-day operational conversations.

Today, the FMSC faces vexing challenges in supply chain operational and logistical issues, including poor stock management, poor temperature control management, product damage, lack of traceability, reduced agility, demand uncertainty, shelf-life management and packaging design (Mena et al., 2011). Therefore, FMSC members should be unified or aligned in their supply chain operational and logistical activities with supply chain partners, which will improve the efficiency of the entire FMSC, which leads to maintaining seamless FMSC, as pointed out by Arshinder et al. (2008) and Dani (2015), because working and operating alone is not sufficient to resolve these common issues and achieve the desired goals (Matopoulos et al., 2007). Therefore, Adams et al. (2014) also showed through a survey analysis that to achieve efficiencies and effectiveness in the supply chain, supply chain members should coordinate their supply chain operational and logistic activities with each other. In spite of these major operational and logistical issues, Holweg et al. (2005) said that the majority of scholars have seldom addressed these issues in their FMSC collaborative literature because the previous definition of collaboration put more emphasis on relationships and less on the components of the coordinating supply chain and the logistical process. Therefore, previous scholars paid more attention to developing long-term or sustainable buyer-supplier collaborative relationships in the FMSC to improve FMSC performance, as claimed by Matopoulos et al. (2007) and Cao and Zhang (2011). In addition, on the basis of case study results, Matopoulos et al. (2007), Morita et al. (2015) and Holweg et al. (2005) revealed that FMSC structure, demand characteristics and the nature of the product all impinge greatly on the operational process and logistical activities. While, Wiengarten et al. (2010) stated a vital factor for the success of collaborative practice among the FMSC partners is the coordination of their supply chain operational and logistical activities through exchange of high quality information, RFID and knowledge integration, because coordinating supply chain operational and logistical activities will undoubtedly impact on the outcome of the specific plan, as per Barratt (2004) analysis.

In the case study approach of Ramanathan (2012), she proposed demand factors and attributes of supply chain information to measure FMSC collaboration, which leads to improved forecast accuracy. Vorst et al. (1998) assessed the collaborative supply chain decision process through simulation and a pilot study to eliminate uncertainty in the FMSC. Ma and Lv (2014) described the collaborative service model for improving quality of product, efficiency and customer satisfaction. The collaborative service model is based on a broad view of collaboration in each stage of the FMSC, namely demand collaboration, procurement collaboration, production collaboration, logistical collaboration, R&D collaboration and quality control collaboration. Naspetti et al. (2011) proposed a set of collaborative activities, including information sharing, decision synchronisation, incentive alignment and a collaborative performance system in an organic FMSC. They found that collaborative efforts along the organic FMSC enable a better performance. On the other hand, Nair and Lau (2012) proposed a framework for cold chain collaboration. The proposed collaborative framework among cold chain partners at the post-harvest stage was measured through information sharing, aligned performance measurement and leveraging the skills and resources that lead to an efficient, effective, robust and caring cold chain.

Most of the above FMSC collaborative literature underlying FMSC collaborative constructs has been conceptualised and analysed from different perspectives or issues and it is often limited to entire operational issues and to the logistic-related activities of the collaborative FMSC, as pointed out by Matopoulos et al. (2007) through case study results and Sandberg (2007) on the basis of a survey study with logistics managers. Meanwhile, according to Ramanathan (2014), the objectives of past research into collaboration in FMSCs were improved financial and long-term partnership performance rather than to enhance supply chain operational and logistics-related performance in the FMSC. Therefore, as per Wiengarten et al. (2010), analysis of the existing literature on collaboration is conceptualised and defined in several different multidimensional constructs, such as the buyer-supplier relationship and simply information sharing; but, indeed, those constructs or measurements which reflect the exact nature and attributes of FMSC collaboration, and link it to the alignment of the FMSC supply chain's operational and logistical activities of the collaborative FMSC firms are not well comprehended, as argued by Matopoulos et al. (2007).

Thus, as per the above discussion, given the complexities associated with collaboration in the FMSC and the absence of a commonly utilised measurement scale for FMSC, it becomes critical to measure or define the FMSC collaboration carefully to obtain the most insightful results.

Therefore, by synthesising the previous literature's findings, including Holweg et al. (2005), Banchuen et al. (2015), Mahalik and Nambiar (2010), Singhry et al. (2015) Kumar and Budin (2006), Eksoz et al. (2014), Cao and Zhang (2011), Nash (2010), Kurtulus et al. (2012), Shinbaum et al. (2016), Patel et al. (2012), Verghese et al. (2013) and Teo and Bhattacherjee (2014), this research defines FMSC collaboration as comprising five components: joint demand forecasting, joint training programme, smart packaging, knowledge integration and using RFID. These five components of FMSC collaboration are more efficiently aligned supply chain operational and logistic activities; and that aligned activities help in the planning of day-to-day activities, including developing and sharing forecasts of customer demand, sharing production planning and schedules, solving problems confronted and eliminating potential barriers. This leads to more efficient operation and resource management, and also enhances transparency between the FMSC members (Kim and Lee, 2010). They also add to the value of FMSC collaboration and are more likely to improve their entire operation (supply chain and logistic) to generate collaborative effectiveness, such as improving visibility, safety, accurate forecasting and monitoring (Banchuen et al., 2015, Kanter, 1994).

2.4.2.1 Joint demand forecast

During the past decades, the FMSC has faced inefficiency arising due to demand uncertainty and poor forecasting planning (Kurtulus et al., 2012), leading to a huge amount of EF being sent to landfill (Mena et al., 2014). Demand forecasting is a crucial process for food manufacturing companies for effectively managing their various activities, including production planning, promotion planning, sales budgeting, etc (Danese and Kalchschmidt, 2011b). Joint demand forecast means food manufacture and their downstream partners are combining their forecast - related information to form a single, more accurate forecast that has support of the entire FMSC (Kurtulus et al., 2012, Eksoz et al., 2014). The aim of joint demand forecast is to improve the ability of the FMSC to match demand and supply of product correctly that leads to reducing over-production of EF waste (Mena et al., 2014). Hence, Eksoz et al. (2014)'s study on forecasting in FMSC that mentions that joint demand forecasting between the FMSC partners plays an important role in efficiently managing demand against such shortcomings and product- related ambiguities. The authors further affirmed that if FMSC members shared their own demand information with each other, it would generate consensus and accurate forecasts for the seasonal, promotional and short-shelf life of perishable food products that would help to efficiently manage current inventory status, reduce lead time and cost (Eksoz et al., 2014), and lead to reducing forecasting error related to EF waste.

Many authors have stressed the challenges involved in joint demand forecasting in the FMSC. Some scholars have addressed the unstructured information sharing process between the FMSC partners as one of the major obstacles for poor collaborative forecasts (Chen et al., 2000, Zhu et al., 2011, Eksoz et al., 2014). Other authors have considered the dominance of retailer (Småros, 2007, Aviv, 2007), poor interdepartmental integration of partners (Småros, 2007, Helms et al., 2000), lack of trust and commitment as identified, important barriers in joint demand forecasting (Eksoz et al., 2014). Moreover, manufacturers have focused on its production plan and lead time and retailer have concentrated on safety stock and shelf-availability, inhibiting joint demand forecast (Eksoz et al., 2014, Småros, 2007). On the basis of interviews with FMSC companies, Mena et al. (2014) identified that poor forecasting is one of the most common causes for generating the high level of EF waste in the UK FMSC.

Helms et al. (2000) have argued on the basis of analysed previous studies that joint demand forecasting is one of the best approaches that FMSC members have found to overcome some of the inherent problems with forecasting, and that it breaks down the functional silos, such as lack of trust and commitment, and opens the information flow from both sides to the benefit of the entire FMSC. Furthermore, Aviv (2001) examined the value of joint demand forecasting in a two-echelon FMSC through comparing the joint forecast with the company's individual forecast and concluded that FMSC companies which combined their forecasting process with their supply chain partners toward developing a single shared demand forecast, were more satisfied with the results of joint demand forecasting than their individual forecast; where FMSC companies efficiently manage demand variability and meet service level commitments that lead to improving their forecasting accuracy and also reduce time, cost and slack from both sides of the supply chain (Helms et al., 2000).

Zhu et al. (2011) and Chen et al. (2000) pointed out that the unstructured information sharing process exacerbates inventory in each level of the FMSC, leading to a higher level of over-production of EF waste. Thereby, Eksoz et al. (2014) recognised that, under the joint demand forecasting process, FMSC partners are more willing to share agile and undistorted information (in term of correct, relevant and timely information) to strengthen their information sharing process; that is, they are better able to coordinate inventory level with changing demand (Helms et al., 2000) that could reduce EF waste generated due to demand variance.

In addition, time-sensitive, perishable, seasonal and promotional products need timely forecasts, but weather conditions, unexpected events and diverse product ranges are the main causes of demand variability and obstruct generating on-time and accurate demand forecast in the FMSC (Doukidis et al., 2007, Fang Du et al., 2009, Lowe and Preckel, 2004), and thus generate a higher level of EF waste in the FMSC. Therefore, to judge forecast for the next promotion and the next season, many scholars suggested that FMSC members could use historical information (Helms et al., 2000); also, analysing the point-of-sales data before, during and after promotions (Danese and Kalchschmidt, 2011a) could help in making clear production quantity planning for future promotions and seasonality that would lead to reducing EF waste generated due to planning error and poor forecasting.

Furthermore, some exception identified by Ramanathan (2012) in historical information. On the basis of a case study approach, Ramanathan (2012) clearly stated that historical information can generate reasonably accurate promotional forecasts, if the current promotion mechanism is similar to the previous year's promotion. Jain et al. (2008) stated that not only historical demand information but even other information is necessary to create a more accurate and timely demand forecast to reduce demand variability and forecasting error. Supporting this, Eksoz et al. (2014) contend that a high degree of demand information sharing, such as product-related demand information and a description of each promotional sale could help to reduce variability and related cost. During promotion, cannibalization has a highly negative impact on existing food product sales, which results in higher level of EF waste. Therefore, Ramanathan (2012)'s UK- based case study results revealed that sharing as much demand factor related information (such as pricing, special dates, sales record, weather report, trend, cannibalization, promotional information, product life cycle information) and attributes of information exchange (such as source, availability, reliability) between the FMSC members is more likely to get higher accuracy in demand forecast and reduce demand variability, particularly in the time-sensitive and perishable food product sector; as per Mena et al. (2014), that leads to reducing planning error, forecasting error, poor promotional management and most importantly, cannibalization- related EF waste in the UK FMSC.

RFID systems are also used for communication. Because it provides a unique identification code (an electronic product code) to each food product. RFID systems also help to generate a web database of each food product's nuanced information through capturing data in real time (including product inventory, product history and the movement of products), which is more useful to the collaborative FMSC members to easily generate joint demand forecasts (Bibi et al., 2017). With the instant RFID-enabled information sharing capability, the FMSC members can precisely calculate the amount of on-hand inventory across the FMSC tiers, reduced errors in demand forecasting, improved real-time food product visibility and shortened lead time of product delivery (Wang et al., 2011). In spite of the high demand uncertainty and short product life cycle, the RFID system has the ability to assist FMSC partners in generating a better forecasting result, which leads to a better financial performance and improved operations efficiency (Ren et al., 2017).

2.4.2.2 Using Radio-frequency identification (RFID) technology

RFID is an emerging technology in the FMSC. RFID is defined by Nash (2010) as "a technology that enables large amounts of information to be stored on chips (tags/transponders) that can be read at a distance by readers, without requiring line of sight scanning".

Use of RFID technology by FMSC members has the potential to improve the efficiency and security of the entire FMSC (Lee et al., 2011). Instead of a labour-intensive barcode system, RFID employs an automated scan of the food products to manage out-of stock, restocking and replenishment tasks, and most importantly, improve the ability of FMSC members to track and trace the source of contamination in their FMSC network, which ultimately improves food product safety (Unnevehr, 2000, Lee et al., 2011), which could lead to reducing contaminated and safety-related EF waste. That is authenticated by Zhou (2009) who found that RFID technology provides "an food product's instantaneous status, the processes it has gone through, and its history of movements across transactions". Therefore, availability of timely information across the various stages of the FMSC easily enables FMSC members to rapidly intervene in targeted situations, as per Piramuthu (2005).

The effect of RFID in the presence of inventory record inaccuracies was examined by Heese (2007), who found that RFID solves the inaccuracies in inventory information specifically in the decentralized supply chain; where the FMSC as a decentralized supply chain structure was mentioned by Bourlakis and Weightman (2008). Furthermore, Heese (2007) stated that RFID technology improves coordination between decentralised supply chain members. Zhou (2009) examined the beneficial aspects of RFID in the manufacturing sector and revealed that RFID provides item-level product information rather than categorical-level information, such as a barcode; which improved visibility across and within the company, asnoted by Lee et al. (2011). Therefore, improved visibility enhanced stock- level transparency, order processing and productivity, and cut lead time (Lee et al., 2011, Cachon and Fisher, 2000), that led to reducing EF waste generated due to poor inventory record or stock management (Mena et al., 2014). According to Sahin et al. (2002), RFID continuous monitoring of perishable items throughout the FMSC process gives complete visibility of the remaining shelf-life of food products and the location of the oldest stock, which could help to reduce expiry date related EF waste in the FMSC, as claimed by Grunow and Piramuthu (2013).

Despite the potential value of advanced RFID technology in FMSC management, still FMSC members (food manufacturers and their downstream supply chain partners, such as retailer) have not always adopted the technology as expected (Lee et al., 2011). There are two main barriers for using RFID technology in the FMSC: first, lack of operating standards, and second, investment cost of an RFID system (Narsing, 2011). Due to the higher cost of applicability of RFID, critics claimed that "envisaged scenarios are based on optimistic assumption and the vision are likely not to be realised", as mentioned in Kärkkäinen (2003) study.

On the other hand, Whang (2010) raised a very interesting point for using item-level RFID tags that can be faced by food manufacturing companies, namely the "one-sided 'free-rider' problem, where the downstream would wait to free-ride on the up-stream's first move", which means an item-level RFID tag attached by a food manufacturer which may be reused by the retailer at zero variable cost. Kärkkäinen (2003) suggested RFIDs applied at the unit level, such as on cartons (holds many items) , not on individual packaging or pallet (holds many cartons) , can significantly reduce the capital investment for FMSC members as compared to an RFID tag at item-level. On the contrary, Grunow and Piramuthu (2013) focused on adopting item-level RFID and stated that it incurs related fixed and variable costs, such as cost of RFID tags and associated systems; where fixed cost occurs at one time and variable cost decreases over time because an RFID tag will last for a long time, typically for 10 years, and even work in under extreme environmental conditions (Vlachos, 2014).

Moreover, Kärkkäinen (2003) has discussed a real trial case of RFID adoption at a UK- based multi-national food supplier and its retailer companies: where plastic transportation crates are equipped with an RFID system which is distributed from the food manufacturer's production site to the retailer's warehouse. Through the RFID trial, the company achieved faster and better control of stock rotation policy (easily managing first-in, first-out), maintained food quality and temperature, reduced spoilage of EF in the supply chain and significantly reduced operational cost, by nearly

21%. Therefore, Kärkkäinen (2003), Sahin et al. (2002) and Zhou (2009) have contended against critics that using the RFID system in short-life products would provide quick payback of capital investment by FMSC members and provide significant benefits, including higher information accuracy, better knowledge of out-of-stock situations, reduction of inventory, more efficient control of the supply chain, better management of returns and better management of product recalls. Watson et al. (2015) compared RFID with green and sustainable technology which efficiently help in reduction of EF waste and additionally, improve sales, reduce costs, and thereby increase profits for shareholders. Therefore, FMSC members, rather than focus on the challenges, should look at RFID's value-added benefits as more profitable for the entire FMSC (Nash, 2010).

2.4.2.3 Smart packaging design

Packaging plays an important role in food preservation in the FMSC. Smart packaging is defined by Verghese et al. (2013) "to protect the food product; provide information about food product usage, health and safety; enable the convenient transportation; support efficient handling of the food product throughout FMSC operation". While Farmer (2013) defined packaging as providing "an extra function beyond the traditional function of storing, protecting and information about the food product; where the extra function is the incorporation of mechanical, chemical, electrical and electronic forces or a combination of these, within or on the package". As per Farmer (2013), there are the many terms in use for smart packaging, such as 'active', 'controlled', 'intelligent', 'diagnostic', 'functional', 'communicative', and 'enhanced'. On the other hand, Vanderroost et al. (2014) has defined smart packaging in a very simple way as "the innovations in food packaging aim at improving, combining, or extending the four basic functions of traditional food packaging".

Smart packaging design accounts for only 10% of total energy and ensures that the other 90% is being not wasted (minimize the packaging material waste) (Verghese et al., 2013). In fact, Conte et al. (2015) pointed that traditional food packaging design is focused only on environmental assessment related criteria such as materials and their recyclability, but does not consider the impacts caused by EF waste. Traditional packaging of food is highly vulnerable to microbiological contamination and cross-contamination (Verghese et al., 2013). Molina-Besch (2016) argued that packaging design should not only be held responsible for environment -related problems, but it is also highly accountable for food product waste rates and logistical efficiency; therefore, FMSC members should require the assessment of packaging design (Molina-Besch, 2016). Thus, packaging design should balance between the environmental impact of the packaging itself, and the packaging's ability to reduce waste of the packaged product, as suggested by Conte et al. (2015).

Further, Molina-Besch (2016) reviewed food life cycle assessment on the basis of smart packaging perspectives and mentioned that smart packaging can prolong the shelf-life of food; provide heavy interaction between the user and product; low resources needed for transportation, handling and storage; and generate a low amount of litter, that would lead to reduce significantly the amount EF waste . Conte et al. (2015) stated that shelf-life extension of food products plays a very important role in reduction of EF waste in the FMSC.

An interesting finding by Williams and Wikström (2011) was that if packaging design addressed all the fundamental functions efficiently, including protection, convenience and communication , it can reduce food waste. Consequently, Smart packaging design is providing more than those basic functions (such as extra functions) that help to reduce the large amount of EF waste in food distribution centres (O'Callaghan and Kerry, 2016, Williams and Wikström, 2011, Farmer, 2013). The main benefit of Smart packaging design is facilitate visual communication function of the packaging system (means to know about food quality, temperature indicator, food safety, best before date) so that appropriate actions may be taken to achieve desired results in food quality and safety enhancement; monitoring and improving distribution and storage condition (Yam and Lee, 2012).

Active packaging and intelligent packaging are two of the food packaging innovations activities of Smart packaging design (O'Callaghan and Kerry, 2016, Verghese et al., 2013), that protect the EF from a series of causes of damage. Active packaging means "packaging in which subsidiary constituents have been deliberately included in or on either the packaging material or the package headspace to enhance the performance of the package system" (Dobrucka and Cierpiszewski, 2014). Intelligent packaging means "packaging that contains an external or internal indicator to provide information about aspects of the history of the package and/or the quality of the food" (Dobrucka and Cierpiszewski, 2014).

Active packaging controls the surrounding environments of a product through certain additives into the packaging film or within the packaging containers to extend the shelf life, and also improve food safety during the period of time the food spends in the supply chain, which leads to significantly reduce EF waste (Verghese et al., 2013, Dobrucka and Cierpiszewski, 2014). Modified atmosphere packaging, oxygen scavengers, moisture absorbers, anti-microbial and ethylene scavenging are types of active packaging which help to delay product degradation from humidity, temperature, CO2 and O2 concentration (Verghese et al., 2013).

An intelligent packaging system monitors a food product as it moves through the supply chain and also the environment in which it is kept (Dobrucka and Cierpiszewski, 2014, Watson et al., 2015); data is recorded and sent back to manufacturers on quality, safety, shelf-life and logistic efficiency related information (Verghese et al., 2013, Watson et al., 2015). Thermal sensor, time-temperature indicators, physical shock indicators and leakage and microbial spoilage indicating are types of intelligent packaging system. Through intelligent packaging, a food manufacturing company easily matches the remaining shelf-life of each food product with the remaining transport duration options during stock rotation, which leads to reducing EF waste related to poor shelf-life management (Jedermann et al., 2014).

The use of modern smart packaging greatly contributes to improvements in the sensory characteristics of food products and may ensure their microbiological safety, which helps to reduce food waste and also enables longer transportation and storage times (Wyrwa and Barska, 2017). However, Wyrwa and Barska (2017) note that the smart packaging design increases the risk of the emergence of smart packaging-related hazards. For this reason, smart packaging is not without its disadvantages, among which one should mention especially higher costs of use than the traditional packaging.

Smart packaging design - such as liquid absorbers packaging design, relative humidity regulators packaging design and moisture scavengers packaging design made from excessive migration of chemicals (including carbon dioxide, sulphur dioxide, silica gel, zeolites, cellulose fibres, or sodium chloride) and it might release certain substances which can affect the composition of food, such as those chemical compounds which may help to extend the shelf life of food, but adversely it may change the food colour and organoleptic characteristics of food. Chemical compounds also have a strong characteristic smell which may have a negative impact on the customer. Moreover, on some occasions, in the event of damage to smart packaging, harmful chemical compound reactions may occur. Moreover, Dainelli et al. (2008) have raised specific safety issues. In the oxygen scavengers, sachets are used for food preservation technology. Sachets have the risk of being accidentally ingested by consumers.

RFID technology is also used in intelligent packaging systems. An RFID sensor tag (components of the RFID technology) is one of the major technologies in the field of identification which can be used in the smart packaging design. RFID sensor tags are very new technology to provide a better detection of food degradation markers in the smart packaging design (Bibi et al., 2017) and easier product identification compared to others, such as barcodes. The RFID sensor tag enables smart packaging to monitor different aspects of food quality; for example, milk freshness, bacterial growth and fish spoilage (Bibi et al., 2017).

2.4.2.4 Joint training programme

Badea et al. (2015) have suggested on their finding that joint, essential staff training process in collaborative FMSC is most crucially profitable for FMSC members in terms of enhancing the effectiveness of action teams in FMSC, helps in achieving collaborative goals and also helps in improving the entire FMSC efficiency. Joint training is needed in order to improve employees' proficiency and their competencies to meet the different risk factors that can harm the entire process of the FMSC (Badea et al., 2015). Based on a US Food and Drug Administration report, Shinbaum et al. (2016) noted that due to ineffective employee training, such as employees improperly handling food, more than one third of all food is wasted in the FMSC. Training is defined by Shinbaum et al. (2016) in the context of the FMSC "to ensure that all employees (including temporary workers) are adequately trained, instructed and supervised in food safety principles and practices, commensurate with their activities". The authors further mentioned that training needs to be documented and its effectiveness should be evaluated time to time. However, Shinbaum et al. (2016) stated that joint training programmes in a collaborative FMSC gives experience and enhances the existing skills of employees to do something in the correct procedure, rather than just giving information about what their jobs entail.

As per the meat industry guide on wrapping, packaging and transport hygiene (MIG, 2015), during the distribution of EF, there is a higher chance of exposure to microbiological and physical hazards because employee have followed poor food handling operational procedure, such as inappropriate wrapping, poor cleaning or maintenance of transport vehicles and unlined cardboard cartons; therefore, a joint training programme is needed to prevent or minimise the risk of all such hazards causing a higher level of EF waste (Mena et al., 2014). Furthermore, supported this, Shinbaum et al. (2016) and Rowell et al. (2013) point out that joint training programs should be based on food safety or food management related training and Hazard Control Analysis Critical Control Point (HACCP) principles; the programmes should be highly committed to by collaborative members, and delivered in the best way that employees learn all their job responsibilities that make up an integrated food safety system, including maintaining EF within required temperatures; protecting the EF product from spillage, damage, contamination and microbial growth; and regularly checking the quality and function of packaging areas, vehicles and equipment.

Joint training programmes are supported by Zutshi and Sohal (2004), who suggested that a company should conduct robust training programmes with their supply chain partners with the aim of increasing awareness and understanding of environmental issues among employees whose individual actions have direct and/or potential impact on the environment, such as food being wasted in distribution due to not following the correct procedure: employees do not follow the correct inventory policy (first-in, first-out in storage), do not maintain cold chain integrity, and use incorrect labels. Because of these causes, a third of EF was recalled between 1999 and 2003, as claimed by Shinbaum et al. (2016). However, Rowell et al. (2013) point out that only achieving food safety training certification by employees is not sufficient to increase food safety knowledge and practices among employees. On the contrary, on the basis of survey analysis, Park et al. (2010) concluded that continuous and repetitive joint training programmes would be effective even in improving food safety knowledge among all levels of employees. Moreover, this exercise should enable collaborative FMSC members to improve their logistical operations and procedures; encounter potential challenges; and comply with continuous improvement in the entire FMSC (Park et al., 2010).

However, the training methods have some drawbacks. Most training tends to focus more on theoretical than practical activities. Some training has rare implementation of the training content by trainees in their job activities roles (Chatzoglou and Diamantidis, 2014). Often employees feel that training is “time consuming”, “not beneficial”, and “boring” (Soares et al., 2013, Lee and Sozen, 2016). Joint training programmes have a “lack of flexibility, lack of ease to permit learners to delve into additional information on a chosen topic, trainer controlled sessions, and only offering one learning level”, as stated by Lee and Sozen (2016) page-53) on the basis of interviews with workers. Sometimes employees are not interested in being trained because they are likely to be moving to another job or the reverse, trained employees move to another company, therefore an American author and motivational speaker, Zig Ziglar, once said “the only thing worse than training employees and losing them is to not train them and keep them” (Shinbaum et al., 2016 page-15). Training modules are only delivered in English and many of the FMSC’s employees have a limited advanced English proficiency (Lee and Sozen, 2016).

2.4.2.5 Knowledge integration

Prior literature has recognised that knowledge integration is a major source of innovation and new product development (Olander et al., 2010, Cao and Zhang, 2011) in the FMSC. FMSC members are increasingly leveraging unique knowledge in order to improve the efficiency of the FMSC, which a firm could not achieve/realise alone. As per Haddad and Bozdogan (2009) study on knowledge integration on operational perspectives, knowledge integration “is the process of transferring knowledge, both tacit and explicit, across organizational boundaries, sharing it with individuals and teams at the recipient site, and applying the resultant knowledge to solve problems”.

Due to the complexities of FMSC structure and potential mismatch of management styles, FMSC members may be incapable of co-ordinating knowledge transfer across individual firms (Jayaram and Pathak, 2013). Thus, collaborative FMSC companies have to take responsibility for integrating substantial resources to overcome mismatched management styles and build knowledge architectures (Mishra and Shah, 2009). Further, Jayaram and Pathak (2013) have proposed knowledge sharing and enrichment are the mechanisms of knowledge integration for a collaborative FMSC network. In addition, knowledge integration with either upstream FMSC partners or a downstream FMSC partner has been shown to be a source of collaborative advantage (Koufteros et al., 2005). Other studies have also reported the positive impact of collaborative knowledge integration with downstream supply chain partners on product variety management and process effectiveness (Forza and Salvador, 2008, Swink, 1999).

In the survey-based study, Jayaram and Pathak (2013) show knowledge integration in terms of sharing tangible forms of knowledge between collaborative FMSC members is easy to document and integrate. Moreover, sharing tangible knowledge means sharing of detailed design blueprints, such as demand data and training routines, this could reduce uncertainties and improve food manufacturer performance. Meanwhile, Teo (2012) found on the basis of a survey study that three factors, namely characteristics of knowledge, willingness to share knowledge and trust between partners, influence knowledge integration in a collaborative FMSC network. Wherein, trust is a highly important factor when uncertainty is involved in the non-collaborative relationship and trust acts as a mechanism to reduce such uncertainty in non-collaborative relationships among the FMSC partners (Teo, 2012). In willingness to share all knowledge, collaborative FMSC partners easily transferred all tacit and explicit knowledge through contacts between people at different levels in the vertical collaborative organization. But, according to Teo (2012), findings suggested that knowledge transfer can be impeded if transfer knowledge cannot be in a codified form. In contrast, due to the higher maintenance cost of codified knowledge, collaborative partners can show less willingness to transfer the knowledge (Yang and Farn, 2009). Therefore, research on 41 companies by Hansen (2002) and their results suggested that established vertical collaborative relationships among FMSC members and also more relatedness in knowledge content (such as expertise or specialized skills and knowledge, which is useful for tasks performed) can mitigate problems of transferring non-codified knowledge.

Knowledge integration is one way that increases communication and cooperation among FMSC members; and so FMSC members are more willing to transfer more knowledge and coordinate more shared activities (Crook et al., 2008, Cao and Zhang, 2012). That helps in achieving collaborative effectiveness and can lead to decreased costs through reduced inventory and shorter order times in the FMSC (Crook et al., 2008). Many authors have suggested that collaborative FMSC members generate new and relevant knowledge (knowledge exploration) through assimilation of existing knowledge (knowledge exploitation) to find the best way to reduce EF waste in their FMSC operation (Cao and Zhang, 2012, Harland et al., 2004).

On the other hand, as a critical view, Hirunyawipada et al. (2010) contended against the above creation and dissemination of knowledge integration and represented their view that this type of knowledge integration is tantamount to providing limited insight. The authors further mention that collaborative FMSC members form the team involving multiple forms of functional expertise with the aim of knowledge transformation, rather than focusing on knowledge creation. An individual expert's tacit knowledge including the person's lifetime of experience, practice, perception and learning can be transformed into a group's tacit knowledge to generate collective knowledge, known as a group's "know how": this is the knowledge transformation process (Hirunyawipada et al., 2010).

Collective knowledge can be applied to solve unexpected problems (e.g. weather uncertainty), conflicts (e.g. quality) and disagreements (e.g. demand forecast) among the collaborative FMSC members (Kumar et al., 2017). Using this collective knowledge or group "know how", Eriksson et al. (2012) mentions that collaborative FMSC members can easily understand the reality in which specific stages and locations the EF waste occurs and find out why it occurs. Collective knowledge or group "know how" also helps to identify where and how EF waste reduction measures should be applied in the FMSC network (Eriksson et al., 2012).

A joint training programme is the best way to obtain and create new knowledge because new knowledge is not only created within the FMSC firm, but can also be obtained from collaborative FMSC members. The joint training programme is an effective learning technique to enhance organisational and employee productivity because "learning itself is a process of integrating knowledge, absorbing new knowledge, capturing and internalising new knowledge, combining new knowledge with original knowledge" (Zhao et al., 2014 ,Page-567). Therefore, collaborative FMSC members can achieve knowledge transfer and knowledge acquisition through joint training programmes, and that knowledge integration become valuable assets (relational specific assets) through joint training programme (Zhao et al., 2014). Furthermore, a joint training programme systematically helps employees to obtain abilities (including knowledge, skills and other abilities) to apply into daily work to improve their productivity and efficiency and generate collaborative effectiveness that leads to improved organisational performance. Therefore, FMSC members should carry out activities of knowledge integration through a joint training programme so that the acquired knowledge generates common benefits or collaborative benefits (Zhao et al., 2014).

Therefore, this research expects that there will be a positive relationship between FMSC collaboration and collaborative effectiveness; and also a positive relationship between FMSC collaboration and EF waste reduction (over-production of EF waste, processing of EF waste and storage of EF waste). So, this study proposes the following hypotheses:

H1: FMSC collaboration is positively associated with collaborative effectiveness.

H2a: FMSC collaboration is positively associated with over-production EF waste reduction.

H2b: FMSC collaboration is positively associated with processing EF waste reduction.

H2c: FMSC collaboration is positively associated with storage EF waste reduction.

2.4.3 Collaborative effectiveness

FMSC collaboration is embedded in a paradigm of collaborative effectiveness rather than competitive advantage (Cao and Zhang, 2012). A firm gains competitive advantage through performing strategically better than its competitors (Gimenez and Ventura, 2003). In support of this, Ferratt et al. (1996) stated that the benefit obtained by a group of firms is as the result of their cooperation rather than their competition. Moreover, as per Dyer (2000)'s study, it is a crucial fact that past collaborative studies has focused only on firm profit and performance, particularly competitive advantage, and have overlooked collaborative effectiveness. Further, that author stated that when a firm collaborates with other firms, the firm should not only pay attention to its own advantage but it must be willing to harmonise with the collaborating firm to seek collaborative advantage (collaborative effectiveness), e.g. Toyota company and its supplier generated collaborative advantage through the set of collaborative processes, such as knowledge sharing (Dyer, 2000).

Collaborative effectiveness means "a supernormal profit jointly generated in an exchange relationship that cannot be obtain by either firm in isolation and can only obtain through the joint contribution of the collaborative partners" (Cao and Zhang, 2012). According to Huxham (1996), it characterised as a firm's positive form of working in close-connection with their partners for mutual benefits. And, according to Chang et al. (2016), collaborative effectiveness is the integrated activities and processes between the FMSC members which can effectively address the changing needs of their partners.

Collaboration in the agricultural-FMSC by Rota et al. (2012) focused on a sustainable relationship as the effectiveness of a collaborative relationship, measured by trust, commitment and satisfaction. However, there has not been empirically measured collaborative effectiveness in the context of FMSC's operational and logistic activities. Supporting this, Cao and Zhang (2012) have confirmed that collaborative effectiveness in the previous collaborative studies has been measured as strategic benefits, such as for newer products, newer markets, firm profitability and competitive advantage. None of the previous studies have considered collaborative effectiveness as joint value creation, but they considered it as mere exchange (Cao and Zhang, 2012).

This study measures collaborative effectiveness with the following six items: accurate forecasting (Mena et al., 2011, Mena et al., 2014), better promotional planning (Mena et al., 2011, Mena et al., 2014, Williams et al., 2014.), improving product safety (Mena et al., 2011, Mena et al., 2014, Verghese et al., 2013, WRAP(2), n.d.), improving temperature monitoring (Mena et al., 2011, Mena et al., 2014, George, 2000), better inventory control (Mena et al., 2011, Mena et al., 2014, Verghese et al., 2013), and better shelf-life management (Mena et al., 2011, Betz et al., 2015, Verghese et al., 2013).

Accurate forecasting refers to the firm and its collaborative partners generating the correct demand for the product through undistorted and agile information sharing (Eksoz et al., 2014). Joint demand forecasting and RFID also help to improve demand visibility that leads to creating an accurate and timely forecast for short-life products; therefore it may lead to excellent stock management and reduce overproduction, and also storage-related EF waste.

Better promotional planning, during a promotion, a substitute product sale may also be affected, which generated EF can waste. Collaborative FMSC members should plan well in advance through sharing all promotional related information, and also tacit and explicit knowledge integration (Mena et al., 2011); that will help in reduction of EF waste generated due to promotions.

Improving product safety refers to safe storage, safe handling procedures, preventing cross-contamination, and less food damage and spoilage during logistical activities. By means of training, this will improve the knowledge of food safety practice among employees. Antioxidant and antibacterial additives on packaging materials also play a key role in maintaining product safety. Trained employees would follow food safety principles and practices, and also commensurate with their activity this is highly likely to reduce EF waste generated due to spillage and damage.

Improving temperature monitoring refers to recoding the food temperature at regular intervals. By means of an intelligent indicator, indicator colour changes when food temperature is altered. Temperature abuse is the most common cause of generating EF waste due to lack of monitoring and lack of knowledge to maintain product temperature at an optimum level (Mena et al., 2011). Therefore, trained employees regularly log the product temperature during transportation and storage, which also leads to reduce EF waste generated during distribution.

Better inventory control refers to improving stock rotation and efficiently managing the inventory according to demand variability through joint demand forecasting, which is highly decreases stochastic inventory errors and that lead to storage-related EF waste.

Better shelf-life management refers to maximizing the shelf-life of the food product. Smart packaging can protect the food from damage, help in extended the shelf-life of food through slowing down the oxidation of food products, which helps in reduction of EF waste generated due to short shelf-life.

Therefore, based on the literature review, this study expects that collaborative effectiveness is positively associated with proposed EF waste reduction (over-production of EF waste, processing of EF waste and storage of EF waste), so the following hypothesis are proposed:

H3a: collaborative effectiveness is positively associated with over-production EF waste reduction.

H3b: collaborative effectiveness is positively associated with processing EF waste reduction.

H3c: collaborative effectiveness is positively associated with storage EF waste reduction.

2.4.4 EF waste

Actually, there is no consistency in measuring EF waste in previous literature. Therefore, in this study, EF waste is measured on the basis of where it can be found in the FMSC. As per various authors' studies – Chabada et al. (2012), Kummu et al. (2012), Gustavsson et al. (2011) and Darlington et al. (2009) – on EF waste in the FMSC, this study has synthesized previous studies of EF waste, and in that way, EF waste is measured on three dimensions: over-production of EF waste, processing of EF waste and storage of EF waste. Instead of using only one construct of EF waste, here, there are the three different endogenous variables used for precisely measuring each dimension of EF waste.

2.4.4.1 Over-production EF waste

It is an unsustainable practice. (Chabada et al., 2012) defined as "it can be indicated from planning based on forecasting and production planning based on optimal batch-sizes". It constitutes higher cost to food manufacturing companies as raw materials, ingredients, water, labour and energy are wasted given that the prepared food no longer has an end customer and is scrapped as commercial waste and diverted to land fill (Darlington et al., 2009).

2.4.4.2 Processing EF waste

This means EF waste is generated in the different operational process of the FMSC. It is also known as 'process control waste' (Mena et al., 2014). There are a number of different sources responsible for processing EF waste. Poor housekeeping procedures, process inherent losses and poor conformity are the major sources for processing EF waste. Cross-contamination of food product due to operator neglect, inappropriate handling of product during distribution processes causing spillage and forming equipment making improper seals on packs which damages the food product, are responsible for this type of waste (Darlington et al., 2009, Mena et al., 2014). Imperfect processes and ingredient under-yield may cause processing food waste. Poor conformity of a food product, such as quality or flavour, is also a source for generating processing food waste (Darlington et al., 2009). Sometimes, EF may be recalled from the market due to wrong labelling, wrong ingredient and nutritional data information, wrong price and promotional sticker; these types of wrong operational process lead to a high level of wasted EF.

2.4.4.3 Storage EF waste

This means "the amount of EF product is wasted in the multiple storage point at the food manufacturer, such as EF product is waiting for order to arrive" (Chabada et al., 2012). It is also called 'inventory waste' (Chabada et al., 2012). Food manufacturing companies keep an excessive safety inventory to fulfil the uncertain customer demand to avoid shorting their customer when possible (Chabada et al., 2012). The excessive safety inventory generates a huge amount of EF waste in the food manufacturing companies (Mena et al., 2014). There are many reasons for storage EF waste. Sometimes EF is not sold within the deadline determined by safety regulation. Often, an existing product is not sold due to a new product being introduced or an alternative product being promoted, such as cannibalization (Mena et al., 2011). Occasionally, EF may deteriorate due to poor temperature control during storage and also contamination in storage, such as chemicals, pests, insects, rodents or microbes (Parfitt et al., 2010).

2.5 Level of FMSC collaboration

Barratt (2004) classified supply chain collaboration into two taxa: first, vertical collaboration and second, horizontal collaboration.

Vertical collaboration means collaboration typically between firms and their upstream or downstream supply chain members (Barratt, 2004). Vertical collaboration can take the form of upstream collaboration and downstream collaboration. Upstream collaboration (backward integration) means a "company [is] working with upstream company in order to ensure the sufficient inputs and material for internal production" (Piboonrungroj, 2012). Downstream collaboration (forward integration) is where there are collaborative activities with the downstream supply chain partners, which include collaborative demand replenishment, collaborative forecasting and shared distribution (Barratt, 2004). Horizontal collaboration means collaboration between the firms at the same level as the supply chain member (Piboonrungroj and Disney, 2015), which includes collaboration with competitors, internally and with non-competitors (Barratt, 2004).

This study has adopted Barratt (2004)'s classification because this study focuses on the dyadic relationship in vertical downstream collaboration between the food manufacturer and its downstream partners (retailer)

On the basis of interviews with FMSC professionals in the UK, Mena et al. (2011) revealed that a high amount of EF is wasted between the food manufacturer and the retailer interface (downstream relationship). Previous studies such as Eksoz et al. (2014), Nair and Lau (2012) and Matopoulos et al. (2007) have focused on collaboration in a two-echelon relationship between the food manufacturer and retailer. In a vertical collaboration, production, processing, and distribution of a food product is appropriately interrelated to the next, so that decisions about what to produce, and how much, are communicated with downstream FMSC partners (webref, n.d.). The structure of the FMSC is really complex and has numerous interactions, because a food product is quite extended, including several entities. The more entities there are participating in a collaboration, the more this becomes problematic, which causes a deterioration in the collaborative relationships among the FMSC members (Matopoulos et al., 2007). Downstream collaboration is very closely linked to end consumers and diligently communicates consumers' demands with partners (Pimentel Claro and Oliveira Claro, 2010). A dyadic relationship can easily make adaptations in day-to-day management. Therefore, this study presents a theoretical framework within the dyadic configuration and it is easier for the researcher to analyse formally.

2.6 Globalisation and FMSC collaboration

Nowadays, growing global FMSC operations help to drive costs down substantially, but on the other hand globalisation make the collaboration more vulnerable to numerous new risks and the magnitude and scope are larger than ever before (Zeng and Yen, 2017). In fact, those risks are not just limited to FMSC operations, but have already extended to relationship-related aspects between FMSC partners (Zeng and Yen, 2017). As per Kummu et al. (2012) analysis on food waste and food loss globally, this study assumes that the collaborative effectiveness may not be feasible in other regions of world, such as low-income countries, where mostly food is lost at the prime agricultural stage due to limited infrastructure availability (Bond et al., 2013). Moreover, the achievement of EF waste reduction is further complicated by economics, distance, environment and culture (Kummu et al., 2012). For example, in economic terms, low-income countries cannot afford the advance technology expenses (using RFID). Probably, the leading FMSC companies in other regions of world could initiate collaborative risk management with their key partners to reduce local risks. Hence, this study suggests that future scientific research should examine the impact of globalisation and its limitations towards collaborative effectiveness to reduce EF waste.

2.7 Brexit and FMSC collaboration

This study is the first to discuss Brexit. According to a Food and Drink Federation report on UK food and drink export statistics in 2016, UK FMSC exported £9.9 billion of food product to European Union (EU) and the tonnage was approximately 7.3M, equating to roughly 1,100 vehicles per day (Pendrous, 2017, FDF(1), 2017).

However, one and a half years after the referendum, there is still a big dilemma about the Brexit deal. The European Union will not let the UK 'cherry pick' a Brexit trade deal, as stated by MORRIS (2018). If the UK and the European Union are both going to agree on hard Brexit or no trade deal, the FMSC will be the worst hit of all supply chains, which means several disruptions between the UK FMSC and their EU supply chain partners because half a million food container vehicles cross the channel via Dover every year. If border controls and tariffs are introduced between the UK and European Union, trade could be gridlocked.

In the hard Brexit or no trade deal scenario, there is a higher chance of food container vehicles being held at Dover for any length of time as part of increased border inspection (Pendrous, 2017). Delays could be made much worse, including reduced shelf-life for food, increased stocks and cost, and the risk of unreliability (Pendrous, 2017). All of these can severely disrupt the FMSC operational and logistical activities and increase EF waste. There might be possibility that UK FMSC companies may open their production or manufacturing unit in any country of the European Union and then adopt the collaborative measures of this study to coordinate supply chain operational and logistical activities with their EU supply chain partners to reduce EF waste.

2.8 Summary:

This chapter provided a clear picture of EF waste and the UK FMSC. This chapter discussed the background and various definitions of the UK FMSC; and also illustrated the UK food manufacturing contribution to the UK economic value, and their characteristics as well. Here, types of food waste, causes of EF waste and their environmental, economic and social impacts were described as well. This chapter has laid out the understanding of the main subject of this thesis. This chapter has discussed the RV theory and proposed a conceptual model. This chapter also addressed the research gaps in the literature and provided advanced knowledge of FMSC collaboration and collaborative effectiveness. This chapter also explained the understanding of FMSC collaboration and collaborative effectiveness; and outcomes of FMSC collaboration and collaborative effectiveness, which resulted in the development of research hypothesis.

3 CHPATER 3: RESEARCH METHODOLOGY

This chapter presents the development of the research design and justification for the selection of the research methods used in this thesis. Here, we also justify the reasons for not using other alternative methods. Since the aim of this study is to examine causal relationships between the latent variables, the methodology adopted in this study is chiefly quantitative, particularly based on structural equation modelling (SEM) namely Partial Least Squares (PLS-SEM). PLS-SEM is regarded as the only tool to examine those relationships simultaneously. The chapter starts with a research design process, research philosophy, and research approach and strategies. Here, the Churchill Jr (1979) nine-step questionnaire guideline process is used for the formation of the questionnaire instruments. This chapter also introduces unit of analysis, sampling design and sampling population. Next this chapter explains the concepts of validity and reliability in detail. Finally, the data analysis techniques of this thesis, limitation of the research methodology and ethical consideration are described.

3.1 Research design

Research design is the most crucial part of any research study and it is always based on the research question (Blumberg et al., 2014). Saunders et al. (2012) defined that research design is the overall research strategy of the researcher in answering the research questions. Moreover, Bless et al. (2006) mentioned that it is a “specification of the most adequate operations to be performed in order to test specific hypotheses under given conditions”. Research design is a blueprint for research that deals with what type of data are relevant, what data to collect, and what kind of sampling and technique will be used to collect and analyse data (Yin, 2013). It is extremely important that the researcher selects the appropriate research design for their study. Furthermore, authors De Vaus and de Vaus (2001) and Leedy and Ormrod (2010) , have reported that ambiguous research design will not address the research problems adequately, one result of the study is the risk of being weak and unconvincing and, finally, overall research validity will be undermined. Furthermore, Halldórsson and Arlbjørn (2005) and Saunders et al. (2012) consider that the researcher must focus on showing a consistency between the research question and the chosen research design. Therefore, to select the research design in this study, researcher addressed all the relevant factors and, also took guidance from logistical research journals (Sachan and Datta, 2005), (Garver and Mentzer, 1999), (Mentzer and Flint, 1997); research methodological books and most importantly, sought supervisors' advice to develop an appropriate research design to obtain, unambiguously, the answers to research questions.

3.1.1 Research design process approach

Saunders et al. (2012) developed the research process onion to formulate effective research design. In other words, this study defined the research onion as the "overall configuration of pieces of research" (Frankel et al., 2005). Saunders et al. (2012) have systematically categorized the research onion that helps the researcher in building, revising and choreographing the overall research study (Frankel et al., 2005) This provides more detailed information about each stage of the research design process. In this study, the researcher peels off, step-by-step, each layer of the research onion to develop appropriate and coherent research design. Research philosophy is concerned with the "study of study" (Maylor and Blackmon, 2005), and the research approach is a choice between testing and building theory. Research strategy is a general plan for answering the research questions, such as survey and case study. Data collection is about choosing a method of data collection.

3.2 Research philosophy

Research philosophy is the vital part of the research design process because of the fact that research strategy, methodological choice, data collection technique and data analysis procedure rest on the foundation of ontological and epistemological assumptions (Neuman, 2014) (Saunders et al., 2012). According to Saunders et al. (2012), research philosophy means "a system of belief and assumptions about the development of knowledge". Furthermore, Kuhn (1970) mentions that the researcher can view the world differently on the basis of their perception, belief, assumption, and nature of reality and truth. Thus, the researcher may design their research differently. Based on a concept of paradigm, Lincoln et al. (2011) classified research philosophy into four different types of philosophies: Positivism, Interpretivism, Realism and Critical theory; which referred to as "lenses through which we view the world" by Frankel et al. (2005). However, each one of these research philosophies is characterized by three axiomatic components: ontological, epistemological and methodological. Ontological is concerned about the "nature of the reality", epistemology deals with the "relationship between the researcher and research", and methodological deals with "how we gain knowledge about the world" (Guba, 1990). A summary of the characteristics of research philosophies can be found in the table 2 below

Table 2: Types of Research philosophy,

Orientation	Positivism	Realism	Critical theory	Interpretive
Ontology	One true reality. It can be obtained through testing. Theories about actual objects, processes and structure in real world. Truth-seeking paradigm.	Reality but only imperfectly and probabilistically able to be apprehended..	Historical realism. Social reality is historically constituted; human beings, organizations, and societies are not confined to existing in a particular state.	Socially constructed through culture and language. The social world is produced and reinforced by humans through their action and interaction.
Epistemology	Objectivist. Finding true. Observable and measurable facts. Verification of hypothesis through rigorous empirical testing. Search for universal laws of principles. Causal explanation, prediction and control.	Knowledge historically situated and transient. Facts are social constructions. Researcher is as objective as possible.	Transactional. Subjectivist. Value mediated findings. Knowledge is justified by a critical evaluation of social system.	Transactional. Subjectivist. Understanding of social world from participants' perspective; through interpretation of their meanings and actions. The researcher's prior assumption, belief and interest always intervene to shape their investigation. (Piboonrungroj, 2012)
Methodology	Typically hypothetical deductive. Verification of hypothesis. Typically quantitative method of analysis.	Falsification of hypothesis. May include qualitative methods.	Dialogic. Critical ethnography. Case study, action research.	Mixed/multiple methods.

***Source:-** (Lincoln et al., 2011), (Piboonrungroj, 2012), (Saunders et al., 2012)*

3.2.1 Research philosophical stance of this thesis

Conducting research on reducing EF waste through collaboration means as per Kumar et al. (2017) joint collaborative activities or joint comprehensive planning between the FMSC members to reduce EF waste, rather than ask to evaluate the collaborative relationship among the supply chain partners or to explore the root causes of EF waste throughout the FMSC. That means the data are specifically based on collaborative activities (mainly, operational and logistic related activities) of the FMSC members, which are less concerned with human feelings, behaviours and actions, and the researcher has become a sort of spectator of the object of the enquiry (Partington, 2002). In addition, EF waste reduction is measured by three types: processing waste, overproduction waste and storage waste, which are all observable, visible and precisely measurable. Based on the above facts, 'Epistemological Positivism' is employed as a philosophical stance for this research as the researcher believes that world and knowledge are observable, measurable and tested empirically, which lead to produce credible and meaningful data (Saunders et al., 2012). Moreover, it will allow us to look for a causal relationship between the FMSC collaboration and EF waste reduction in our data and also help to test our hypothesis. It is also expected that the finding of the study could be made into a generalized law and could be applied externally or more broadly outside the context of the study (Saunders et al., 2012).

3.3 Research approach

A research approach means a relationship between the research and theory. In other words, either a theory guide research or theory is an outcome of research (Bryman and Bell, 2011). However, in the design of the research, theory may or may not be made explicit. Despite this fact, the results and conclusion will usually be made explicit (Saunders et al., 2012). Kovács and Spens (2005) classified three different types of research approaches in supply chain research, namely, deductive, inductive and abductive approaches. Despite this, apparently, research in the supply chain has a predominant emphasis on deductive-positivism approaches (Kovács and Spens, 2005). The deductive approach refers to "derive the conclusion through set of proposition, the conclusion being true when all the propositions are true" (Saunders et al., 2012). Conversely, in inductive reasoning, “propositions are used to generate untested conclusions”. It starts from specific observations to broader generalizations and theories (Saunders et al., 2012). The abductive approach starts from rule to result to case (Kovács and Spens, 2005). It begins from data collection to explore a phenomenon, identify themes and patterns, discover in a conceptual framework and test this through subsequent data collection (Saunders et al., 2012).

The present study is based on a “top-down” deductive approach. The researcher studies what others have done in terms of EF waste reduction and FMSC collaboration. On that basis, this study moves from general premises, meaning “collaboration is associated EF waste” to the specifically deduced conclusion meaning “reduce EF waste through FMSC collaboration”. Here, research begins with building a conceptual framework of FMSC collaboration and EF waste reduction on the basis of existing literature reviews. Then, the researcher deduces the hypothesis from the conceptual framework and tests this hypothesis through collecting the appropriate data. Finally, on the basis of the collected data, the researcher measures the causal relationship between the FMSC collaboration, collaborative effectiveness and EF waste reduction.

3.4 Choice of research methodology

To select appropriate research methodology it is crucial for any researcher to know what type of research strategy and procedure will be used for collecting, organizing and analysing data.

Research methodology is defined as “the theory of how research should be undertaken, including the theoretical and philosophical assumption upon which research is based and the implications of these methods adopted” (Saunders et al., 2012). It is concerned with the “study of how to study” (Maylor and Blackmon, 2005). There are two types of research methodology: quantitative and qualitative. Quantitative methodology is an objective and scientific research style, which puts more emphasis on quantification of the data collection and the analysis of causal relationships between the variables, and that is based on the principles of positivism (Frankel et al., 2005). However, this approach is inflexible and somewhat artificial and it is weak for understanding any process (Easterby-Smith et al., 2012). On the other hand, qualitative methodology has its strength; it has the ability to observe changes that occur during the research process, understand people’s meaning and adjust the new ideas and issues that emerge. Nevertheless, in quantitative methodology, new knowledge can be added to the existing knowledge and the false hypotheses eliminated (Frankel et al., 2005). However, many scholars have criticized the qualitative approach and have mentioned that qualitative methodology is unscientific, focuses only on the exploratory, is full of bias or too personal (Frankel et al., 2005, Denzin and Lincoln, 1994). Furthermore, the qualitative methodology approach is typically given low credibility (Frankel et al., 2005), and this argument is supported by Brink (1993) finding that the researcher's interpretive approach may cloud the interpretation of the data, and where the results of the study are viewed with scepticism by the scientific community. Many traditionalists have seen the qualitative researcher as "a person who assembles image into montages" (Denzin and Lincoln, 1994).

Furthermore, Yin (2013) specially recommended that the qualitative case study method is an ideal method when a) "how" or "why" format research questions are being posed, b) "investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Wedawatta et al., 2011). This type of interpretivism study needs a qualitative case study to uncover subtle distinctions and provide a richness of understanding the phenomenon (Frankel et al., 2005).

The selection of an appropriate research methodology in supply chain management is influenced by many factors (Frankel et al., 2005). Here, the researcher identified some of the factors on the basis of Frankel et al. (2005) study to choose specific research methodology for this research. In this study, the format of the research question is "what" and the researcher's philosophical stance is positivism. Therefore, based upon these, this study has posited "quantitative methodology" as a research methodology, (Saunders et al., 2012), (Näslund, 2002) . The UK FMSC is the second largest supply chain in the country, which means it looks at quite a large size of population for data collection. Therefore, quantitative methodology easily covers a wide range of the population in a quick, economic and more efficient way from the larger supply chain of the UK (Näslund, 2002, Onwuegbuzie et al., 2009). Moreover, this study is conceptual and theory-oriented from the onset, where key variables are identified through the literature review and focuses on precisely measuring the causal relationship between FMSC collaboration and EF waste variables. Onwuegbuzie et al. (2009) called this type of study a variable-oriented study which is more apt for quantitative research in general and quantitative analysis in particular.

Another reason to select quantitative methodology is based on Sachan and Datta (2005) finding. Further, the authors have examined 442 supply chain operational and logistic research papers and found that economic performance of related supply chain research is highly influenced by positivism methods (quantitative), while psychological and sociological related supply chain research is suited to interpretive methods (qualitative). This study is focused on reducing EF waste in the FMSC, which means reduction of EF waste indirectly can maximize company's profit and minimize costs; that, in turn, means this study indirectly falls in the economic performance related supply chain research.

3.5 Research strategy:

The author Jenny (2014) precisely defines research strategy in "5 Phases of an effective marketing research process"; it means "a step-by-step plan of action that gives direction to organize research systematically and on schedule to produce quality results and detailed reporting". It is the link between the choice of methodology and philosophy to collect and analyse data (Saunders et al., 2012). However, Neuman (2014) points out that research strategy is only an approximation of knowledge, each strategy provides a different glimpse of reality, and all have their own weakness. Saunders et al. (2012) have mentioned a number of research strategies; some of these strategies are principally related to quantitative methodology, some are linked with qualitative methodology and some are connected with mixed methods. On the contrary, De Vaus and de Vaus (2001) stated that any research strategy does not imply any particular form of research methodology, for example, the case study method with certain types of methodology. However, the choice of research strategy is guided by the research question, philosophy, approach and methodology. Moreover, pragmatic concerns are also important in selecting a specific research strategy for study, such as the extent of existing knowledge, amount of time and access to potential respondents (Saunders et al., 2012).

3.5.1 The current trend of research strategy in the supply chain operation and logistic research:-

In recent decades, various research strategies have been used for supply chain operation and logistic research (Kovács and Spens, 2005). There are several discussions from many scholars (Sachan and Datta, 2005, Näslund, 2002, Kovács and Spens, 2005, Mentzer and Kahn, 1995, Carter et al., 2014) on the use of different research strategies in supply chain operation and logistic research.

As per table 3, the majority of supply chain operation and logistic research has adopted a detached, objective and external perspective related research strategy; here, surveys are the most popular emerging strategy. In contrast, subjective and cognitive perspective related research strategies are used by a small number of scholars in their research, such as case study, and observation (Frankel et al., 2005).

Table 3: Types of Research Strategies used in supply chain operational and logistic research

Types of research strategies.	Carter et al. (2014)	Chicksand et al. (2012)	Giunipero et al. (2008)	Burgess et al. (2006)	Frankel et al. (2005)	Sachan and Datta (2005)	Näslund (2002)
Unit in percentage.							
Survey.	43	36.3	61	23	55	34.3	54.3
Interview.	2				9	6.8	13.8
Simulation.	0	3.3	9	6		5	14.9
Archival studies/ secondary data.	10	1.7	NA	NA	NA	20.8	9.6
Mathematical modelling.	NA	2.8	NA	7	NA	10.4	4.3
Case study.	12	34.6	11	31	10	16.1	3.2
Literature review with meta-analysis	6	2.4	3	NA	14	NA	NA
Laboratory study.	5	NA	NA	NA	NA	NA	NA
Conceptual model.	22	12.7	9	39	NA	6.3	NA

3.5.2 Research strategy of this study

There are two ways to collect data: first, the mono-method research strategy and second, multi-method research strategies (Saunders et al., 2012). Mono-method means use of single data collection strategy; either survey or case study; while multi-method means to use more than one type of quantitative or qualitative data collection strategies, such as survey and an experiment (Saunders et al., 2012). According to Boyer and Swink (2008), multi-method approaches are specifically required when research has the "subjective aim to explore and understand particular phenomena". In addition, Choi et al. (2016) gave four plausible criticisms for multi-method strategy: 1) it is difficult to use multi-method strategies with equal weight and competence; 2) multi-method strategies are time consuming and expensive; 3) many times, they create bias in people's minds, such as the original work is poor because the research cannot be done rigorously using a mono-method strategy; 4) Paradigm shift. Furthermore, Frankel et al. (2005) have argued that the multi-method research strategy may cloud the information, and generate more complexity to understand, and sometimes researchers face difficulty in interpreting research findings. Historically, the majority of supply chain researchers have employed a mono-method strategy to address specific research problems (Choi et al., 2016). This study uses "survey" as a mono-method research strategy.

3.5.2.1 Survey as a main research strategy or Rational of survey

A survey means a collection of data by asking questions from a sizeable population. A survey method is performed through questionnaire and interviews (Saunders et al., 2012, Bryman and Bell, 2011). The "positivism" supply chain operation and logistic research is highly influenced by survey research strategy (Sachan and Datta, 2005). More than half of the supply chain operation and logistic research have used a survey research strategy (Sachan and Datta, 2005, Carter et al., 2014, Mentzer and Kahn, 1995). Interviews with a number of respondents in a survey strategy is considered as a case study by Frankel et al. (2005). A number of supply chain collaborative studies (Humphreys et al., 2001, Fawcett et al., 2012, Naesens et al., 2007) used an interview strategy as a data collection process because those studies aim to explore how they perceive their collaborative relationship with their supply chain partners. According to Forza (2002), "when knowledge of the phenomenon has been developed in the theoretical form using well-defined concepts, models and propositions", in that case, the survey is the most appropriate strategy.

To collect standardized data from the larger UK FMSC at a greater accuracy, faster response times and in a highly economical manner; the self-completion questionnaire survey is an appropriate method for the current study. Moreover, the purpose of the self-completion survey in this research is to elicit specific information on a causal relationship between the FMSC collaboration and EF waste reduction and to test the proposed model of these relationships (Saunders et al., 2012). This can be obtained through people's opinions of objective reality, rather than seeing people's reactions to a particular situation or condition. Here, the self-completion questionnaire survey allows the researcher to generalize information legitimately from a few people to many more (Neuman, 2014).

There is also some pragmatic reason for the use of an email-based online survey questionnaire in this study. As stated by Wagner and Kemmerling (2010), supply chain operational and logisticmanagement are very fragmented and have several locations within the firms. Therefore, an email-based survey questionnaire is convenient to gather data within the short period of time and at reasonable cost from many locations of a food manufacturing company. Secondly, the target respondent is the upper managerial and executive level of a food manufacturing company. For that reason, an email-based online survey questionnaire is the only way to approach them directly (without any barrier) in their work place.

3.5.2.2 Critiques on survey strategy

The survey is the most common strategy in the supply chain research, but simultaneously, much of the controversy surrounds the surveys strategy as well (Boyer and Swink, 2008), such as perception measurement, low response rate and bias from single source of data (Boyer and Verma, 2000, Boyer and Swink, 2008, Näslund, 2002). However, these limitations are overcome by employing proper statistical techniques, sampling techniques or independent variable tests to mitigate them (Boyer and Swink, 2008). Additionally, Frohlich (2002) has suggested various techniques to deal with the low response rate and address potential bias in survey research strategy. Most importantly, to enhance participation and minimise social desirability bias, Kaufmann and Astou Saw (2014) affirmed that Internet-based survey administration is the best transparent data collection process because in survey administration the “respondents do not need to disclose their information and can submit their responses anonymously”.

3.5.3 Remarks:

As per Wagner and Kemmerling (2010) analysis, researchers in the field of supply chain operational and logisticmanagement have widely adopted the survey-based methodology; approximately 54% of supply chain operational and logisticpublished articles relied on quantitative-survey methodology (Sachan and Datta, 2005, Mentzer and Kahn, 1995). While Kovács and Spens (2005) noted that the deductive-positivism research approach seems to be predominant (majority of 50%) in logistics and supply chain research (Wagner and Kemmerling, 2010). Many researchers encouraged the logistics and supply chain scholars to expand their methodological approach towards inductive or abductive and qualitative methods (Wagner and Kemmerling, 2010, Kovács and Spens, 2005, Näslund, 2002).

Despite the increasing critique on the limitations of the deductive-positivistic approach and survey-based methodology, there are several reasons given by Wagner and Kemmerling (2010) for a deductive-positivistic approach and survey-based methodology highly prevails in supply chain operational and logisticresearch. For this research, there are two main reasons for adopting a deductive-positivistic approach and survey-based methodology. First, a deductive-positivistic approach “simplifies the operationalization of complex constructs, and allows for the identification of causal links between the constructs of interest” (causal link between the FMSC collaboration, collaborative effectiveness and EF waste reduction) (Wagner and Kemmerling, 2010). Second, as per Wagner and Kemmerling (2010), “if a researcher is using a methodology which is not widely used within a particular academic discipline”, such as many supply chain collaborative studies that used survey-based methodology (Cao and Zhang, 2011, Jayaram and Pathak, 2013, Mishra and Shah, 2009). Therefore, here, the researcher used survey-based methodology to avoid misunderstanding and subsequently under-valuing the present research (Wagner and Kemmerling, 2010).

3.6 Questionnaire design and scale development

The questionnaire is a technique for collection of primary data. It is the most important part of the survey process to design an effective questionnaire that motivates the respondents to provide complete and accurate answers. Ambiguous design of a questionnaire will influence the reliability and validity of the data, and also affect the response rate. Therefore, a well-designed questionnaire is the crucial part of research design to achieve the research objectives (Rowley, 2014, Oppenheim, 2000, Saunders et al., 2012).

Designing a questionnaire is more an art than a science and it is quite a challenging task (Churchill, 2009). Many authors (McDaniel and Gates, 1991, Baines and Chansarkar, 2002, Churchill Jr, 1979) have published a questionnaire design process to develop compatible questionnaires. To do so, this study has adopted a nine steps procedure suggested by Churchill Jr (1979) to draw up a well-constructed questionnaire survey because Churchill Jr (1979) guidelines provide "a rigorous and concise sequential procedure for the formation of the questionnaire instrument".

3.6.1 Step -1 Information sought

The research hypothesis of this study determines what type of information is needed to elaborate the relationship between the FMSC collaboration, collaborative effectiveness and EF waste reduction. According to Churchill Jr (1979) and Hinkin et al. (1997) suggestion, the procedure for developing a better deductive measurement scale and domain of the constructs should be operationalized (defined) in this stage. This study extensively conducted a relevant literature review for developing the initial list of construct and variables. Following this, the questionnaire was designed on the basis of three main domain constructs; FMSC collaboration, collaborative effectiveness and EF waste reduction. Additionally, the questionnaire has a demographic measurement scale related to the respondents and food manufacturing companies.

3.6.2 Step-2 Types of questionnaire and method of administration

As mentioned in the survey strategy, the type of questionnaire is a self-completed questionnaire in order to ensure that every respondent will ask questions with the same content and order. Most of the questions have predefined answers so respondents will quickly complete the survey.

In its method of administration, this study has considered the several factors suggested by Synodinos (2003) to choose the most appropriate method of delivering the questionnaire. Self-completion questionnaires are distributed through three types of administration methods: internet, postal, and delivery and collection (Saunders et al., 2012). As Sachan and Datta (2005) reviewed, the majority of supply chain operation and logistic research use self-completion and web-based questionnaire surveys. This study selects an email-based online questionnaire as an administration method, which is the most applicable method to collect data from a large sized geographic area, because the FMSC is the second largest supply chain in the UK. An email-based questionnaire is delivered through "Qualtrics" software. Bryman and Bell (2011) pointed out that email-based online questionnaires have achieved high response rates, were of lower cost, and had fewer unanswered questions and a faster response as compared with other administrative methods. Postal administration is too expensive, while, in delivery and collection administration, it is quite difficult to get direct access at the food manufacturing sites. Email-based online questionnaires can be accessed through any internet-based device, such as desktop, laptop and mobile, at any time. In this way, respondents can complete the questionnaire in their own time. Most importantly, through an email-based online survey, researchers can track who has responded, who has not yet responded, and who has opted out.

3.6.3 Step-3 Individual question generation and content (item generation)

In this study, item generations are based on a theoretical foundation and literature reviews, which were discussed in an earlier chapter. The measurement items were cover the content domain of a construct (Cao and Zhang, 2011). To develop a parsimonious scale, this study was rigorously extracted the items for each dimension from the existing literature. However, collaboration and collaborative effectiveness have been measured by large number of items. But, this study was selected the items most relevant to FMSC and the research context. According to Churchill (2009), here, researcher checked whether any sensitive question was asked of the respondent. The following table 4 presents all the measurement scales for construct in this study.

Table 4: Measurement scales

Construct and variables	Measurements items	References
FMSC collaboration: -		
Joint demand forecasting (JDF)	Our FMSC partners can forecast and plan collaboratively with us through the integrated information system. We can depend on our supply chain partners to provide us with a good market forecast and planning information. We plan volume demands for the coming seasons together with our FMSC partners.	(Kurtulus et al., 2012). (Singhry et al., 2015), (Rajaguru and Matanda, 2013)
Knowledge integration (KI)	We and our partners provide resources to each other to explore new ideas and innovations. Whenever we and our partners get new ideas, we communicate with each other straight away. We and our partners have regular meetings to encourage knowledge dissemination. We and our partners combine our expertise to jointly solve task-related challenges.	(Hudnurkar et al., 2014), (Cao and Zhang, 2011), (Crook et al., 2008). (Teo and Bhattacherjee, 2014).
Smart packaging design (SPD)	Use a range of packaging indicators, such as thermal sensor, intelligent (smart) tag, and microchip; to provide the information about the condition of packed food. We and our partners serve smaller packing of food products.	(Verghese et al., 2013), (Mahalik and Nambiar, 2010)

	Use the Active Packaging system, such as modified atmosphere packaging, oxygen scavengers, moisture absorbers, aseptic packaging, and carbon dioxide production; to slow down the oxidation of certain food components. Well-designed packaging provides better protection to the food product as it moves through the supply chain, such as during distribution or transit.	
Using RFID (radio frequency identification) technology. (RFID)	We and our partners currently use RFID technology for on-time replenishment. We and our partners are currently using an RFID system for tracking the food product throughout the FMSC. We and our partners are currently using RFID technology for improving cost efficiency, e.g. through improved asset visibility which reduces stock loss. We and our partners are using RFID technology for supply chain operations integration.	(Angerhofer and Angelides, 2006), (Hudnurkar et al., 2014), (Lee et al., 2011), (Crook et al., 2008). (Chen, 2015), (Tsai et al., 2010),
Joint training programme (JTP)	We and our partners jointly organise food-related courses for employees, such as food management certification. We and our partners jointly organise food-related training sessions for employees to learn the correct procedures and their importance. We and our partners organise joint training programmes to enhance existing skills among all levels of employees. We and our partners see training as an important way of helping the company to achieve its goals.	(Arendt et al., 2011, Jayakumar and Sulthan, 2014), (Murphy et al., 2011), (Patel et al., 2012), (Kim et al., 2013), (Shinbaum et al., 2016), (Kumar and Rahman, 2015).

	We and our partners frequently update our joint training programme.	
Collaborative effectiveness:-		
Accurate forecasting (AF)	We and our partners potentially increase our profitability through accurate forecasting.	(Mena et al., 2011), (Mena et al., 2014).
Better promotion planning. (BPP)	We and our partners jointly analyse previous promotions.	(Mena et al., 2011), (Mena et al., 2014), (Williams et al., 2014.)
Improving product safety. (IPS)	We and our partners introduced a logging system to record temperatures at both ends of the food chain.	(Mena et al., 2011), (Mena et al., 2014), (Verghese et al., 2013), (WRAP(2), n.d.)
Improving temperature monitoring. (ITM)	We and our partners introduced a logging system to record temperatures at both ends of the food chain.	(Mena et al., 2011), (Mena et al., 2014), (George, 2000).
Better inventory control. (BIC)	We and our partners are better at integrating warehouse management.	(Mena et al., 2011), (Mena et al., 2014), (Verghese et al., 2013)
Better shelf life management. (BSLM)	We and our partners are reducing processing time in the supply chain to maximise the available life of food products (minimum life on receipt (MLOR))	(Betz et al., 2015), (Mena et al., 2011), (Verghese et al., 2013).
Processing EF waste. (PEFW) My company has achieved a significant reduction of EF waste that is….	…generated due to spillage in our processing stage. …generated due to the poor conformity of the food product, such as quality, appearance, flavours. …generated from wrong labelling, such as wrong date code, wrong ingredient and nutritional data information, wrong price and promotional stickers. ….generated due to frequent changes in the production schedules in our processing stages.	(Darlington et al., 2009), (Mena et al., 2014), (Beretta et al., 2013).

Over production of EF waste. (OPEFW) My company has achieved a significant reduction of EF waste that is	…generated by planning errors, such as forecast error, promotion error, and poor stock management. …generated during seasonality and special days, such as Christmas, Easter etc. …generated due to weather uncertainty or variability. …generated during promotional events.	(Darlington et al., 2009), (Mena et al., 2014), (Beretta et al., 2013).
Storage of EF waste. (SEFW) My company has achieved a significant reduction of EF waste that is	…generated due to cannibalisation (new product 'eats' up the sales of and demand of an existing product) of the food product. …generated from the expiry dates of food products. …generated due to the recall of food products from markets.	(Darlington et al., 2009), (Parfitt et al., 2010), (Mena et al., 2014), (Mena et al., 2011).

3.6.4 Step-4 Form of response

There are the two types of form of response: open-ended questions and closed questions (Seymour, 2012).

The open-ended question refers to the fact that respondents are free to reply to open-ended questions in their own words (Churchill, 2009). Respondents can include their feelings, attitude and understanding toward the subjects. The questionnaire allows respondents to express an unusual response, which the researcher may not have contemplated (Bryman and Bell, 2011). Sometimes, it explores new areas that are worthwhile for developing a new hypothesis (Oppenheim, 2000). Open-ended questions are often easy to ask, difficult to answer and more difficult to analyse (Oppenheim, 2000). Open-ended questions are more beneficial in qualitative and exploratory research (Seymour, 2012). However, Bryman and Bell (2011) have given the number of disadvantages of open-ended questions. First, it is time consuming for the researcher to administer. Second, it requires a greater amount of respondent time, thought and effort to write the answer, which causes a low response rate. Third, comparisons and statistical analysis has become more difficult.

Closed-ended questions can be attitudinal as well as factual (Oppenheim, 2000). Closed-ended questions have many advantages. First, they can facilitate the comparability of answers and make it easier to show relationships between variables (Bryman and Bell, 2011). Second, if the respondent may not be clear about a question, the availability of answer may help to clarify the meaning of a question (Bryman and Bell, 2011). Third, they reduce the possibility of variability. On the other hand, they have some disadvantages as well; 1) it is more time consuming to design closed-ended questions. 2) Sometimes, it may be irritating to the respondent, if the respondent is not able to find their desired category answer (Bryman and Bell, 2011).

This study employs the seven-point Likert scale in closed-ended questions that seven-point's larger number of scales give higher reliability (Allen and Seaman, 2007). The Likert-type scale is generally utilised to draw out opinions and attitudes in social science research (Ryan and Garland, 1999), and widely used in the supply chain operation and logistic research. Here, respondents are asked to record their opinion ranging from strongly disagree to strongly agree. In addition, the "neither disagree nor agree" option is also available for respondent, if the respondent cannot have knowledge about a certain type of question; which can help to reduce the non-response rate (Ryan and Garland, 1999). The Likert scale is the most powerful scale for statistical analysis (Hair et al., 2010).

3.6.5 Step-5 Question wording

This is the critical task. The phrasing of each question is necessary to ensure collecting a valid response (Saunders et al., 2012). There are the few basic principles suggested by Churchill (2009), which helps to avoid the most obvious problems during the question framing. Here, the following Churchill (2009) recommendations are used by the researcher in the phrasing of each question. The researcher is carefully using simple word and avoids using ambiguous word and questions, leading questions, implicit alternatives, generalizations and double barrelled questions.

3.6.6 Step-6:- Question sequence

The question sequence should be in the correct order and start with easy-to-answer and positive types of questions (Ghauri and Grønhaug, 2005). The questions should start with a logical flow from general to specific. Here, the funnel approach is adopted for question sequence. First, the survey questionnaire starts with demographic details, then FMSC collaboration questions, then again, it narrows down the scope to collaborative effectiveness questions and last, there is a very specific question about EF waste reduction. Oppenheim (2000) pointed out that the question sequence is exactly determined after the results of pilot work.

3.6.7 Step-7 physical characteristics of questionnaire

The characteristics of a questionnaire can influence the accuracy of the replies that are obtained (Churchill, 2009). The physical characteristics of a questionnaire should be attractive to encourage respondents to participate in the survey, and also complete it and return it on time. Here, Qualtrics has a series of style templates, colour and page layout to quickly make questionnaires look more attractive. Through Qualtrics, in the survey email, the researcher clearly and concisely explained about the research aims and objectives: why they are selected and their confidentiality with a survey questionnaire link attached in the email. At the end of the questionnaire, there is a thank-you message for participation and a request for suggestions. Saunders et al. (2012) mentions that longer questionnaires have a low response rate, and very short questionnaires may make it seem that the research is an insignificant one. Following Saunders et al. (2012) suggestion, this survey has seven A4 pages.

3.6.8 Step-8 Re-examining the previous steps

After the first draft, the researcher must reassess all their decisions taken at a previous stage. Here, the researcher rechecked each question again and again, and ensured that there was not any ambiguous, offensive, confusing and bias inducing question in the questionnaire. Before going to the pilot study, item sorting was conducted to ensure domain coverage. This procedure provided adequate evidence of construct validity of each construct.

The first draft of the questionnaire survey was thoroughly examined by two different experts. First, the author's supervisors and two PhD scholars (one from Anglia Ruskin University and the other from Middlesex University) for content adequacy assessment. Second, the author also consulted industry experts (one quality manager, one production manager and one logistics manager) for checking the questions' content adequacy. Academic and industry experts suggested some changes. According to these suggestions, an amended questionnaire is sent again to an academic expert for further comments.

3.6.9 Step-9 Pre-test questionnaire and revision

This is the vital stage for the researcher. The researcher can do a real test of the questionnaire before the formal survey to know how it will work in an actual data collection stage (Churchill, 2009). Through the Pilot test, the researcher is enabled to evaluate feasibility of the data collection techniques, figure out any issues prior to the actual study and obtain an assessment of validity and reliability of the questionnaire and data collection technique as well (van Teijlingen and Hundley, 2001, Saunders et al., 2012) To test the questionnaire, a copy of the questionnaire was sent to 22 participants, who worked at managerial level in the UK food manufacturing company. Participants were asked to give their opinion and perception of their food manufacturing company in relation to their most familiar FMSC partner, in order to ensure the reliability of the data. The respondents were also asked in terms of questionnaire wording, order, layout, clarity and check the time to complete the entire survey. A total of nine valid responses were collected in the pilot test. Based on respondents' feedback, some statements in questionnaire needed further clarification. The table 5 illustrates the changes.

Table 5: Changes after pilot study

	Before pilot study.	**After pilot study.**
Demographic section	There is not any instruction about how many answers need to be selected.	Give instruction, "please click on one option only".
FMSC collaboration section:- packaging design question:-	We and our partners use a range of packaging indicators to provide the information about the condition of packed food. Respondent asks researcher what type of indicators?	The researcher adds the example of packaging indicators in the question; so now the question is… We and our partners use a range of packaging indicators, such as thermal sensor, smart tag, and microchip; to provide the information about the condition of packed food.
Storage waste:-	My company had achieved a significant reduction of EF waste that was generated due to cannibalization. Respondent ask to clarify word "cannibalization".	My company had achieved a significant reduction of EF waste that was generated due to cannibalization (new product eats up the sales and demand of an existing product).

3.6.10 Justification for using the word "partners" in the research instruments

As per a previous collaborative study, the questionnaire administered by Cao and Zhang (2011), this study adopted the same questionnaire style as Cao and Zhang (2011) or the words "we and our partner", which means the dyadic relationship between manufacturers and their primary or key retailers. Before starting to answer the questionnaires survey in "Qualtrics software", this study gave a brief introduction or instructions to our respondents about the questionnaires survey in the "Qualtrics". We asked our respondents "please answer all of the questions from the perspective of your organisation and your primary or key retailer". "These items measure your firm's collaboration with your primary or key retailer".

3.7 Sampling design

Becker (2008) has said on sampling, “sampling designing is a challenging task for researchers”. Moreover, Silverman (2013) has specifically mentioned that it is not an easy process, even for a quantitative study. Sampling means “researcher tries to find out something that will apply to everything of a certain kind by studying a few examples, and the results of the study being, as generalizable” (Becker, 2008).

3.7.1 Unit of analysis

According to Kaufmann and Astou Saw (2014), 90% of supply chain operation and logistic research was analysed under three different types of unit of analysis, namely, the firm, dyad and business unit. Previous studies, (Stank et al., 2001, Koçoğlu et al., 2011, Kumar and Banerjee, 2014), have focused on the collaboration approach in supply chain management with various echelons. The unit of analysis of those research studies is from an individual company that forms part of the supply chain activities. Furthermore, Cao and Zhang (2011) focused on the dyadic relationship between the manufacturers and key suppliers, where the unit of analysis is the dyadic relationship but viewed from a focal manufacturer’s perspectives. This study has focused on reducing EF waste in the UK FMSC, specifically food manufacturing sectors. This study concentrated on the vertical collaboration at two-echelons between the food manufacturing company and their downstream key or primary partner, meaning retailer. Hence, vertical collaboration is viewed from food manufacture perspectives. Therefore, the unit of analysis of this study is an individual food manufacturing company and the kind of respondent to obtain the information is the upper managerial and executive levels of such a food manufacturing company.

3.7.2 Target respondent

It is a very challenging and essential task for any study to select respondents for a survey questionnaire. It requires great caution in selecting target respondents because they are vital to guarantee reliability and validity (Scandura and Williams, 2000). According to Kaufmann and Astou Saw (2014), there are two types of approaches used in supply chain operational and logistic research: single-informant and multiple-informant. Nearly 85% of supply chain research use single-informant samples (Kaufmann and Astou Saw, 2014). Due to the low response rate typically in food manufacturing companies, strict regulation on data sharing and limited resources led the researcher to use the single-informant approach in this study. Where Boyer and Verma (2000) mentioned this, the single informant may be biased because that informant may potentially present a skewed or inaccurate view of the organization as a whole. However, Kaufmann and Astou Saw (2014) specifically clarify that if a single-informant used as a one-sided assessment of evaluating a supply chain relationship, this may result in a misleading conclusion. However, the limitation of a single-informant can be alleviated through selecting the informant who is the most knowledgeable about the research topic (Wang and Yu, 2006). Upper managerial and executive level of respondents in the food manufacture companies are the most knowledgeable and, therefore, single-informant used as the target respondent to respond our survey (Wang and Yu, 2006).

3.7.3 Sampling population

A sampling population is defined by Churchill (2009), as "the totality of cases that conform to some designated specifications"; where specification means "the elements that belong to the target group and those that are to be excluded" (Churchill, 2009). In this study, the total sampling population was 3957; where target respondents were CEO, directors, logistic manager, operational manager, general manager and owner of the food manufacturing companies across the UK. Based on Cao and Zhang (2011) study's sampling design, this study collected the targeted respondents sample list from the FAME database. FAME database is the large database of the UK and Ireland base companies. The emails list of targeted respondents cover all the UK SIC (Standard

Industrial Classification) codes of food manufacturing companies: Processing and preserving of meat and production of meat products (SIC 101), Processing and preserving of fish, crustaceans and molluscs (SIC 102), Processing and preserving of fruit and vegetables (SIC 103), Manufacture of vegetable and animal oils and fats (SIC 104), Manufacture of dairy products, Manufacture of grain mill products (SIC 105), starches and starch products (SIC 106), Manufacture of bakery and farinaceous products (SIC 107), Manufacture of other food products (SIC 108). This study excluded the UK SIC 109 code (pet food manufacturing company) because this study does not focus on pet food.

3.7.4 Sampling procedure

There are two types of sampling method: probability sampling and non-probability sampling. Probability samples are "distinguished by the fact that each population element has a known, non-zero chance of being included in the sample" (Churchill, 2009). While in a non-probability sample, "there is no way of estimating the probability that any population element will be included in the sample" (Churchill, 2009).

Wagner and Kemmerling (2010) have examined leading supply chain operational and logistic journals and found that supply chain operational and logistic researchers "hardly ever deploy their survey to the entire population of interest". When looking at the sampling frame of previous scholars' studies, particularly in supply chain collaboration Yan and Dooley (2014) , Simatupang and Sridharan (2004), Chen et al. (2013), Wu et al. (2014), Cao and Zhang (2011), Kumar and Banerjee (2014), Ibrahim and Hamid (2014), Sukati et al. (2012) and Koçoğlu et al. (2011), the sampling frames of those studies rely on members of professional logistics related associations (such as Council of Supply Chain Management Professionals), industry association members and registered members on large databases (FAME, ORBIS). As per the Wagner and Kemmerling (2010) study, this type of sampling frame is not representative of the population, because many supply chain professionals may not be members of the logistics associations or register on the large databases. Therefore, supply chain operation and logistic researches are highly influenced by convenience sampling, instead of random sampling.

On the other hand, Fricker (2008) mentioned that sampling method is generally driven by the contact mode (how the respondents are contacted), not the response mode (how they are asked to complete the survey). Furthermore, the Internet-based contact mode (web and e-mails) does not reflect the general population and that means it is not considered a 'de facto' sampling frame, as per Fricker (2008) analysis. This study used an Internet-based contact mode which generally falls into non-probability sampling.

On the basis of previous supply chain collaboration studies, low response rate between 4% and 30% in supply chain (Griffis et al., 2003), availability of sampling frame through the FAME database and the impossibility of including every individual from a large population (UK food manufacturing has the fourth largest turnover in the EU and represents 17% of the UK's total manufacturing sector (Gibbons, 2014)) lead to researcher to employ convenience sampling for this research. Where, convenience (or availability) sampling means respondents either known by the researcher and/or readily available to the researcher.

This study then searched target respondents' e-mail addresses in the FAME database. The study selected only named e-mail addresses of target respondents and omitted generic e-mail addresses (companies' general contact e-mails) from the FAME database. The FAME database generated 3957 target respondents listing their job titles and named e-mail addresses.

3.8 Validity and reliability

In quantitative research, validity and reliability are central concerns for the quality of research (Saunders et al., 2012). Reliability and validity are used to assess the accuracy of measurement scales (Bannigan and Watson, 2009). As Heale and Twycross (2015) said, validity and reliability not only depend on the findings of research, but also the rigour of the research. The following section elaborates the concepts and sub-dimension of validity and reliability in detail.

3.8.1 Validity

This is the foundation of the supply chain operation and logistic research process (Garver and Mentzer, 1999). Validity is defined as "the issue of whether or not an indicator (set of indicators) that is devised to gauge a Bannigan and Watson (2009) concept really measure that concept" (Bryman and Bell, 2011). Validity is concerned with the meaning and interpretation of a measurement scale (Bannigan and Watson, 2009). There are several ways to establish validity, which are discussed in the following sections.

3.8.1.1 Content validity

It is often referred to as measurement validity. Content validity exists when the scope of the construct is adequately reflected by the scale items (Dunn et al., 1994). However, Dunn et al. (1994) said that there is no rigorous way to assess content validity because it relies on the researcher's subjective judgment and also their understanding about the conceptual nature of the construct (Garver and Mentzer, 1999). However, Churchill Jr (1992) and Churchill (2009) have contended that content validity lies in the 'procedures' which are used to develop the instrument; where the instrument is conceptually defining the domain of the characteristic. Furthermore, content validity should be satisfied through specifying the domain of the construct, generating an exhaustive list of items and purifying the resulting scale (Churchill, 2009). In addition, if the domain of the concept is measured by a larger number of items, it is therefore considered as having greater content validity (Sekaran and Bougie, 2010). As mentioned in the questionnaire design section, measures were designed on the basis of the theory through the literature review, and also involved food industry and subject experts for assessment of content validity to ensure that scales really measure the domain of the construct.

3.8.1.2 Convergent validity

Convergent validity refers to the fact that "the degree to which individual items reflecting a construct converge in comparison to items measuring different constructs" (Afthanorhan, 2014). It means measures highly correlate with alternative measures of the same construct (Hair Jr et al., 2016). In the case of reflective indicators, it is considered as several approaches to measure the similar construct (Hair Jr et al., 2016).

3.8.1.3 Discriminant validity

Discriminant validity refers to “the degree to which the measures of different constructs differ from one another” (Afthanorhan, 2014). It means low correlation between the items of each variable. Thus, the construct should be unique and capture phenomena and also not be described by the other construct for establishing discriminant validity (Hair Jr et al., 2016).

Convergent validity is focused on the sensitivity, while, divergent validity assesses the specificity of a scale (Bannigan and Watson, 2009). Convergent validity is assessed through outer loading of the indicator and average variance extracted (Jan et al.) (Hair Jr et al., 2016). Higher outer loading on a construct indicates that the associated indicators have much in common, which is also called indicator reliability (Hair Jr et al., 2016). Hair Jr et al. (2016) suggested that the result of AVE is higher than 0.50 indicating that the construct has captured more than half of the variance of its indicator (Afthanorhan, 2014); which means convergent validity is achieved. AVE is only available for the reflective indicator; where AVE value is not a meaningful criterion for formative indicators (Hair Jr et al., 2016). However,, discriminant validity is assessed through cross loading and the Fornell-Larcker criterion that evaluated only a reflective indicator (Hair Jr et al., 2016) and is inappropriate for formative indicators. Outer loading and square root of the AVE should be higher with any other construct.

3.8.2 Reliability

The accurate estimation of reliability is highly important for any research. Reliability refers to “the consistency of a measure of a concept” (Bryman and Bell, 2011). Reliability is distinguished from validity by Churchill (2009), validity measures the same construct through maximally different methods; while reliability measures the same construct through maximally similar methods.

Reliability can be assessed through many statistical methods, such as test-retest, split-half technique Cronbach’s alpha and composite reliability (Churchill, 2009, Black, 1999). Among them, the test-retest approach is costly, and a major problem is that the same respondents could remember their first answers (Heise, 1969, Black, 1999).Furthermore, the problem in the split-half technique is that the correlation results of the two random sets depend on how the researcher splits the items. On the contrary, Cronbach's alpha technique is the most commonly used to evaluate reliability (Kline, 2005).

Cronbach's alpha provides an "estimate of the internal consistency reliability based on the inter-correlation between the various indicators used to capture the underlying construct" (Ghauri and Grønhaug, 2005, Hair Jr et al., 2016). Cronbach's alpha depends on the number of measurements in the scale and assumes all indicators have equal outer loading on the construct, which tend to affect the internal consistency reliability (Hair Jr et al., 2016, Bryman and Bell, 2011). Due to the limitation of Cronbach's alpha, composite reliability is more reliable for internal consistency reliability, and this method managed to overcome some of Cronbach's alpha deficiency (Hair Jr et al., 2016, Afthanorhan, 2014). Cronbach's alpha and composite reliability are interpreted in the same way. It ranges between 0 and 1, with higher value indicating a high level of reliability (Hair Jr et al., 2016). However, composite reliability is applied in the reflective indicators.

Formative indicators represent different facets of construct, so facets do not correlate with one another (Edwards, 2011). Furthermore, the formative indicator is assumed to be error free. Therefore, internal consistency reliability, convergent validity and discriminant validity criteria are not meaningful for formative indicators (Hair Jr et al., 2016). Moreover, low-item correlation can be dropped to increase internal consistency reliability in reflective indicators; while in formative indicators, removal of the measurement scales may lead to change the empirical and conceptual meaning of the construct (Thongrattana, 2010). To evaluate the formative indicator, the researcher should focus only on content validity, suggested by Hair Jr et al. (2016), because measurement error in formative indicators is not represented at the indicator level, but appeared at the construct level (Kline, 2005, Hancock and Mueller, 2013).

Exploratory factor analysis (EFA) is also an alternative approach to check convergent and discriminant validity. It is also referred to as first-generation analysis technique (Hair Jr et al., 2016). EFA is a statistical approach to calculate the correlation among the set of indicators, which is associated with theory development (Kline, 2005). EFA is applicable only as a set of non-nominal scales and theoretically, it should belong to reflective indicators only. Hence, EFA is an inappropriate method to evaluate a formative construct (Christophersen and Konradt, 2006). The research model of this study has a formative indicator as well. However, indicators are not interchangeable, are free to vary and covary, and correlation among measures is not required; therefore, EFA does not work in a formative indicator (Edwards, 2011, Kline, 2005).

3.9 Data analysis technique

This is the systematic approach, where "collected data are statistically analysed to check if the hypothesis that was generated have been supported or not" (Sekaran and Bougie, 2010). There are many types of statistical techniques to analyse study results. Selecting the correct statistical technique to analyse study results is a daunting process (Gardener, n.d.). Khusainova et al. (2016) indicated that misapplication of statistical techniques may lead to incorrect interpretation of study results and also erroneous conclusion, and so research studies can lose their scientific value. To select an appropriate statistical data processing technique, Bryman and Bell (2011) have suggested that statistical techniques must coincide with the types of variables that are used in research, and the researcher must also consider the size and nature of the sample when selecting a statistical technique.

There are two types of statistical methods: first-generation technique and second-generation technique (Hair Jr et al., 2016). Boehm (2008) criticized the first-generation technique and point out that indicators are measured without measurement error and are restricted to one side of the model's equation in the first-generation technique. Therefore, to overcome the weakness of the first-generation technique, in the past 20 years, supply chain operation and logistic researchers have increasingly used the second-generation technique (Hair Jr et al., 2016).

Table 6: Statistical Method

statistical methods (Hair Jr et al., 2016)	Primarily exploratory.	Primarily confirmatory.
first-generation technique	Cluster analysis. Exploratory factor analysis. Multidimensional scaling.	Analysis of variance. Logistic regression. Multiple regressions.
second-generation technique	PLS-SEM. (Partial Least Squares) (variance-based technique)	CB-SEM (Covariance-based technique) Confirmatory factor analysis.
Adopted from Hair Jr et al. (2016)		

Structural equation modelling (Brace et al.) is a second-generation data analysis technique, and its popularity has tremendously increased in supply chain operation and logistic research in recent years (Kaufmann and Gaeckler, 2015), because SEM can smoothly deal with more than one relationship in the model. The yields benefits through the use of SEM and is not possible with the first-generation technique (Bagozzi and Yi, 2012). There are many benefits of SEM summarized by Bagozzi and Yi (2012), as follows.

- Provide a broad and integrative function.
- "Precisely in specification of hypotheses and operationalization of constructs".
- "Useful in experimental or survey research, cross-sectional or longitudinal studies, measurement or hypothesis testing endeavours".
- Easy to use.
- Random or measurement error in indicators of latent variables and systematic or method error can be represented and estimated explicitly.

SEM has tackled two sub-models: inner model and outer model. The inner model is also referred to as the structural model (Kaufmann and Gaeckler, 2015), which represents the "relationship existing between the independent and dependent variables". while the outer model is referred to as measurement model (Kaufmann and Gaeckler, 2015) and it represents the "relationship between the latent variables and their observed indicators" (Wong, 2013).

There are two approaches in SEM (Chin, 1998). 1) Covariance-based SEM (CB-SEM). 2) Partial Least Squares (PLS).

However, the structural equation model is used as a synonym of covariance-based procedure through many researchers (Chin, 1998), and CB-SEM is the one of the most widely used approaches in SEM. CB-SEM is used to confirm and reject theory through testing hypothesis. The CB-SEM method is exemplified by software such as LISREL, EQS, AMOS, SEPATH AND RAMONA (Chin, 1998). PLS-SEM is soft modelling, non-parametric and no assumption for data distributional technique (Wong, 2013). PLS-SEM is "predicting key target construct" or "identifying key driver construct" (Hair Jr et al., 2016). PLS-SEM and CB-SEM have the basic aim of estimating the relationship between the construct and indicators, but both differ fundamentally in terms of statistical conception and the way of deal with measurement models of construct (Sarstedt et al., 2016). In contrast, Kaufmann and Gaeckler (2015) believe that PLS-SEM is designed as an alternative to CB-SEM for a complex multivariate relationship.

3.9.1 Differences between CB-SEM and PLS-SEM

Stan and Saporta (2005) have distinguished features between the CB-SEM and PLS-SEM, which are summarized here:

- PLS-SEM is prediction oriented means, optimal for a prediction accuracy technique, while CB-SEM is a parameters estimation oriented technique.
- In PLS-SEM, each latent variable is calculated as a linear combination of its own manifest variable, whereas in CB-SEM, latent variables are using the whole set of manifest variables.
- PLS-SEM works efficiently with reflective and formative measurement models, while CB-SEM is used with only reflective indicators.
- If a theoretical model or measure is not well formed or the theory is less developed, Hair Jr et al. (2016) recommended that PLS-SEM is a more appropriate technique than CB-SEM. It makes practically no assumption about the underlying data.
- PLS-SEM can easily handle larger and complex models with many structural relations (Hair Jr et al., 2016), such as 100 latent variables and 1000 indicators that are managed through PLS-SEM. In contrast, CB-SEM manages small to moderate model complexity, such as less than 100 indicators.
- PLS-SEM achieves a higher level of statistical power even with a smaller sample size (Hair Jr et al., 2016). According to Stan and Saporta (2005), minimal recommendations range between 30 and 100. However, in CB-SEM, the minimal required range is from 200 to 800.
- In missing data treatment, CB-SEM is focused on maximum likelihood estimation procedure. PLS-SEM adopts an ordinary least squares regression based method, whereas PLS-SEM estimates the path relationship with minimal error term (Hair Jr et al., 2016).

3.9.2 Criticism on PLS-SEM

There are the on-going debate for use of PLS-SEM between the critics and proponents. Critics Rönkkö (2014) noted that "due to correlation between the error terms, PLS-SEM is unsuitable for any type of statistical inference". Where Kaufmann and Gaeckler (2015) place emphasis on PLS-SEM strength, PLS-SEM is a "purely composite-based method to separate itself from factor-based SEM and as well as developing a different approach to measure validation". The current heated debate on use of PLS-SEM should not preclude the researcher from using PLS-SEM in their research. Rather than focusing on debate, this study uses the proper methodological guidelines on how to correctly use PLS-SEM because Kaufmann and Gaeckler (2015) have mentioned that not one single statistical methodology is thoroughly perfect.

3.9.3 Rational for using PLS-SEM for this study

Kaufmann and Gaeckler (2015) have analyzed 75 publications in supply chain operation and logistic research and noted that 29% of publications did not give a reason to use PLS-SEM in their research. The following table 7 illustrates the reason for using PLS-SEM in a previous supply chain operation and logistic study.

Table 7: Reason for using PLS SEM in past studies

Reason	Proportion of study in percentage.
Small sample size	58%
Non-normal data	42%
Formative measure	32%
Exploratory research	30%
Focus on prediction	25%
Model complexity	21%
Consistence with study objective	6%
Other	30%
Some study used more than one reason to use PLS-SEM.	
Adopted from Kaufmann and Gaeckler (2015)	

Most importantly, Wagner and Kemmerling (2010) pointed that Low response rates limit the type of statistical techniques that can be applied to small samples. Sample size is extremely important in SEM because it directly influences reliability, model fit and statistical power. On the basis of previous researchers Griffis et al. (2003), the response rate is between the 4% and 30% in supply chain operation and logistic research. If this study receives a smaller sample size, CB-SEM will generate non-convergence problems and improper results from findings in a small sample (Kaufmann and Gaeckler, 2015). Furthermore, Kaufmann and Gaeckler (2015) mention that CB-SEM can be used in small sample sizes, if the researcher can drop the number of indicators. The conceptual framework of this study has first-order reflective and second-order formative indicators. Therefore, dropping the formative indicators may alter the conceptual domain of the construct (Petter et al., 2007) and create model misspecification. PLS-SEM easily reaches much more convergence and achieves higher level of statistical power in small sample sizes (Sarstedt et al., 2014).

In addition, Kaufmann and Gaeckler (2015) have noted that CB-SEM might cause identification problems when there is incorporation of both reflective and formative indicators (hierarchical component model). On the other hand, PLS-SEM consists of a series of ordinary least square analyzes so it does not lead to identification problems in recursive models. Therefore, PLS-SEM is well suited in hierarchical component models rather than CB-SEM (Sarstedt et al., 2014). Moreover, Diamantopoulos (2011) defended that CB-SEM can be used in formative indicators; but specific constraints are required by researchers to ensure model identification. Although it is against Diamantopoulos (2011) suggestion, we consider the Hair et al. (2012) note that “these constraints often contradict theoretical considerations and the question arises whether model design should guide theory or vice versa”; which is cited by Sarstedt et al. (2016).

The conceptual model of this study has comprised many constructs, many path relationships and many item scales per construct. Therefore, PLS-SEM can efficiently handle all these latent variables rather than CB-SEM (Sarstedt et al., 2014). while, Świerczek (2014) used PLS-SEM model because the relationships between the constructs in their study have not been previously tested. As best knowledge by author of this research, relationships between the foods supply chain collaboration and EF waste reduction have not been tested yet

The objectives of this study are to find to what extent the FMSC collaboration reduces EF waste and also hypotheses are derived as predictions of theoretical relationships. Therefore, the conceptual model is predictive and not intended to be explanatory. PLS-SEM is a potentially appropriate tool for predictive outcomes (Rönkkö et al., 2016) when identifying the predictive power of the exogenous variables on the endogenous variables (Peng and Lai, 2012). Moreover, Peng and Lai (2012) found that PLS-SEM might be more appropriate for testing hypothesized relationships between the supplier and buyer in a dyadic supply chain.

3.10 Limitation of the research methodology

Our survey has some limitations. This study selected only named email addresses of target respondents by a convenience approach dependent on volunteering and willingness of participants; this may have introduced selection bias and may not be representative of the UK as a whole; therefore the generalisability of the results may be limited. This survey is also limited by the fact that this data is self-reported and observed the process of answering the self-administered survey. Inherently, in a self-administered survey, a respondent's feelings may be biased at the time of answering the questionnaire. For example, if a respondent feels bad at the time of filling out the questionnaire, it might be possible that their answers will be more negative. If the respondent feels good at the time, then the answers will be more positive. Due to the self-administered survey, we received many item non-responses. As per the guidelines of Hair Jr et al. (2016), this study had removed many missing value responses (which have more than 5% of item non-responses) and therefore the overall response rate was rather low. Moreover, there is a limitation in the job position category variable. This study has got few contact email address of production managers through the FAME database. Due to the limited number of production manager participants, there is the possibility that results of the statistical tests may be weakened. This is because production managers are well-informed regarding processing and production-related EF waste.

The key respondent, a top manager, was elicited to respond to the survey because top management is the most knowledgeable individual taking the survey. This may introduce common-method bias so the stability of the findings needs to use multiple informants from each participant organisation.

Another limitation in the categories questions is that this study did not mention any question to identify FMSC Company's nature of business and their business activities, such as UK SIC (Standard Industrial Classification). Therefore, this study may have limitations for comparison and contrasting between the different types of FMSC companies, such as comparing and contrasting between the manufacture of meat, dairy and bakery. More importantly, the classification codes of each FMSC company and their name is available for anyone to view on the public record. There is a possibility that anyone can trace or identify the FMSC Company's name through SIC codes. Therefore, to maintain confidentially of FMSC companies, this study did not ask the respondents their company's SIC code in the questionnaire.

3.11 Ethical consideration

Ethical consideration is a critical aspect for any research project. For collecting data, part of the ethical approval form is approved by a University of Bedfordshire's research ethics committee. The research ethics committee approved the proposed research project by granting permission to commence the research. This study has considered a number of ethical principles, which are set out by The Economic and Social Research Council (ESRC, 2005).

- This study maintained quality and integrity of the proposed research.
- This study created a participant information sheet which included "information about the purpose of the research study, the requirement and implication of taking part, respondent's right, consent form, how their data will be analysed, reported and stored and whom to contact in the case of concerns" (Saunders et al., 2012, page-252).
- This study was designed in a way that the confidentiality of information supplied by respondents and the anonymity of respondents is protected and respected at all times; and their participation was voluntary, free from any coercion.
- This study maintained that the research was independent and impartial.

- This study did not do any data fabrication or falsification, and maintained validity and reliability of research work.
- Collected data was specifically stored solely (hard disk) under password protection for as long as the research project lasted (published) and was closely supervised.

3.12 Summary

This chapter described the research design process of this thesis. This thesis employed the positivist–deductive approach and a mono-method quantitative approach. This study used an email-based survey questionnaire. The questionnaire was designed on the basis of Churchill Jr (1979)'s nine-step procedures. Sampling method, validity, reliability and data analysis technique were discussed. This chapter also justified the adoption of the survey, convenience sampling, formative indicator and PLS-SEM.

4 CHAPTER 4: DATA ANALYSIS

This chapter analyses the data under two main sections. Section 4.1 is descriptive statistics and Section 4.2 is statistical analysis. Data were analysed to examine the relationships between FMSC collaboration, collaborative effectiveness and edible food waste reduction. Obtained data from the questionnaire survey is analysed through PLS-SEM to deal with a large number of endogenous and exogenous variables. The first section undertakes an initial data analysis including the descriptive statistics of the data. Implementing initial data analysis is important not only for a general picture of the data by exploring and summarising it, but also for model formulation prior to the statistical analysis. The second section examines the research model and hypotheses. Results of the statistical analysis section will also contribute to the body of knowledge in FMSC and will also provide a managerial insight into FMSC. All analyses were performed by using SPSS version 19 for Windows and PLS-SEM statistical software.

4.1 Section 4.1: Descriptive statistics

Brace et al. (2012) defined descriptive statistics as “a set of statistical tools that allows a researcher to accurately describe a large volume of data with just a few values”. Here, this study describes the descriptive statistics of the collected responses to understand the characteristics of survey participants and their responses to the questions. Pallant (2013) included the number of uses of descriptive statistics.

- It helps to describe the characteristics of a sample.
- It helps to check the “research variables for any violation of the assumptions underlying the statistical techniques that will be used to address the research questions”.
- It helps to address specific research questions.
- Summarising large amounts of raw data in a meaningful way.
- To illustrate an overview of respondents’ profiles and their responses, this chapter discusses response rate, non-response bias, common method bias, sample size and data screening.

4.1.1 Response rate

Response rates are "calculated as the number of returned questionnaires divided by the total sample who were sent the survey initially" (Fincham, 2008). This study follows a very systematic procedure during data collection in order to achieve a higher response rate. A total of 3957 e-mails were sent through Qualtrics software with personalised cover letters and the aim of the study. Here the researcher used their official university e-mail address in Qualtrics for sending questionnaires to respondents. Every invitation e-mail has a customised message for each respondent so respondents did not feel the survey questionnaire was randomly sent to them. Each e-mail had an individual link for each respondent so they could use it only one time and cannot forward it to other people. When tracking the e-mails, the majority of them were never opened. Excluded from the total sample e-mail list were the undelivered e-mails, opt out and bounced e-mails, respondents' automatic e-mails temporarily available and a few returned e-mails replying that they had a policy not to participate in any survey. The actual mailing list contained 1253 respondents. To improve response rate, three rounds of e-mails were sent over four weeks. A total of 122 usable responses were received, which represents a 9.7% response rate (122/1253). It does seem nearly a similar response rate when compared with previous supply chain collaboration studies, such as 6% in Cao and Zhang (2011), 9.7% in Kumar and Banerjee (2014) and 10.4% in Yan and Dooley (2014). Moreover, Griffis et al. (2003) reported that a minimum 4.0% response rate was acceptable in supply chain operational and logisticresearch. However, a 9.7% response rate is somehow low but when considering Hair Jr et al. (2016) recommendation for sample size in the PLS-SEM technique, the number of 122 respondents is good enough to run PLS-SEM. In our conceptual model, the maximum number of arrows pointing at a construct is five. The minimum R-squared value is 0.25 in any of the constructs for a significant level of 5%, so minimum requirement of sample size is 70 as per Hair Jr et al. (2016) recommendation. Thus, this study met the minimum sample size requirement.

4.1.2 Non-response bias

This is also called unit non-response bias. Unit non-response bias means "the failure to gather any information from an approached unit of the sampling frame" (Wagner and Kemmerling, 2010). There are several reasons for unit non-response, such as delivery errors, absence of respondents and company policy. This study adopted a mail survey, so it is necessary to measure unit non-response bias. There are several techniques to detect the existence of unit non-response bias. As per Armstrong and Overton (1977), the extrapolation method is one of the most widely accepted methods for unit non-response bias. Non-response bias is assessed through comparing the early respondents and late respondents because late respondents are most similar to non-respondents (Wagner and Kemmerling, 2010). Pace (1939) stated that it is not a sufficient test to indicate the extent of bias, but Pace (1939) further mentions that it is a "simple and valuable technique to determine easily the probable direction of bias". The extrapolation method is implemented through Mann-Whitney u test and Wilcoxon matched pairs test comparing the first two weeks responses and last two weeks responses to obtain the results of non-response bias. The results show that there is no statistical significant difference ($p>0.005$) between the two respondent groups. There are only one variables recognised to have p-value less than 0.005.

RFID_2 is 0.45

Therefore, as per studies by Armstrong and Overton (1977), Mentzer and Flint (1997) and Wagner and Kemmerling (2010), it is concluded that unit non-response bias is not a critical concern in these data.

4.1.3 Overall demographic detail of sample

This section summarised the characteristics of the respondents. The characteristics of respondents were analysed by their designation and their work experience in the FMSC.

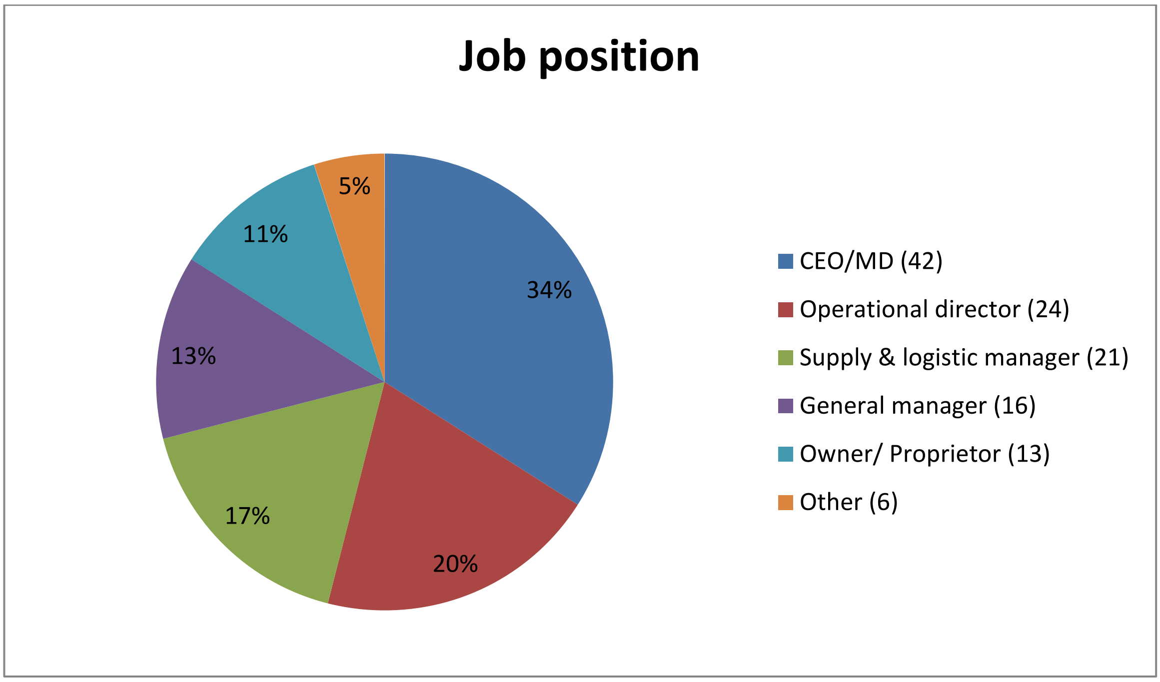

Figure 4: Job position

The diagram presents the respondent's job position in their company. The reported position of the respondents illustrated that 34% of them were in CEO/MD level positions. The operational directors were the second highest respondents in this study, 20%, followed by supply chain operation and logistic managers who were nearly half as compared with CEO/MD level, at 17%. The general managers and owners or proprietors were 13% and 11% respectively. While only six respondents filled in the other categories, which had only 5%. In other categories, respondents were two environmental managers, three production managers and one sustainability manager. All the respondents come from a range of departments. Based on their designation within the company, the majority of respondents were on an executive and upper managerial level and remainder were in middle managerial positions, which suggested that respondents had a comprehensive knowledge of the company's supply chain operation.

4.1.3.1 *Job experience*

The largest work experience group had more than 20 years of work experience (32%) with 39 respondents out of 122, while 21% of 25 respondents had 10-14 years of work experience in the FMSC. Respondents with 15 to 19 years of work experience accounted for 18%, 22 out of 122. 21 respondents (17%) had 5 to 9 years of work experience in the FMSC. Others, 12% of respondents (15 out of 122) had less than 5 years of work experience in the FMSC.

Considering the respondents' designation and work experience, the majority of them had expertise in the FMSC and possessed reliable knowledge in FMSC collaboration and EF waste reduction.

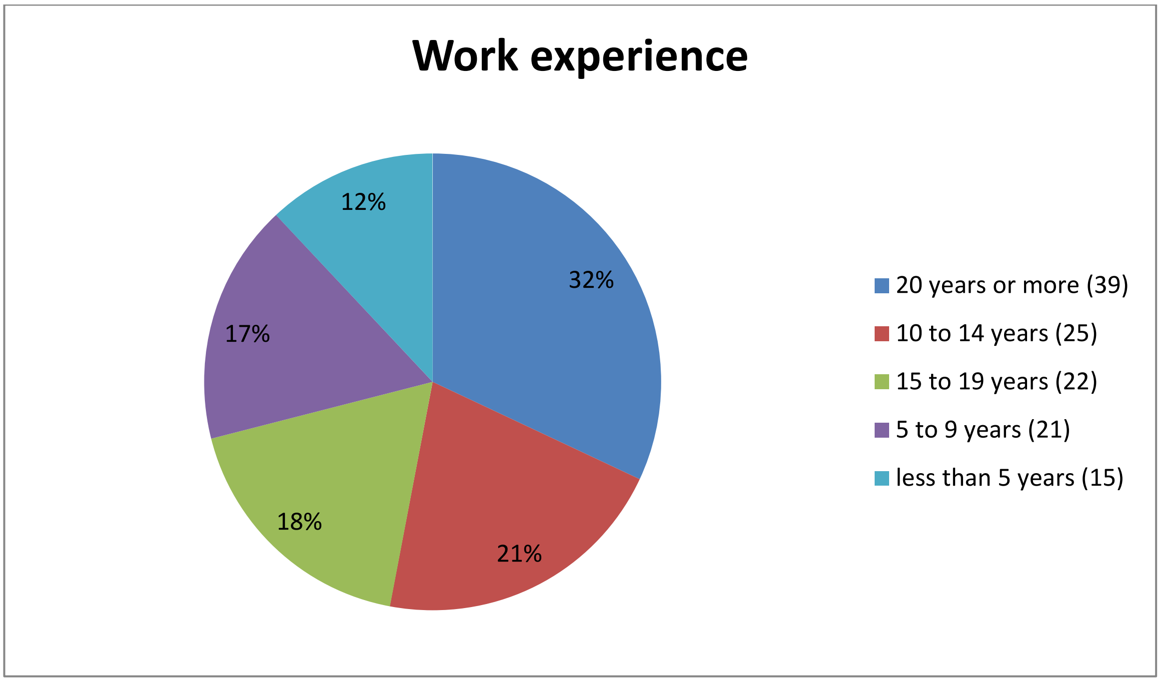

Figure 5: Work Experience

4.1.3.2 Firm characteristics

This is as per Eurostat's statistical classification for firm size into three categories on the basis of employee numbers. A firm with fewer than 50 employees is a small food manufacturing firm, between 51 and 250 employees a medium firm, and more than 251 employees a large firm. As per collected responses, nearly half (47%) of the respondents worked in a medium size food manufacturing company (58 out of 122); 33% of respondents (41 out of 122) belonged to a small company, and the other 18% (23 out of 122) were from a large food manufacturing company. This shows that the majority of respondents worked in small and medium size food manufacturing company. Table 8 illustrates the characteristics of the respondents' firms.

Table 8: Firm Characteristics

Employees	Total firms
0 to 50	41
51 to 100	38
101 to 250	20
251 to 500	10
More than 501	13

4.1.4 Descriptive statistics for main questions

After characterising the descriptive statistics of the survey respondents and their firms, now, to determine how they answered the survey questions related to FMSC collaboration, collaborative effectiveness and EF waste reduction. The following table 9 shows that percentage frequencies for all the items are presented with mean and standard deviation. Firstly, the respondents were asked about FMSC collaboration related survey questions, where FMSC collaboration was measured through a seven-point Likert scale. The range of Likert scale was strongly disagree, disagree, somewhat disagree, neither disagree nor agree, somewhat agree, agree, strongly agree.

Table 9: Overall descriptive statistical findings

Variables	Mean	Std. Deviation	1 SD %	2 D %	3 SWD %	4 NDNA %	5 SWA %	6 A %	7 SA %
JDF_1	4.28	1.563	4.2	12.7	13.6	20.3	22.0	23.7	3.4
JDF_2	4.49	1.484	2.5	10.2	13.6	16.1	28.8	24.6	4.2
JDF_3	4.72	1.501	3.4	7.6	10.2	12.7	31.4	28.0	6.8
SPD_1	5.21	1.239	0.8	4.2	6.8	5.9	33.1	41.5	7.6
SPD_2	4.97	1.198	0.0	2.5	11.9	13.6	39.0	24.6	8.5
SPD_3	4.81	1.309	.8	5.1	11.0	16.1	38.1	20.3	8.5
SPD_4	4.45	1.588	5.1	9.3	13.6	16.1	23.7	28.0	4.2
KI_1	4.47	1.545	2.5	13.6	8.5	17.8	33.1	16.1	8.5
KI_2	3.92	1.433	3.4	17.8	18.6	16.1	32.2	11.0	.8
KI_3	4.23	1.625	5.9	13.6	11.0	18.6	29.7	14.4	6.8
KI_4	4.40	1.548	5.1	9.3	12.7	15.3	35.6	15.3	6.8
RFID_1	2.60	1.817	39.8	23.7	2.5	18.6	5.1	5.9	4.2
RFID_2	2.52	1.769	39.8	26.3	1.7	16.9	5.9	5.9	3.4
RFID_3	2.45	1.674	40.7	24.6	4.2	16.9	5.9	5.9	1.7
RFID_4	2.45	1.684	40.7	24.6	4.2	17.8	4.2	5.9	2.5
JTP_1	3.79	1.943	14.4	21.2	11.0	11.0	15.3	21.2	5.9
JTP_2	4.02	2.030	13.6	20.3	8.5	9.3	14.4	24.6	9.3
JTP_3	5.19	1.648	5.9	5.1	2.5	11.0	20.3	36.4	18.6
JTP_4	3.92	1.915	13.6	18.6	6.8	19.5	14.4	19.5	7.6
Accurate forecasting	4.91	1.371	1.7	4.2	8.5	21.2	25.4	29.7	9.3
Better promotion planning	4.10	1.818	9.3	17.8	10.2	12.7	22	22	5.9
Improving product safety	5.16	1.542	3.4	6.8	5	7.6	26.3	35.6	15.3
Improving temperature monitoring	5.41	1.750	6.8	4.2	1.7	11.9	9.3	36.4	29.7
Better inventory control	3.95	1.557	8.5	12.7	11.0	30.5	21.2	12.7	3.4
Better shelf-life mx.	5.09	1.491	3.4	4.2	5.9	14.4	24.6	33.1	14.4
PEFW_1	4.91	1.585	5.1	4.2	3.4	27.1	18.6	25.4	16.1
PEFW_2	5.14	1.404	2.5	2.5	2.5	25.4	22.0	27.1	17.8
PEFW_3	4.87	1.447	2.5	4.2	7.6	27.1	16.1	32.2	10.2
PEFW_4	4.95	1.484	4.2	1.7	6.8	25.4	19.5	28.8	13.6
OPEFW_1	5.02	1.519	3.4	4.2	5.9	20.3	22.0	28.0	16.1
OPEFW_2	4.89	1.449	3.4	2.5	8.5	23.7	22.9	27.1	11.9
OPEFW_3	4.66	1.445	3.4	5.1	6.8	33.1	18.6	24.6	8.5
OPEFW_4	4.75	1.548	4.2	4.2	7.6	30.5	16.9	22.9	13.6
SEFW_1	4.28	1.679	8.5	9.3	5.1	36.4	13.6	17.8	9.3
SEFW_2	4.72	1.585	4.2	7.6	4.2	29.7	16.1	26.3	11.9
SEFW_3	4.58	1.905	8.5	11.9	.8	30.5	8.5	19.5	20.3

When examining the 19 items of FMSC collaboration, the responses indicated that 10 items are rated above 4.0, where 5 items were ranged between 4.5 and 5.0 and the other 5 items from 4.0 to 4.5. The mean ranged from 3.71 to 4.0 in 4 items. Surprisingly, all the items of RFID (RFID_1, RFID_2, RFID_3 and RFID_4) had 2.5 mean values, which mean respondents largely indicate the 'disagree' position about the RFID technology in their FMSC operation.

Secondly, 6 items concerning the collaborative effectiveness were marked on a seven-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. Five items had above 4.0 mean values. In particularly, four items had mean values above 5.0, where one item was nearly 4.0. It is likely that responses on collaborative effectiveness tend to the 'agree' position.

Third, respondents were asked to rate to what extent their food manufacturing company reduced EF waste in their supply chain operation. A seven-point Likert scale ranging from 'strongly disagree' to 'strongly agree' was used. EF waste reduction was classified into three categories, namely processing food waste, overproduction food waste and storage food waste. All these three had 11 items to measure EF waste reduction. All 11 items had mean values above 4.5.

4.2 Section 4.2: Statistical analysis

This section outlines the hypotheses tests of this study and the analysis of their results. A number of methodologies are used for hypothesis testing, but for the purpose of this study the PLS-SEM technique has been employed. Firstly, this section carried out missing value and common method bias. Then, an evaluation was made of reflective measurements indicators through internal consistency reliability, indicator reliability, convergent validity and discriminant validity to confirm reliability and validity. While formative measurements indicators validity is assessed through variance inflation factor and significance testing. In addition, an estimate of the structural model between the latent variables has been checked. After testing the proposed model, for further testing, this study also tests the mediating effect of collaborative effectiveness on a relationship between FMSC collaboration and EF waste.

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4.2.1 Missing data

Missing data is one of the most pervasive issues in quantitative research (Montiel-Overall, 2006). It is also known as item non-response, where respondents do not answer one or more items in the survey (Wagner and Kemmerling, 2010). There are several reasons for item non-response including "skip[ping] the answer of question due to lack of knowledge, unintentional oversight, and intentional non-observance because the item demands disclosure of sensitive information" (Wagner and Kemmerling, 2010). A few item non-responses are of little concern, but when there is a large number of item non-responses it may cause bias in the estimation of parameters, reduced statistical power and have a significant effect on the study's conclusion (Kang, 2013). Several researchers have tried many strategies to avoid or minimise item non-response during data collection (Kang, 2013). The 'forced answer' option eradicates item non-responses but it provides spurious answers (Denscombe, 2009). Instead of using the 'forced answer' option, researchers use the potential technical advantage of Qualtrics; namely a request responses reminder, which helps researchers to minimise item non-responses in their study. On the basis of suggestions by Hair Jr et al. (2016) and Montiel-Overall (2006), here, Qualtrics used the request reminder option for respondents to complete each item before going to the next question. This approach can motivate some respondents to stop answering the survey, but it is more helpful to prevent respondents avoid either purposely or inadvertently failing to answer one or more items (Hair Jr et al., 2016).

Still, the data from this study had item non-responses. According to Hair Jr et al. (2016) recommendation, responses exceeding 5% of item non-response were removed from the data and mean value replacement used where there were less than 5% missing values per indicator.

4.2.2 Common method bias

Common method bias (CMB) is defined by Podsakoff et al. (2003) as "variance that is attributable to the measurement method rather than to the construct of interest". This study used a survey research approach for testing theorised relationships and data were collected through a single respondent per company. Due to the mono-method research design, there is a chance for spurious correlation between the independent and dependent variables to emerge and lead to erroneous conclusions about relationships between variables (Craighead et al., 2011, Sharma et al., 2009).

There are a number of statistical techniques to address CMB in single source research. Sharma et al. (2009) reported that other statistical techniques are not well-specified in practice and have low accuracy rates, such as the marker variable technique. Therefore, the most popular, the Harman single-factor test was conducted in this study to determine whether the majority of the variance can be accounted for by one general factor. Analysis of the Harman single-factor test revealed that the first factor explained 30.95% of the variance, which is not the majority of CMB (Craighead et al., 2011). Hence, the CMB is not a serious problem with the data.

4.2.3 Model specification/ statistical analysis on model specification

In order to conduct analysis, smart PLS-SEM version 3.0 software was purchased and used as a main statistical tool in this study. The PLS path model of this study consists of the inner and outer model. The inner model is also known as a 'structural model', which is comprised of the constructs and their path relationship (hypothesized relationship) between them (Hair Jr et al., 2016, Świerczek, 2014). The outer model is known as a 'measurement model', where it describes the relationship between the indicators' variables and their corresponding construct (F. Hair Jr et al., 2014). This study first assessed the measurement model, followed by the assessment of the structural model.

4.2.3.1 Outer path model (measurement model) evaluation

The proposed measurement model is a hierarchical component model, which has first-order reflective and second-order formative types of constructs. Here, reliability and validity of the construct measures is evaluated by PLS-SEM algorithm. The PLS-SEM findings are highly reliant on the measurement model because it ensures the quality of the measure even before the path model construction (Riou et al., 2015).

For assessing the hierarchical component model, Becker et al. (2012) cited three-types of approaches from the past literature:

1) Repeated indicator approach or Hierarchical Components Approach
2) Two-stage approach
3) Hybrid approach.

Each approach has some pro and cons. In short, this study adopted the repeated indicator approach rather than the two-stage approach or hybrid approach. The repeated indicator approach is widely adopted by previous supply chain studies, such as Peng and Lai (2012), Sarstedt et al. (2014), Han et al. (2017) for specifically evaluating first-order reflective and second-order formative types of conceptual model because it easy to use and includes the whole nomological network. Here, this study followed previous studies' adopted approach to evaluate reflective and formative constructs.

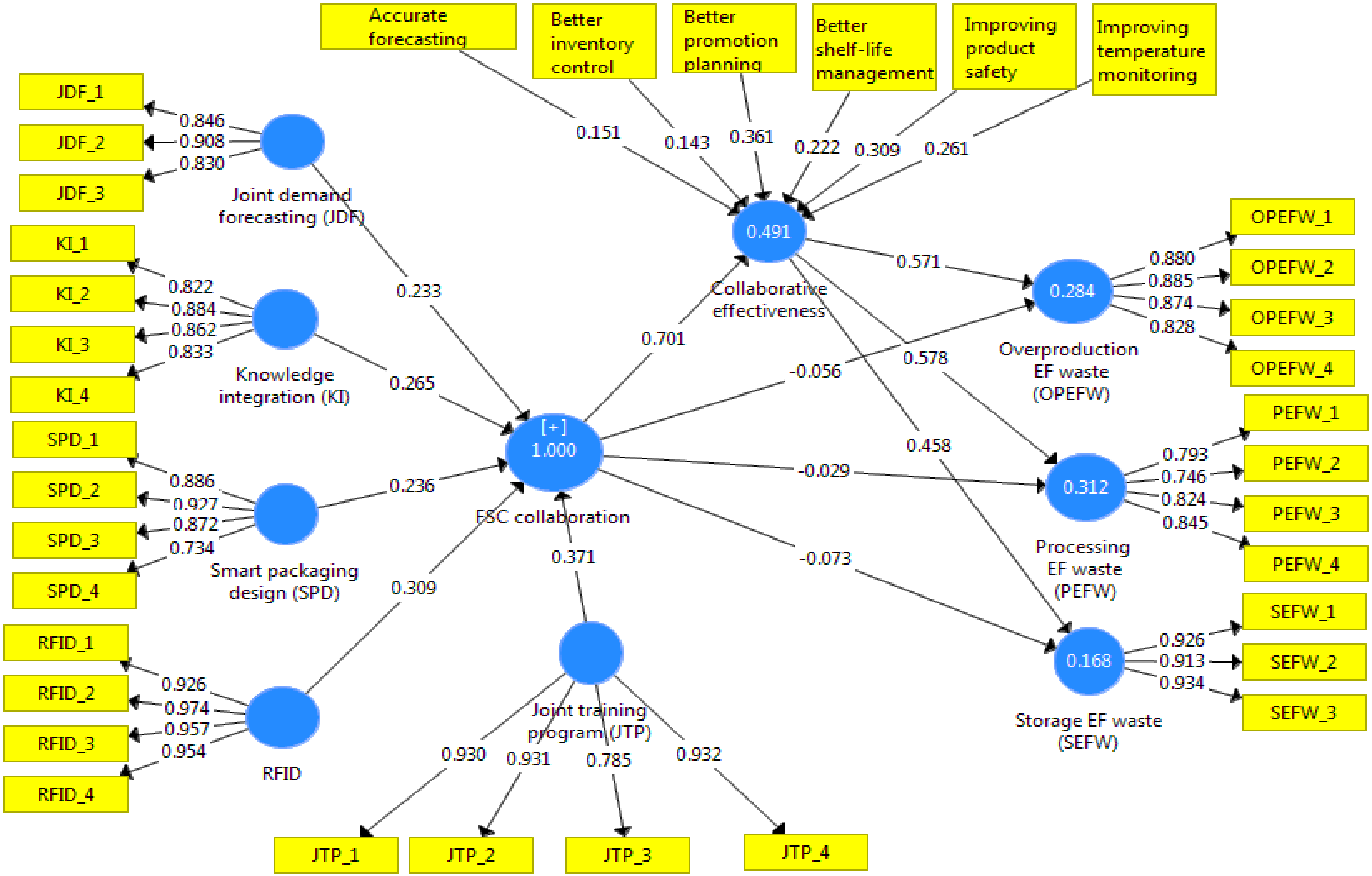

Figure 6: Structural Model

4.2.3.1.1 Evaluation of the reflective measurement indicators

This study follows the recommendations made by Hair Jr et al. (2016) for evaluating a reflective measurement model. It was assessed by considering composite reliability (evaluate internal consistency), individual indicator reliability, convergent validity and discriminant validity.

Internal consistency reliability

Traditionally, Cronbach's alpha is used for internal consistency reliability. But, due to Cronbach's alpha's limitation, Hair Jr et al. (2016) gave two specific reasons to use composite reliability for evaluating internal consistency reliability of reflective indicators in PLS-SEM. Firstly, composite reliability does not assume that all indicators loadings are equal in the population and secondly, it is able to accommodate individual indicators' reliability (F. Hair Jr et al., 2014). According Hair Jr et al. (2016)'s suggestion, the threshold value required is 0.70 or higher to demonstrate a satisfactory internal consistency reliability. The scores of composite reliability are summarised in Table 10. The composite reliability of each reflective construct in the measurement model was well above the recommended threshold of 0.70, ranging from 0.88 to 0.96. On the basis of the results, all reflective constructs met the recommended threshold value for acceptable reliability.

Indicator reliability

The square of a standardized indicator's outer loading represents "how much of the variation in an item is explained by the construct" (Hair Jr et al., 2016). It is evaluated by observing the factor loading and each indicator's variance. The threshold values of indicator reliability should be larger than 0.70 and the latter should be no less than 0.50 (Cao et al., 2015). All indicator reliability of the all reflective measurements met the above two criteria, which indicates satisfactory indicator reliability.

Convergent validity

This refers to the model's ability to explain the indicator's variance (Wong, 2015). It was assessed through average variance extracted (Jan et al.). Table 10 indicates that Average Variance Extracted (Jan et al.) values of each reflective measured construct exceed the minimum threshold value of 0.50. Convergent validity is also satisfactory.

Discriminant validity

This represents whether a construct is truly distinct from other constructs (Hair Jr et al., 2016). There are the two methods to evaluate discriminant validity, the Fornell-Larcker criterion and cross-loading examination. In the Fornell-Larcker criterion, "the square root of AVE value of each construct must be larger than its correlation with any other construct" (Hair Jr et al., 2016). While in the cross-loading method, "loading of each reflective indicator on its construct should be higher than cross loadings on other constructs" (F. Hair Jr et al., 2014). The column and row intersection presents the square root of the AVE value, which clearly indicates that the square root of the AVE for each reflective construct is much larger than its highest correlation with other constructs. That means each construct shares more variance with its own indicators rather than with the indicators of any other construct (F. Hair Jr et al., 2014). The second test, based on the cross-loading results in Table 11, show loading of each reflective indicator was highest on the construct it was associated with. Thus, overall results suggested that construct discriminant validity was met for this research.

The obtained results clearly indicate that all evaluation criteria for reflective measurement indicators have met reliability and validity.

Table 10: TABLE Composite reliability scores and Average Variance Extracted values of the reflective measured constructs.

Construct.	Indicators	Loading.	Indicator reliability.	Cronbach's Alpha	Composite Reliability	AVE
Joint demand forecast	JDF_1	0.846	0.715	0.827	0.897	0.743
	JDF _2	0.908	0.824			
	JDF _3	0.83	0.689			
Knowledge integration	KI_1	0.822	0.676	0.873	0.913	0.724
	KI _2	0.884	0.781			
	KI_3	0.862	0.743			
	KI_4	0.833	0.693			
Smart packaging design	SPD_1	0.886	0.785	0.878	0.917	0.736
	SPD_2	0.927	0.86			
	SPD_3	0.872	0.76			
	SPD_4	0.734	0.54			
Using RFID	RFID_1	0.926	0.857	0.966	0.975	0.909
	RFID_2	0.974	0.948			
	RFID_3	0.957	0.915			
	RFID_4	0.954	0.91			
Joint training programme	JTP_1	0.93	0.864	0.917	0.942	0.805
	JTP_2	0.931	0.866			
	JTP_3	0.785	0.616			
	JTP_4	0.932	0.868			
Processing EF waste.	PEFW_1	0.793	0.628	0.819	0.878	0.644
	PEFW_2	0.746	0.565			
	PEFW_3	0.824	0.678			
	PEFW_4	0.845	0.714			
Over production of EF waste	OPEFW_1	0.880	0.774	0.890	0.924	0.752
	OPEFW_2	0.885	0.783			
	OPEFW_3	0.874	0.764			
	OPEFW_4	0.828	0.685			
Storage of EF waste	SEFW_1	0.926	0.857	0.915	0.946	0.855
	SEFW_2	0.913	0.833			
	SEFW_3	0.934	0.872			

Table 11: Table Cross-loading results for the reflective measured constructs

Fornell-Larcker criterion	CE	FMSCC	JDF	JT	KI	OPEFW	PEFW	RFID	SEFW	SPD
CE	NA									
FMSCC	0.701	NA								
JDF	0.537	0.741	0.862							
JTP	0.621	0.793	0.465	0.897						
KI	0.498	0.702	0.482	0.342	0.851					
OPEFW	0.532	0.345	0.335	0.365	0.146	0.867				
PEFW	0.558	0.377	0.265	0.334	0.26	0.658	0.803			
RFID	0.419	0.608	0.246	0.431	0.235	0.24	0.238	0.953		
SEFW	0.407	0.248	0.197	0.192	0.108	0.691	0.625	0.218	0.925	
SPD	0.352	0.675	0.559	0.382	0.534	0.071	0.201	0.081	0.147	0.858

4.2.3.1.2 Assessment of formative measurement indicators

The assessment of formative measurement is quite different as compared with reflective measurement assessment. Peng and Lai (2012) recommended two levels of tests for evaluating formative measurement indicators. The Table 12 summarizes the two levels of test.

Table 12: TABLE Tests for assessment of formative measurement indicators

	Aspect of validity	Description	Test
Item-level tests	Contribution of each item to the formative construct	Items weight should be large and significant.	Check the outer weight. Which is should be no less than 0.10.
	Multicollinearity between the items.	No collinearity issues among the items.	Check variance inflation factor. Which should be lower than 5.
Construct-level tests	Convergent validity.	Examine the correlation with an alternative measure.	Test through single item measure.
Adopted from Peng and Lai (2012).			

This research is unable to assess the convergent validity of the formative construct because the research design does not include an additional reflective construct (single-item measure) that serves as a 'shadow' of the formative constructs (Peng and Lai, 2012), because Kaufmann and Gaeckler (2015) pointed out that a single-item construct might be "aggravate PLS's tendency to underestimate structural model relationship".

Due to adopting the repeated indicator approach, here, FMSC collaboration was the formative second-order latent variable, which was specified through using all 19 manifest variables of the underlying first-order latent variables, as per Becker et al. (2012) guideline.

In the next step, the variance inflation factor (VIF) values were evaluated with collinearity statistics for assessing the multicollinearity level of the formative construct. As per Hair Jr et al. (2016) guideline, the 'formative indicators of a specific formative construct' were used as independent variables and dependent variable to see collinearity of indicators. In the results table 13, all VIF values were below the threshold value of five. That means collinearity is not an issue for the formative construct and also the estimation of the PLS path model.

Table 13: TABLE Variance inflation factor results.

Formative measurement scales	**VIF values**
Accurate forecasting	1.624
Better Inventory control	1.387
Better Promotions planning	1.484
Improving product safety	1.73
Better shelf life management	1.429
Improving temperature monitoring	1.213

Now, the bootstrapping process runs to examine the significance and relevance of the formative indicators. The significance and relevance of the formative items were estimated through the values of outer weight (Peng and Lai, 2012). Based on the report of the bootstrapping process, as per Peng and Lai (2012)'s recommendation, Table 14 illustrates that the item weight for promotion, safety and temperature were greater than 0.10 and they were significant at the $p<0.01$ level, so they were statistically significant. Rest of the three, accurate forecast, inventory and shelf-life management, were not significant at the $p<0.01$ level. Despite that, according to Hair Jr et al. (2016), these three non-significant indicators' outer loading were higher than 0.50, so they were retained. Thus, the formative measurements were valid.

Table 14: TABLE Significance testing results for the formative items.

Significance testing results.	Item weight	Item weight P Values	Significance level	Outer loading
JDF_1 <- FMSCC	0.093	0	***	0.643
JDF_2 <- FMSCC	0.096	0	***	0.678
JDF_3 <- FMSCC	0.08	0	***	0.592
KI_1 <- FMSCC	0.075	0	***	0.559
KI_2 <- FMSCC	0.078	0	***	0.591
KI_3 <- FMSCC	0.09	0	***	0.674
KI_4 <- FMSCC	0.07	0	***	0.553
SPD_1 <- FMSCC	0.069	0	***	0.597
SPD_2 <- FMSCC	0.073	0	***	0.595
SPD_3 <- FMSCC	0.075	0	***	0.605
SPD_4 <- FMSCC	0.056	0	***	0.512
RFID_1 <- FMSCC	0.077	0	***	0.552
RFID_2 <- FMSCC	0.085	0	***	0.597
RFID_3 <- FMSCC	0.082	0	***	0.583
RFID_4 <- FMSCC	0.08	0	***	0.583
JTP_1 <- FMSCC	0.104	0	***	0.718
JTP_2 <- FMSCC	0.097	0	***	0.701
JTP_3 <- FMSCC	0.099	0	***	0.659
JTP_4 <- FMSCC	0.113	0	***	0.763
ACCURATE FORE -> Effectiveness	0.151	0.18	NS	0.661
INVENTORY -> Effectiveness	0.143	0.243	NS	0.614
PROMOTION -> Effectiveness	0.361	0.003	***	0.769
SAFETY -> Effectiveness	0.309	0.019	**	0.733
SHELF LIFE -> Effectiveness	0.222	0.118	NS	0.685
TEMPERATURE -> Effectiveness	0.261	0.016	**	0.599
NS means not significant. *p<0.10, **p<0.05, ***p<0.01				

4.2.3.2 Structural model evaluation

Structural model represents the underlying concept of the path model. As per F. Hair Jr et al. (2014)'s suggestion, once the measurement model's reliability and validity were confirmed then the next step is to assess the hypothesized relationships within the structural model. The result of the structural model determines how well the data support the concept of the path model (Hair Jr et al., 2016). This step is also known as the 'assessment of the model's quality'. There are several procedures for structural model assessment.

4.2.3.2.1 Collinearity assessment

Collinearity assessment is pivotally important in the structural model, specifically to check path coefficient bias through collinearity levels among the predictor constructs. As per the step-by-step guidance by Wong (2015) for collinearity assessment, on the basis of the latent variable scores in the PLS-SEM calculation report, four different sets of predictor constructs were evaluated through linear regression in SPSS version 19 to obtain their corresponding VIF values. The results are summarized in Table 15, where all VIF values are well below the threshold values of 5. That means there is no indication of collinearity between each set of predictor variables.

Table 15 Multicollinearity assessment

First set	VIF	Second set	VIF	Third set.	VIF	Fourth set	VIF
JDF	1.686	**FMSCC**	1	**Collaborative effectiveness**	1	**OPEFW**	2.278
KI	1.5					**PEFW**	1.954
RFID	1.274					**SEFW**	2.12
JTP	1.554						
SPD	1.646						

4.2.3.2.2 Path coefficients

The significance and relevance of the structural model relationships are show in Figure 7 and table 16, which represents the hypothesized relationships among the constructs. The standardized value of path coefficients ranges from -1 to +1. Results from the bootstrapping procedure (122 cases, 5,000 sample, and no sign change option) revealed that four out of seven structural relationships were significant. As the figure shows, FMSC collaboration was strongly related to collaborative effectiveness. Surprisingly, FMSC collaboration was not significant to over-production of waste, processing of waste and storage of waste. While, collaborative effectiveness was significantly related to over production of waste, processing of waste and storage of waste.

Table 16: Hypothesis result summary

Summary results of the hypotheses testing.				
	Hypothesized path	Standard path coefficient	P value	Hypothesis test.
Hypothesis -1	FMSCC -> CE	0.701	0.000	Significant
Hypothesis-2a	FMSCC->OPEFW	-0.056	0.766	Not significant
Hypothesis-2b	FMSCC->PEFW	-0.029	0.847	Not significant
Hypothesis-2c	FMSCC->SEFW	-0.073	0.542	Not significant
Hypothesis-3a	CE->OPEFW	0.571	0.000	Significant
Hypothesis-3b	CE->PEFW	0.578	0.000	Significant
Hypothesis-3c	CE->SEFW	0.458	0.000	Significant

4.2.3.2.3 Coefficient of determination (R2)

This means 'the exogenous latent variables' combined effect on the endogenous latent variables' (Hair Jr et al., 2016). R^2 is a 'measure of the model's predictive accuracy'. From the PLS path model estimation diagram 7, the R^2 value of processing of waste, overproduction of waste and storage of waste were 0.311, 0.284 and 0.168, respectively; which are deemed moderate and weak coefficients of determination.

4.2.3.2.4 Control variables

As per previous studies of Cao and Zhang (2011) and Kim and Lee (2010), firm size is used as a control variable. Therefore, firm size is measured by the total number of employees in a responding firm. Testing the effect of the control variable in PLS-SEM, firm size, shows the control variable is insignificant for this study.

4.2.3.2.5 Mediation analysis:

As per Hair Jr et al. (2016)'s study, this study conducted the mediation analysis procedure in PLS-SEM. To do so, the results showed that VAF is greater than 80 percentage which means the hierarchical approach of the mediation test and bootstrapping test found that the association between FMSC collaboration and EF waste (over-production of EF waste, processing of EF waste and storage of EF waste) is fully mediated by collaborative effectiveness.

4.3 Summary

Section 4.1 provided the descriptive analysis, which is the initial analysis of data collected through the email-based survey, by using Qualtrics software. Descriptive analysis is very important to provide the basic picture of the collected data and also very useful for model formulation prior to the empirical analysis. The total response rate was 9.7 percent. Response rate, non-response bias and respondents' characteristics were summarised in this section.

Section 4.2 described the statistical findings of the study, providing empirical testing of the causal relationship between the FMSC collaboration, collaborative effectiveness and EF waste reduction. The findings are mostly consistent with those in the literature review. Through empirical evidence, the chapter confirmed validity and reliability of the research model, and also showed all the constructs' measurement scales are statistically satisfied, which is the critical role of this section. Mediation analysis was done.

5 CHAPTER 5: FINDING AND DISCUSSION

The overall goal of the study was to examine the causal relationship between FMSC collaboration, collaborative effectiveness and EF waste reduction in the UK FMSC. In order to fill the research gap, through the rigorous literature review and theoretical foundation, this study developed the conceptual model and proposed the hypotheses. Subsequently in this study, the proposed hypotheses are empirical tested. PLS-SEM was used to review all the conceptualised constructs and specify them as formative and reflective; then the validity and reliability of both formative and reflective indicators was tested. All the first-order and second-order formative and reflective indicators are shown to meet the validity and reliability tests.

Here, as per previous collaborative studies Cao and Zhang (2011), Seo (2014) and Piboonrungroj (2012), this study also followed the approach of previous studies to combine findings and discussion chapters. This study explains the findings of each hypothesis, and at the same time also elucidates findings related discussion because hypothesis testing and its associated findings is easily compared and contrasted with the literatures.

5.1 Research finding and discussion

This study attempted to answer the following research questions:

- **Research question 1:** What are the key dimensions of FMSC collaboration?
- **Research question 2:** What are the key dimensions of collaborative effectiveness (in the context of FMSC) and EF waste reduction?
- **Research question 3:** To what extent does the FMSC collaboration influence collaborative effectiveness?
- **Research question 4:** To what extent does FMSC collaboration affect EF waste reduction?
- **Research question 5**: To what extent does collaborative effectiveness affect EF waste reduction?

This study has defined and operationalized a set of all the comprehensive components of FMSC collaboration, collaborative effectiveness and EF waste. To the best of the author's knowledge, this study has made contribution by proposing one of the first multi-dimensional construct models of FMSC collaboration, which also reflects the nature of the FMSC industry. This study has accurately and comprehensively identified what is lacking in the previous literature's frameworks on the extent of FMSC collaboration. The study has identified five key dimensions of the FMSC collaboration: joint demand forecasting, using RFID technology, smart packaging design, joint training programme, and knowledge integration. As per Coltman et al. (2008)'s study, none of five key components of FMSC collaboration in this study shared a common theme and also were not interchangeable; so, they used second-order formative indicators which formed the latent construct (FMSC collaboration). Each second-order component is measured through sub-components, which have shared common themes and are interchangeable, so they were used as first-order reflective items (Coltman et al., 2008).

In addition, this study has emphasized collaborative effectiveness which resides across the firm's boundaries through collaboration between the FMSC members, not within an individual firm (Cao and Zhang, 2012). Although previous studies attempted to conceptualised collaborative effectiveness, in the context of FMSC collaboration, a reliable and valid operationalization of the collaborative effectiveness concept has not been undertaken so far, to the best of the author's knowledge (Cao and Zhang, 2012). In this study, six different dimensions were identified for collaborative effectiveness: accurate forecasting, better promotional planning, improving product safety, improving temperature monitoring, better inventory controls, and better shelf-life management. They are all first-order formative indicators due to the items not sharing a common theme and not even being interchangeable. EF waste is measured by three categories including over-production of EF waste, processing EF waste and storage of EF waste.

Research questions 3, 4 and 5 were converted into hypotheses. All research hypotheses were empirically tested in chapter 4 by using structural equation modelling.

5.1.1 Research finding and discussion relating to hypothesis 1

To explore the relation between FMSC collaboration and collaborative effectiveness the following hypothesis was proposed:

H1: FMSC collaboration is positively associated with collaborative effectiveness.

The study finding shows significant association between both variables ($p < 0.001$). The result suggests that collaborative effectiveness is significantly enhanced through the collaboration between the FMSC members. The finding is consistent with previous research, with Cao and Zhang (2011), Yilmaz et al. (2016), Seo (2014) and Chakraborty et al. (2014) suggesting that there is a positive relationship between the collaboration and collaborative effectiveness. FMSC collaboration enables the FMSC members to improve their efficiency and effectiveness. Collaborative FMSC members can expand their market share through combining and exchanging their idiosyncratic assets, knowledge and capabilities (Cao and Zhang, 2011). According to RV theory, FMSC members involved in intense collaborative efforts through relation-specific assets, share knowledge and combine complementary resources (such as RFID, knowledge integration, joint training programmes and joint demand forecasting) to forge a better idiosyncratic inter-firm relationship, which leads to accruing a source of relational rents (collaborative effectiveness) (Turkmen, 2013).

Knowledge integration between the supply chain partners facilitates the problem solving approach efficiently in the operational process. Collaboration with the downstream partners has a positive impact on manufacturing performance, improving product quality and shortening the lead time (Mishra and Shah, 2009). FMSC collaboration facilitates joint planning, execution for efficient promotion planning and on-time replenishment through demand information sharing (Sridharan and Simatupang, 2009). Through FMSC collaboration, food manufacturing companies are able to attain better tracking and tracing of the food product; synchronize decisions for production planning and ordering; enabling them to fulfil demand with minimum inventory (Sridharan and Simatupang, 2009). Joint expertise sharing and the quality, timeliness and usefulness of demand information shared with each other generates visibility that leads to meaningful operational benefits and develops super-additive synergies, which means collaborative effectiveness (Mishra and Shah, 2009, Barratt and Barratt, 2011). In a decentralized FMSC, RFID technology assists the food manufacturing company in reducing out-of-stock items, compressing lead times, improving transportation efficiency, saving labour, and tracing items in a more practical environment; most vital is strengthening the cooperation between the FMSC partners (Cui et al., 2017). Through smart packaging design, FMSC members monitor the food product and storage conditions of the perishable food products, which helps improve product safety. Joint training programmes enhance the employee's food handing procedure and improves knowledge about cross-contamination, which leads to increased food safety. So it is true that this study finds that collaboration between the FMSC members achieves a higher level of collaborative benefits; and it also improves the efficiency and effectiveness of the entire operational and logistic activities of the FMSC.

5.1.2 Research finding and discussion relating to hypothesis 2

To explore the relation between FMSC collaboration and EF waste reduction the following hypotheses was proposed:

H2a: FMSC collaboration is positively associated with reduction of over-production of EF waste.

H2b: FMSC collaboration is positively associated with reduction of processing EF waste.

H2c: FMSC collaboration is positively associated with reduction of storage EF waste.

Our finding shows that there is a statistically insignificant direct relationship between FMSC collaboration and all three types of EF waste reduction, which indicates that EF waste is not reduced by the direct impact of FMSC collaboration. When this result is compared with those from previous research, the finding is consistent with several previous studies such as Seo (2014), Vickery et al. (2003) and Piboonrungroj (2012) that have shown that supply chain collaboration had no significant direct paths to firm performance. That means, without generating relational rent or collaborative effectiveness, FMSC members cannot reduce EF waste. Moreover, for the direct relationship between FMSC collaboration and all three types of EF waste reduction, Seo (2014) describes the links as spill-over (internal) rents, which means a direct private benefit to the firms. However, according to Seo (2014), the effects of spill-over internal rents were rejected in this study (not the relational rent). Mishra and Shah (2009) reviewed the rich collaborative literature and noted that past research had shown mixed findings on the relationship between inter-firm collaboration and firm performance, which is mostly remained unexplained in previous literature. That is supported by Cao and Zhang (2011), who obtained a positive relationship between supply chain collaboration and firm performance. However, Piboonrungroj (2012) argued that Cao and Zhang (2011)'s study focused on competitive advantage for an individual firm (not collaborative advantage); furthermore, their collaborative construct and competitive advantage constructs were different as compared to this study's constructs, and they also operationalized both constructs completely differently. As per Lavie (2006)'s study, Cao and Zhang (2011) focused on unilateral accumulation of spill-over internal rent that directly generates private benefits (not the common or mutual benefits) for firms.

On the basis of the analyses of Eikelenboom (2017)_and Mishra and Shah (2009) on the mixed results of RV theory, that is a plausible reason for the insignificant effects of FMSC collaboration on EF waste reduction as the FMSC collaborative components used in our study have been derived from existing literature. It might be possible previous works have been optimised towards measuring the collaborative effectiveness (especially regarding the concepts of relational rent and inter-firm linkage), rather than direct relationship related to better organizational outcomes in terms of financial performance and firm performance.

A Second explanation, based on Vickery et al. (2003), Seo (2014) and Piboonrungroj (2012) is that studies have focused on only one industry or one context, FMSC, maritime industry and tourism, respectively; therefore, this could be the reason for no direct path relationship between FMSC collaboration and EF waste reduction. In comparison, Cao and Zhang (2011)'s study showed a significant relationship between collaboration and firm performance because it might be possible that authors have been concentrating on multiple manufacturing industries, not a single industry or context (Vickery et al., 2003).

5.1.3 Research finding and discussion relating to hypothesis 3

To explore the relation between collaborative effectiveness and EF waste reduction the following hypotheses was proposed:

H3a: Collaborative effectiveness is positively associated with reduction of over-production of EF waste.

H3b: Collaborative effectiveness is positively associated with reduction of processing EF waste.

H3c: Collaborative effectiveness is positively associated with reduction of storage EF waste.

The finding reveals that there is a statistically significant relationship between collaborative effectiveness and all three types of EF waste reduction. The finding is consistentwith previous collaborative studies including Cao and Zhang (2011), Seo (2014) and Piboonrungroj (2012); these ascertained that collaborative effectiveness improves operational, logistical and supply chain performance. Through collaborative effectiveness in terms of accurate forecasting, FMSC members can efficiently manage the optimal order quantity at different levels under different circumstances, such as during promotion, which leads to reducing promotion- and forecast-related EF waste. Collaborative effectiveness improves product safety and temperature monitoring efficiency that can help in reduction of EF waste which is generated due to lack of freshness, change in aroma and flavour, microbial spoilage, and temperature fluctuations during the preparation and distribution of perishable food (Lorite et al., 2017). Collaborative effectiveness decreases inventory inaccuracies and maintains proper stock rotation, which can reduce inventory waste and out-of–date-related EF waste (Cui et al., 2017). Collaborative effectiveness is the value-creation from FMSC collaboration, which could enhance profitability and cost-saving through reduction of over-production, processing and storage of EF waste.

Moreover, as per Seo (2014)'s study, this study's finding revealed strong positive relationships between FMSC collaboration and collaborative effectiveness; and collaborative effectiveness and EF waste reduction. However, the empirical evidence demonstrates that the path from FMSC collaboration to EF waste was statistically rejected. Therefore, for confirmatory purposes, it is worthwhile investigating a mediating role of collaborative effectiveness on the association between FMSC collaboration and all three types of EF waste. The mediation analysis confirmed that the relationship between the FMSC collaboration and all three types of EF waste reduction is indirect and confirmed the full mediation effect of collaborative effectiveness on the relationship between FMSC collaboration and all three types of EF waste reduction. That means that FMSC members cannot generate internal rent (private benefits) without the relational rent, which means collaborative effectiveness is necessary to reduce EF waste in the FMSC.

5.2 Summary

The purpose of this chapter is to interpret and describe the significance of the findings of this study. Here, this chapter critically discusses to what extent FMSC collaboration influences collaborative effectiveness and edible food waste reduction. The findings, by using SEM models with the web-based survey, confirmed that FMSC collaboration has a positive impact on collaborative effectiveness, and in turn this improved collaborative effectiveness has a positive impact on edible food waste reduction. This chapter acknowledges that FMSC collaboration does not directly influence edible food waste reduction.

6 CHAPTER 6: CONCLUSION, IMPLICATION, LIMITATION AND FUTURE WORK.

This chapter considered the contribution to theories, theoretical implication, managerial Implication, environmental implication, social implication, economic implication, limitation and future research and finally conclusion.

6.1 Contribution to theories

This study used RV theory as grounds for understanding of role of FMSC collaboration and collaborative effectiveness in EF waste reduction. By adopting RV, this study focused on a two-echelon network in place of individual organisations, and RV helps to provide a more coherent support for understanding of this work's view of collaboration in the FMSC context (Chen and Paulraj, 2004). RV addressed how relationship-specific assets can improve coordination of tasks or activities between FMSC members in order to accomplish mutual goals; and also examined how FMSC members enable themselves to gain collaborative effectiveness (Paulraj et al., 2008). Here, RV also explained the joint value creation process through showing the positive path between FMSC collaboration and collaborative effectiveness. RV also helps in explaining how relational rents (collaborative effectiveness) are generated through collaborative FMSC operational and logistic activities; and also how the generated relational rents reduce EF waste. Cao and Zhang (2011) stated that RV directly generates both types of rents – including relational rent (collaborative benefits or common benefits) and spill-over internal rent (private benefits), but this study results revealed that RV cannot directly generate spill-over internal rent.

6.2 Theoretical implications

This study introduced the conceptual framework that shows relationship between FMSC collaboration, collaborative effectiveness and EF waste. Through using a wide range of collaboration literature, FMSC management literature and RV theory, this study has contributed by developing instruments of FMSC collaboration, collaborative effectiveness and EF waste; and has validated them statistically. Those instruments can be used for collaboration formation and evaluating causes and effects of collaboration in other industry supply chains. The constructs of the conceptual framework and their related measurement scales specifically offer a more nuanced view of FMSC collaboration, and also provide a rich and structured understanding of FMSC collaboration, which has not been adequately addressed in the extant literature (Matopoulos et al., 2007, Cao and Zhang, 2012), which is one of the main contributions of this research.

This research has emphasised the concept of collaborative effectiveness rather than competitive advantage. Collaborative effectiveness resides not within an individual FMSC firm, but across an FMSC firm's boundaries via partnering (Cao and Zhang, 2012). It is the common or relational benefits gained by a group of collaborative FMSC firms. The concept of collaborative effectiveness is discussed in a previous study in another industry supply chain (Cao and Zhang, 2011, Seo, 2014), but a reliable and valid operationalization of the concept, specifically for the FMSC, has never been done to the author's best knowledge. This research has defined and operationalized collaborative effectiveness as six items: accurate forecasting, better promotional planning, improving product safety, improving temperature monitoring, better inventory control and better shelf-life management. The operationalization of the concept facilitates further empirical research efforts. The collaborative effectiveness created by FMSC collaboration is undoubtedly an interesting research issues. Jointly creating the demand forecast, knowledge integration and joint training programme can improve forecast accuracy, planning, monitoring and product safety.

This study results indicate that collaboration has a direct positive relationship with collaborative effectiveness, but it does not have a direct relationship with EF waste reduction. While, collaborative effectiveness has a direct relationship with EF waste. This study is the first which has highlighted that without generating collaborative effectiveness (collaborative or mutual or common benefits), collaborative firms cannot gain internal rent (private benefits or individual benefits); this had not been empirically tested in previous literature (Seo, 2014). These findings offer new and precise insights to the literature on supply chain collaboration (Cao and Zhang, 2012). This study has also theoretically proved that supply chain partners can gain more benefits when they are actively involved in collaborative practices (Cao and Zhang, 2012). The conceptual framework of this study also benefits other sectors, including pharmaceuticals, which has many products, intermittent demand and limited shelf-life of medicines.

In short, the thesis, for the first time, provides a novel conceptual framework and empirical evidence for the impact of FMSC collaboration on EF waste reduction. The concept of FMSC collaboration can be used by food chain members to build collaboration with their FMSC partners that will lead to achieving collaborative effectiveness and which will help in reduction of EF waste.

6.3 Managerial implication

The empirical findings of this study have various practical implications for practitioners in FMSCs. The results of this study suggest that food manufacturing companies and their downstream partners should implement collaborative practices in their supply chain operation and pursue higher collaborative effectiveness.

This study also suggests that firms should need to more proactively synchronize their activities or resources with partners to derive real operational benefits of collaboration. A relation-specific investment may create risk for a collaborative relationship, such as opportunistic behaviour. Therefore, Cao and Zhang (2012) suggested that a FMSC company should be aware of these risk factors to better manage the collaboration with their partners. FMSC companies must also be willing to engage in knowledge transfer or knowledge acquisition, joint learning processes, demand information sharing, regularly update inventory status and maintain train employees to enhance collaborative effectiveness, and that will help to address EF waste issues efficiently.

The conceptual framework and empirical findings of this study provide important guidance to FMSC members to achieve collaborative effectiveness. FMSC members require understanding of each other’s requirements and capabilities as well, and should also focus on coordination rather competition, which helps in creating higher relational rents (Cao and Zhang, 2012) that lead to reducing EF waste; this is because, according to the study results, without generating collaborative effectiveness (relational rent), FMSC members cannot reduce EF waste. The study evaluated five dimensions of FMSC collaboration and the study findings reveal that all five dimensions of FMSC collaboration are significantly important to food manufacturing companies and their downstream partners to capitalize the full benefits of collaboration (Kumar and Nath Banerjee, 2012).

Although, Cao and Zhang (2011) and Piboonrungroj (2012) analysed many previous collaborative studies and found that there are many significant benefits from collaboration, FMSC managers still struggle to achieve this. The study has addressed the issues of EF waste in the UK FMSC and examined to what extant FMSC collaboration affects EF waste reduction through structural equation modelling. It was confirmed through survey that FMSC members can reduce their EF waste from collaboration, if their supply chain's operational and logistical activities are coordinated with their FMSC partners. The results of this study also indirectly suggest to practitioners that to achieve EF waste reduction, FMSC companies and their partners should reduce their operational costs which will lead to a boost in their financial and operational performance. Therefore, FMSC practitioners could use this study's conceptual framework and results to identify the inter-relationship between collaboration and EF waste reduction in their operating environments.

The findings of this study assure the practitioners that deploying advanced technology (RFID) and smart packaging design in a different way (e.g. for safety, communication, tracing and intelligence) and coordinating supply chain operational and logistical activities can reduce EF waste. As per Cao and Zhang (2012), page-160) "advance technology has become a foundation of doing business and their effective use has become a necessary condition for FMSC firms to survive in collaborating with their supply chain partners".

The definition and measurement of FMSC collaboration and collaborative effectiveness of this study help the practitioners to define specific actions to be taken collaboratively to coordinate FMSC operational and logistical activities which lead to benefits for all the members of FMSC; and also help the practitioners to change their mind-sets from competition only to coordination because if FMSC firms work closely with their partners to jointly create values (collaborative effectiveness) that generate common benefits, so FMSC firms can improve their absorptive capacity to earn internal rents (private benefits). Moreover, the measurements of FMSC collaboration and collaborative effectiveness can serve as a powerful tool for practitioners to form effective collaborative relationships as well, improve supply chain operational and logistical processes, and most importantly it will also help FMSC members to minimise the chance of collaboration failure.

6.4 Environmental implication

Reduction of EF waste means improving the cropland, food security and natural resources depletion (such as soil nutrients, water and energy) so it will help to preserve world's natural resources for the generations to come. Another environmental impact of EF waste is to produce methane and carbon dioxide through its final disposal to landfill and also its previous cycle stage of food (such as processing, manufacturing, transportation, storage and refrigeration) before it becomes waste (Papargyropoulou et al., 2014). Embedded carbon and landfill disposal produces the equivalent of at least 17 million tonnes of carbon dioxide every year that is responsible for 7% of all global greenhouse gas emissions (GHGs) (Papargyropoulou et al., 2014), having a direct climatic effect of changing temperature and precipitation. So reducing EF waste reduces the emission of methane and carbon dioxide which make a significant contribution to tackling climate change (Papargyropoulou et al., 2014). There are the other important secondary environmental benefits of reducing EF waste, including protecting soil from degradation, decreasing the pressure for land conversion into agriculture, conserving energy and therefore protecting biodiversity, carbon sinks and reducing the effects of global warming such as avoiding drought and rising sea level (Kummu et al., 2012).

6.5 Social implication

EF wasted has a direct and negative impact on the income of communities; and greenhouse gas emissions also could have adverse consequences for human health (Papargyropoulou et al., 2014). Therefore reduction of EF waste could have an immediate and significant impact on their livelihoods, and poor people can afford more nutritious food products (reducing social inequality in terms of food access) because reducing EF waste could be one of the ways to bring down the cost of food to communities (Papargyropoulou et al., 2014). Moreover, reduction in EF waste that means our future generations are more likely to have access to sufficient quantity and quality of food. Due to the reduction of EF waste, greenhouse gas emissions also reduced which leads to reduced air pollution, and that leads to reducing the incidence of health problems, such as the cancer, asthma and other cosmetic problems (Chen, 2014). There is an indirect rebound effect that takes place, such as when a consumer reduces the amount of food they buy and so their incomes increase. Consumers are able to purchase other goods and more services with the same budget.

6.6 Economic implication

Focusing on the economic contribution of this research, reduction of EF waste that means less energy, raw material, and human capital are usage by FMSC companies and their partners. Hence, both the financial and the operational performance of all downstream FMSC entities could be improved. Bacchi (2017) report in Rome showed that if FMSC companies and their partners spent one dollar on reducing EF waste, businesses could save an average $14, while UK FMSC companies could save average as much as £1,000 per employee. Businesses can cut EF waste disposal costs and also compliance with environmental legislation becomes cheaper and more straightforward (nibusinessinfo, n.d.). By taking environmental responsibilities seriously, businesses can improve their reputation among communities, business partners and employees (nibusinessinfo, n.d.).

Therefore, FMSC collaboration reduces EF waste which leads to significantly reduced environmental impacts, consumer pricing for healthy foods, and generated profit for FMSC companies.

6.7 Limitation and future research

This study has made significant contributions to academia and practice, but there are some limitations, which also point to possible future research areas**.** This study uses a non-probability (convenience) method of sampling. Though appropriate for the exploratory nature of the study, future research should adopt a more rigorous sampling technique in order to improve generalisability. This study has focused on dyadic relationships with vertical downstream partners (specifically, retailers only), so future research should consider dyadic relationships with downstream partners (wholesalers) or upstream partners (suppliers). This study did not consider horizontal collaboration in the FMSC; so future research can use the same scale to evaluate collaborative relationships horizontally among FMSC members. As Mason et al. (2007) suggested, if future research considers the combination of vertical collaboration with horizontal collaboration, it would have more value for FMSC's managers.

Future research can use multiple methods to collect the data from respondents. Cao and Zhang (2011) noted that a single respondent or key respondents may generate some inaccuracy, even though they have direct experience of collaboration; so future research should use a multiple-respondents strategy from each participant organisation to further validate these findings. Future research should use this study's instruments for different industries to validate these findings in other industry contexts, check for generalisability and also help to identify any industry-specific bias towards or against collaboration.

The nature of FMSC collaboration and its impact on collaborative effectiveness and EF waste reduction may take a long time. Also, collaboration induces additional collaboration over time (Seo, 2014). Therefore, future research should adopt a longitudinal study, which may yield accurate insights.

This study is focused on UK-based FMSC to reduce EF waste; but future research should use the same hypothesised structural relationship in different countries to determine any country-specific facilitating and inhibiting factors; and also compare the level of collaboration across countries. Future research can expand the research model by adding new constructs, for example environmental, economic and social sustainability performance.

Some studies (Bombaywala, 2014) mention that power and trust is major barrier for collaboration in the FMSC. It would be worthwhile if any future study qualitatively and empirically scrutinises how this power inequality and lack of trust impacts on FMSC collaboration and collaborative effectiveness to reduce EF waste.

6.8 Conclusion

The aim and objective of this research was to examine the impact of FMSC collaboration on collaborative effectiveness and EF waste reduction, and also to examine the impact of collaborative effectiveness on EF waste reduction. In addition, the research has identified the key dimensions of collaboration and collaborative effectiveness in the context of the FMSC. There has been scant research on the reduction of EF waste resulting from collaboration among FMSC members; therefore this research fills this gap. The vast amount of EF waste is created at the UK FMSC stage. There is high direct and negative impact on the environment, economics and society. The study's results revealed that EF waste can be reduced through collaborative effectiveness, while, surprisingly, a direct relationship between FMSC collaboration and EF waste reduction is not shown as statistically significant. This means when FMSC members collaborate with their downstream partners, it will generate higher relational rent (collaborative effectiveness) or common benefits and that will lead to reducing EF waste in the UK FMSC. This result is interpreted that without collaboration among FMSC members, it will not be possible to reduce EF waste because if FMSC members are not coordinated, this will not generate collaborative effectiveness and if collaborative effectiveness is not generated, FMSC members cannot reduce the EF waste in their supply chain operation and logistic operations. Therefore, this study strongly encourages FMSC members to coordinate with their partners, which will help in coordinating their supply chain's operational and logistical activities to reduce EF waste, which could lead to reducing environmental, economic and social impacts. Overall the key dimensions of FMSC collaboration and collaborative effectiveness will enable FMSC entities to reduce their EF waste and also minimise EF waste's direct and negative impacts, increase their performance, increase their profits, and enable future generations to have access to sufficient and good quality food.

The most important implication is that the outcome of this study justifies raising awareness of the impact of collaboration on EF waste reduction in FMSC among the managers of FMSC companies because managers still struggle to implement collaboration in their supply chain's operation and logistics. Different factors that possibly contribute to a reduction of EF waste have been explored in previous literature (Darlington et al., 2009, Papargyropoulou et al., 2014, Nabhani and Shokri, 2009). The importance of collaboration as a solution to EF waste reduction has been considered in the literature (Mena et al., 2011), but it has never been empirically tested and proven to exist. This study's empirical findings proved that collaboration between FMSC partners could lead to a reduction in EF waste. Therefore, FMSC partners need to rethink to implement collaborative practices in order to reduce their EF waste.

Moreover, the findings of this research could be used as a toolkit to assess existing collaborative relationships in the FMSC. FMSC entities could use the key dimensions of FMSC collaboration of this research (i.e. joint demand forecasting, joint training programmes, smart packaging, knowledge integration and using RFID) as a checklist to assess their existing collaborative relationships with their downstream supply chain partners. By doing so, FMSC entities will be able to see whether their existing collaborative relationships are beneficial for them or not, and whether their EF waste is reduced or not through this collaborative relationship. Thus, based on the assessment, FMSC entities will be able to identify the most beneficial collaborative relationships for them and avoid any imperative barriers (including lack of trust, scepticism about new technologies and conflict of interest) to minimise the risks of collaboration failure.

This study acknowledged its limitations in terms of the dyadic relationships with vertical downstream partners, the alternative methodological approaches and the general methodological issues. Therefore, even though a number of hypothesised relationships were proven, this study provides basic insight into the research of collaboration in the FMSC and its impact on collaborative effectiveness and also EF food waste reduction. Future research needs to address the limitations of this study.

7 Reference

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Appendix

Appendix A: Survey Questionnaire

Q1 To what extent do you agree or disagree with the following statements concerning 'Joint demand forecasting'? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. Our FMSC partners can forecast and plan collaboratively with us through the integrated information system.	❍	❍	❍	❍	❍	❍	❍
b. We can depend on our supply chain partners to provide us with a good market forecast and planning information.	❍	❍	❍	❍	❍	❍	❍
c. We plan volume demands for the coming seasons together with our FMSC partners.	❍	❍	❍	❍	❍	❍	❍

Q2 To what extent do you agree or disagree with the following statement concerning 'Knowledge integration' between you and your FMSC partner? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. We and our partners provide resources to each other to explore new ideas and innovations.	❍	❍	❍	❍	❍	❍	❍
b. whenever we and our partners get new ideas, we communicate with each other straight away.	❍	❍	❍	❍	❍	❍	❍
c. We and our partners have regular meetings to encourage knowledge dissemination.	❍	❍	❍	❍	❍	❍	❍
d. We and our partners combine our expertise to jointly solve task-related challenges.	❍	❍	❍	❍	❍	❍	❍

Q3 To what extent do you agree or disagree with the following statement concerning 'Smart packaging design' between you and your FMSC partner? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. We and our partners use a range of packaging indicators, such as thermal sensor, intelligent (smart) tag, and microchip; to provide the information about the condition of packed food.	❍	❍	❍	❍	❍	❍	❍
b. We and our partners serve smaller packing of food products to meet the needs of single or two person households.	❍	❍	❍	❍	❍	❍	❍
c. We and our partners use the Active Packaging system, such as modified atmosphere packaging, oxygen scavengers, moisture absorbers, aseptic packaging, and carbon dioxide production; to slow down the oxidation	❍	❍	❍	❍	❍	❍	❍

of certain food components.							
d. Our well designed packaging provides better protection to the food product as it moves through the supply chain, such as during distribution or transit.	❍	❍	❍	❍	❍	❍	❍

Q4 To what extent do you agree or disagree with the following statement concerning 'Using RFID (radio frequency identification) technology' between you and your FMSC partner? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. We and our partners currently use RFID technology for on-time replenishment	❍	❍	❍	❍	❍	❍	❍
b. We and our partners are currently using an RFID system for tracking the food product throughout the FMSC.	❍	❍	❍	❍	❍	❍	❍
c. We and our partners are currently using RFID technology for improving cost efficiency, e.g. through improved asset visibility which reduces stock loss.	❍	❍	❍	❍	❍	❍	❍
d. We and our partners are using RFID technology for supply chain operations integration.	❍	❍	❍	❍	❍	❍	❍

Q5 To what extent do you agree or disagree with the following statement concerning a 'Joint training programme' between you and your FMSC partner? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. We and our partners jointly organise food-related courses for employees, such as food management certification.	❍	❍	❍	❍	❍	❍	❍
b. We and our partners jointly organise food-related training sessions for employees to learn the correct procedures and their importance.	❍	❍	❍	❍	❍	❍	❍
c. We and our partners organise joint training programmes to enhance existing skills among all levels of employees.	❍	❍	❍	❍	❍	❍	❍
d. We and our partners see training as an important way of helping the company to achieve its goals.	❍	❍	❍	❍	❍	❍	❍

Q6 To what extent do you agree or disagree with the following statement concerning ‘Accurate forecasting’? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners potentially increase our profitability through accurate forecasting.	❍	❍	❍	❍	❍	❍	❍

Q7 To what extent do you agree or disagree with the following statement concerning ‘Better promotion planning’? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners jointly analyze previous promotions.	❍	❍	❍	❍	❍	❍	❍

Q8 To what extent do you agree or disagree with the following statement concerning 'Improving product safety? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners gain a better insight into where to improve food product safety across the FMSC.	❍	❍	❍	❍	❍	❍	❍

Q9 To what extent do you agree or disagree with the following statement concerning 'Improving temperature monitoring'? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners introduced a logging system to record temperatures at both ends of the food chain.	❍	❍	❍	❍	❍	❍	❍

Q10 To what extent do you agree or disagree with the following statement concerning 'Better inventory control'? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners are better at integrating warehouse management.	❍	❍	❍	❍	❍	❍	❍

Q11 To what extent do you agree or disagree with the following statement concerning 'Better shelf life management'? (Please tick one option for each statement).

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
We and our partners are reducing processing time in the supply chain to maximize the available life of food products (minimum life on receipt (MLOR)).	❍	❍	❍	❍	❍	❍	❍

Q12 To what extent do you agree or disagree with the following statement concerning 'Processing EF waste'? (Please tick one option for each statement).
My company has achieved a significant reduction of EF waste that is…….

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. …generated due to spillage in our processing stage.	❍	❍	❍	❍	❍	❍	❍
b. …generated due to the poor conformity of the food product, such as quality, appearance, flavors etc.	❍	❍	❍	❍	❍	❍	❍
c. …generated from wrong labelling, such as wrong date code, wrong ingredient and nutritional data information, wrong price and promotional stickers.	❍	❍	❍	❍	❍	❍	❍
d. ….generated due to frequent changes in the production schedules in our processing stages.	❍	❍	❍	❍	❍	❍	❍

Q13 To what extent do you agree or disagree with the following statement concerning ‘Over production of EF waste’? (Please tick one option for each statement). My company had achieved a significant reduction of EF waste that is…….

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. …generated by planning errors, such as forecast error, promotion error, and poor stock management.	❍	❍	❍	❍	❍	❍	❍
b. …generated during seasonality and special days, such as Christmas, Easter etc.	❍	❍	❍	❍	❍	❍	❍
c. …generated due to weather uncertainty or variability.	❍	❍	❍	❍	❍	❍	❍
d. …generated during promotional events.	❍	❍	❍	❍	❍	❍	❍

Q14 To what extent do you agree or disagree with the following statement concerning 'Storage of EF waste'? (Please tick one option for each statement). My company had achieved a significant reduction of EF waste that is…….

	Strongly disagree (WRAP(1))	Disagree (WRAP(2))	Somewhat disagree (WRAP(3))	Neither disagree nor agree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
a. …generated due to cannibalization (new product 'eats' up the sales of and demand of an existing product) of the food product.	❍	❍	❍	❍	❍	❍	❍
b. …generated from the expiry dates of food products.	❍	❍	❍	❍	❍	❍	❍
c. …generated due to the recall of food products from markets.	❍	❍	❍	❍	❍	❍	❍

Appendix B: Consent letter

To whom it may concern,

My name is ParmitKumar Shah, and I am an MPhil student at the Business and Management Research Institute, University of Bedfordshire, UK. My current research focuses on EF waste reduction through FMSC collaboration. The aim of the study is to look at how to enhance collaborative effectiveness between FMSC partners to reduce EF waste in the UK's FMSC.

I would like to invite you to participate in this study. All questions are based on a seven-point Likert scale. (*1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = neither disagree or agree, 5 = somewhat agree, 6 = agree and 7 = strongly agree).*

Please answer all of the questions from the perspective of your organisation and your primary or key retailer. This questionnaire should take around 20 minutes to complete.

The survey frame is anonymous. Any information provided will be dealt with in the strictest confidence, and only aggregated results will be reported. No specific details about companies or respondents will be reported. The results of this survey will be utilised only for academic purposes and, if you are interested, a summary of the report will be accessible on request.

To complete the survey, please click on the link below:

Thank you for your kind co-operation.

Yours sincerely,

Pramitkumar Shah

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