

**Gordon Institute
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University of Pretoria

**The extent and drivers of perishable food waste in the
retail supply chain industry of South Africa.**

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ABSTRACT

Food waste is not only the waste of scarce resources but also has a negative environmental and social impact. Food waste has a commercial impact on the supply chain, and therefore the management of food waste in the food supply chain is paramount for the sustainability and can become a competitive advantage in a highly competitive industry. The specific drivers of food waste in the supply chain vary drastically depending on the specific condition and situation.

The purpose of this study is to determine the extent of waste at the retail level within the supply chain of perishables and the relationship thereof with supply chain factors such as shortages, promotions and price, shelf life and seasonal demand and supply. An improved understanding of the extent of food waste and the effect that specific supply chain factors have on food waste can be used by supply chain managers to better manage the efficiencies in the supply chain to reduce food waste.

Quantitative research methods were used to test hypotheses related to the extent of food waste and its relationship with specific food waste drivers. Secondary data were collected from a specific retail group consisting of archived documents of sales, short deliveries, waste and loss of sales for a period of time for all the products in the fruit and vegetable range. Bivariate statistics, linear and multiple regression were applied to determine the relationship between shortages, promotions and price, shelf life, seasonal demand and supply, and food waste.

The study indicated the level of food waste in the retail level of the food supply chain in South Africa. It identified food waste drivers with strong relationships with food waste and used that information to build a predictive model for supply chain managers to use to reduce food waste. Retail organisations should make food waste a key performance indicator and use the predictive model to focus on specific drivers of food waste to facilitate improved waste management practice.

This study contributes towards supply chain management literature by showing that food waste management can contribute to the efficiencies of the supply chain and should be part of performance measures. Food waste management has a direct positive commercial impact on the organisations, improves food supply chain sustainability and food security as a whole.

KEYWORDS

- Food Waste
- Food Waste Drivers
- Shortages
- Supply Chain Management
- Food Waste Management

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Charles le Roux

Date

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CHAPTER 1. THE RESEARCH TOPIC

The extent and drivers of perishable food waste in the retail supply chain industry of South Africa.

1.1. The Research Background

Food waste is a major global problem and is also prevalent in South Africa (Gustavsson, Cederberg, Sonnesson, van Otterdijk, & Meybeck, 2011; Oelofse & Nahman, 2013). The exact drivers of food waste in the supply chain vary drastically depending on the specific condition and situation (Gustavsson et al., 2011; Mena, Adenso-diaz, & Yurt, 2011). Research has tried to identify specific drivers of food waste by looking at market conditions and supply chain factors (Mena et al., 2011; Parfitt, Barthel, & Macnaughton, 2010).

Multiple research attempts were made to quantify the extent of food waste, using rough estimations and assumptions (Gunders, 2012; Gustavsson et al., 2011; Oelofse & Nahman, 2013). Research in the United States has shown that about 40% of food produced in the United States does not get consumed in any form (Gunders, 2012). A study by Gustavsson et al. (2011) has found that an estimated one-third of all the food produced in the world is lost for human consumption. The average food waste generated in South Africa has been estimated to amount to 31.4% of all food produced annually (Oelofse & Nahman, 2013).

The objective of this study is to test the assumptions made to estimate the extent of food waste within the retail levels of the supply chain of perishables. The aim is to measure the extent of food waste and to test the relationship with specific food waste drivers.

Food security is one of the top priorities in South Africa as well as globally (du Toit, Lubbe, Ntushelo, & Ramonyai, 2011; Food and Agriculture Organization of the United Nations, 2015). Gustavsson et al. (2011) call for drastic action to raise awareness of the food waste problem in an efforts to combat hunger and to advance food security in the world. Despite considerable improvements in combating hunger, malnutrition in Africa amount to about 20%, far exceeding the world average of 10% (Food and Agriculture Organization of the United Nations, 2015). Malnutrition is also prevalent in South Africa where about 20% of our population does not have access to sufficient food (du Toit et al., 2011).

Food insecurity is not only caused by the low availability of food but also the unaffordable food prices, inappropriate and inefficient distribution of food and food waste (Food and Agriculture Organization of the United Nations, 2015). With the rapid population growth in South Africa, the country will not sustain self-sufficient production status and will eventually rely more on imports to meet the demand (du Toit et al., 2011). An increase in food production will not

necessarily solve food insecurity and without the right measures in place could perpetuate the food waste problem.

Food waste is not only the waste of a scarce resource, but also represents the waste of all other resources employed in production of food such as water, arable land, energy and other inputs (Eriksson & Spångberg, 2017; Graham-Rowe, Jessop, & Sparks, 2014; Gustavsson et al., 2011; Kaipia, Dukovska-Popovska, & Loikkanen, 2013; Mena et al., 2011; Vandermeersch, Alvarenga, Ragaert, & Dewulf, 2014). In addition, greenhouse gas emissions caused by the production of wasted food gets generated in vain (Gustavsson et al., 2011). The literature suggests collaborative ways to utilise waste to increase sustainability and to reduce greenhouse gas emissions (Cabral, Grilo, & Cruz-Machado, 2012; Gunasekaran, Subramanian, & Rahman, 2015; Jensen, Balslev, & Arlbjorn, 2013; Schöggel, Fritz, & Baumgartner, 2016).

Jensen et al. (2013) argue that food waste is a very complex problem for retail groups and waste management will play an increased role in future sustainability. Sustainability is a common theme in supply chain management. Food waste management has become increasingly important for business from a commercial point of view and holistically from a food security and sustainability point of view (Mena et al., 2011). By quantifying the extent of food waste, the study aimed to raise awareness of the problem and create the commercial will to react to the problem.

Excess inventory accumulated through the supply chain and gets wasted due to the way the system operates. High inventory levels result in a high percentage of overstock, damaged goods and ultimately waste (Gunders, 2012). The way retail and suppliers measure efficiencies incentivise them to make the wrong decisions when dealing with supply chain local optimisation (Aramyan, Oude Lansink, Van Der Vorst, & Van Kooten, 2007). This results in waste but also shortages up and down the supply chain (Watson, Blackstone, & Gardiner, 2007). Shortages are defined when product demand exceeds the immediate availability and supply (Lee, Padmanabhan, & Whang, 1997). Shortages and waste have another devastating effect when looking at the distortion and significant variance in orders it causes to the suppliers upstream in the supply chain (Panda & Mohanty, 2011). This phenomenon is called the bullwhip effect, named after the resemblance to a cracked whip and the variation in reaction down the length of the whip (Panda & Mohanty, 2011). The bullwhip effect implies that the management decisions made at the retail level of the supply chain and their processes have a direct effect on the actions and reactions of all the upstream members. Jensen et al. (2013) argue that what was initially perceived as a problem in the supply chain is transformed into value when that problem is approached from a chain perspective.

1.2. Research Problem

Waste within the food system occurs throughout the different levels of the supply chain. Gunders (2012) identified the significant inefficiency of the food supply chain, the lack of attention it received to date and the amount of data to analyse. Attempts to quantify food waste are motivated by the necessity to measure the extent of waste in each level of the supply chain to identify key drivers of the problem as well as possible solutions (Parfitt et al., 2010).

With previous research done on food waste in sub-Saharan Africa and South Africa, no primary data were collected and thus based on public municipal data and other assumptions (Gustavsson et al., 2011; Oelofse & Nahman, 2013). A more accurate assessment of actual food waste data verify the assumptions made in measuring food waste and could facilitate a better food waste management practice to improving food security and sustainability in South Africa. (Oelofse & Nahman, 2013).

Identifying the extent of the food waste problem alone does not assist with understanding the problem and the different factors associated with it. Research has tried to identify the factors that drive food waste (Gustavsson et al., 2011; Mena et al., 2011; Parfitt et al., 2010).

The literature looks at supply chain management to better understand the drivers within the supply chain and the relationship between the supply chain members. Goldratt & Cox (2004) states among other that the local optimisation of one sector in the supply chain does not necessarily contribute to the efficiency of the whole chain. Multiple supply chain literature suggests that sub-optimisation in the chain at one level can affect the performance of different factors at different levels and therefore analysis from a chain perspective is paramount (Jensen et al., 2013). Focusing on the management of food waste in the supply chain in isolation can have unintended consequences on other factors and levels in the supply chain and thus needs to be analysed in a relationship with each other. Food waste management should play a critical role in supply chain management to ensure future sustainability and competitiveness (Jensen et al., 2013).

1.3. Purpose of the study

The purpose of this study is to determine the extent of waste at the retail level within the supply chain of perishables, and the relationship thereof with other supply chain factors. Other factors identified are shortages, promotions, shelf life and seasonality. Previous research done worked only from averages and assumptions and was not able to collect relevant data to analyse (Gunders, 2012; Gustavsson et al., 2011; Oelofse & Nahman, 2013; Parfitt et al.,

2010). It is therefore essential that the study be done on actual data collected at the retail level and analysed (Gustavsson et al., 2011; Oelofse & Nahman, 2013).

The first step is to quantify the extent of waste at the retail level, and this will determine the size of the problem at the retail level of the supply chain to verify the results put forward by previous studies. A more accurate assessment of food waste at different levels in the supply chain could enable better waste management practices at the different levels towards reducing the environmental impact of food waste and to improve food security (Oelofse & Nahman, 2013).

The next step is to determine the relationship between waste and different factors in the supply chain. For example, Heydari, Mahmoodi, & Taleizadeh (2016) showed that any fluctuation in the production process has an impact on the fluctuation of lead times resulting in unexpected shortages and waste. The relationship between food waste and the different factors in the supply chain that drives it could add to the understanding of supply chain behaviour and what is needed to manage the food waste problem better. Simatupang & Sridharan (2009) argues that effective collaboration is better than acting in isolation as it enables different parties in the supply chain to combine their knowledge and capability and increase competitiveness.

1.3.1. The academic purpose of the study

This research builds on previous academic research and aims to contribute to food waste management, as well as supply chain management literature. The research does not intend to replicate previous studies for the South African contexts but instead aims to verify the assumptions made by Gustavsson et al. (2011) and Oelofse & Nahman (2013) by analysing actual data captured at the retail level of the supply chain of perishables. This research also includes analysis of the relationship between the different supply chain factors and the extent of food waste. The results of this study shed light on the context of food waste within the supply chain of perishables.

1.3.2. The business purpose of the study

The literature shows that food waste has a definite effect on the sustainability of the food supply chain and the environment it operates in. Food waste is a very complex problem for retail groups, and waste management will play a critical role in future sustainability (Jensen et al., 2013). This research aims to analyse different supply chain factors and look at practical ways of manage the supply chain and some of these factors. Jensen et al. (2013) promotes

the investigation of alternative waste management and handling systems as a combined solution to the food waste problem. To limit and manage waste levels is a high priority for every role player in the supply chain. Each member in the supply chain has their own goals driven by incentives put in place by the various companies to improve efficiencies. It is these conflicting goals focusing on the optimisation of each sector that is adding to the complexity that the supply chain actors face (Aramyan et al., 2007). Although food waste has an impact on most management performance measures, food waste itself is usually not a key performance measure (Mena et al., 2011). Lee et al. (1997) and Heydari et al. (2016) argues that the measuring system and incentives for supply chain managers promote the desired behaviour towards a more efficient supply chain.

As the complexity of the environment increases, more and more role players are contributing to the supply chain, and no single entity controls all the functions. In today's marketplace companies need to realise that they are interdependent organisations working together with others to manage and improve the flow of products and information from the primary producer to the end consumer (Verdouw, Beulens, Trienekens, & Wolfert, 2010).

Jensen et al. (2013) call for further research to be done on supply chain innovation to promote collaborations between each of the actors in the chain to add value as a whole. Food waste management should play an ever more critical role in supply chain management to ensure future sustainability and competitiveness (Jensen et al., 2013).

The study sheds light on the drivers of food waste and how these drivers can assist management to decrease food waste. Mena et al. (2011) argue performance measures, and management practices have a massive impact on the drivers of food waste, but that food waste is not always a performance measure in itself. The management of efficiencies in one area of the supply chain does not necessarily contribute to the effectiveness of the complete supply chain (Goldratt & Cox, 2004). Performance measures do not always consider the unintended consequences it has on food waste and the effect food waste have on the bottom line (Mena et al., 2011).

- Food waste has to be measured to improve waste management practice toward improving food security and sustainability. This study will analyse the waste in the retail outlets and propose an ideal waste management target to reduce food waste in the supply chain.
- To focus on all the food waste drivers simultaneously will not necessarily result in the best management of the extent of food waste. This research has developed a multiple regression prediction model to be used by supply chain managers to better manage the extent of food waste by focusing on the efficiencies of specific food waste drivers.

By using the multiple regression prediction models, supply chain managers can predict what the net effect on food waste by focusing on specific food waste drivers.

1.4. Research Aims and Objectives of the Study

The research aims to determine the extent of food waste within the supply chain of perishables and the relationship with drivers of food waste. This research focused on the supply chain of perishables within the South African retail industry. It explored the extent of waste within this retail level of the supply chain of perishables to validate assumptions made to calculate waste within the sector. It also set out to explore the relationship between different drivers of food waste and the extent of waste.

The primary objectives of the research are to accomplish the following:

Table 1 Research Objectives

Objective	Description
Objective 1	To determine the extent of waste within the supply chain of perishable foods in the South African retail industry.
Objective 2	To determine the relationship between shortages and the extent of food waste.
Objective 3	To determine the relationship between promotions and the extent of food waste.
Objective 4	To determine the relationship between shelf life and the extent of food waste.
Objective 5	To determine the relationship between seasonality and the extent of food waste.
Objective 6	To determine if a functional model can be developed to reduce food waste using the drivers of food waste.

Source: Own research

1.5. Conclusion

Food waste is a burning issue for organisations, for the country of South Africa and the world at large. Food waste has to be measured to improve waste management practice toward improving food security and sustainability. Organisations can reduce the extent of food waste in the food supply chain by finding innovative ways to drive efficiencies without causing unintended consequences like food waste in other areas of the supply chain. There are specific drivers that affect food waste, and supply chain managers can manage these drivers to reduce the food waste in the supply chain.

The results of this study provided insights into the food waste problem that will encourage conversations and future research in a domain that is critical for a responsible and sustainable food supply chain. This study aims to test the assumptions made to estimate the extent of food waste within the retail levels of the supply chain of perishables. The aim is to measure the extent of food waste and to test the relationship with specific food waste drivers.

In the following chapter will be literature will be reviewed to better understand food waste and the drivers that affect it.

CHAPTER 2. LITERATURE REVIEW AND THEORY

2.1. Introduction

In the previous chapter, the background of the research problem was discussed, and purpose of this research was set out. The following chapter focuses on the literature surrounding food waste within the supply chain as well as other supply chain factors. It also explores supply chain management and other aspects of the supply chain that is relevant to explain the relationship between food waste, the drivers of food waste and other factors within the supply chain.

2.2. Food Waste in the Supply Chain

2.2.1. Introduction to Food Waste

The literature agrees that food waste is a major global problem and awareness needs to be raised in the efforts to combat hunger and advance food security in the world (Gunders, 2012; Gustavsson et al., 2011; Oelofse & Nahman, 2013; Parfitt et al., 2010). Food waste is an important topic as it has an impact on the world's food security, the price of food and the sustainability of food production (Gunders, 2012; Gustavsson et al., 2011). Multiple attempts were made to quantify the global food waste to highlight the extent of food waste in the food supply chain in relation to global malnutrition (Oelofse & Nahman, 2013; Parfitt et al., 2010).

Food waste is any food produced and lost for human consumption within the supply chain regardless of the cause (Corrado, Ardente, Sala, & Saouter, 2017; Gustavsson et al., 2011; Jensen et al., 2013; Kaipia et al., 2013; Mena et al., 2011). Food waste occurs at different levels of the supply chain. Parfitt et al. (2010) differentiate between food waste and food losses depending on what level the waste is situated. Food losses are linked to the production, storage and processing of products and food waste to finished product wasted at distribution, retail and final consumption stages (Gunders, 2012; Parfitt et al., 2010). Parfitt et al. (2010) point out that it is not only essential to differentiate between the levels of the supply chain, but also the category of food as it has different biological material subject to different rates of degradation and different nutritional values. Therefore, the difference between perishable and non-perishable foodstuffs is an essential distinction in food waste and consideration for the supply chain.

For this study, the research will focus on the amount of food waste accumulated at the retail level of the supply chain. It will only focus on the perishable category for fresh fruit and vegetables within the South African context.

The literature agrees that food waste have a direct impact on food security which in itself is an increasing pressing global issue (du Toit et al., 2011; Filimonau & Gherbin, 2017; Food and Agriculture Organization of the United Nations, 2015; Irani & Sharif, 2016; Papargyropoulou, Lozano, K. Steinberger, Wright, & Ujang, 2014). Food security is one of the top priorities in South Africa as well as globally (du Toit et al., 2011; Food and Agriculture Organization of the United Nations, 2015). Despite considerable improvements made in combating hunger, malnutrition in Africa of about 20%. The figure far exceeds the world average of 10% (Food and Agriculture Organization of the United Nations, 2015). Malnutrition is also the case in South Africa where about 20% of our population does not have access to sufficient food (du Toit et al., 2011).

The definition of food security by the Food and Agriculture Organization of the United Nations (2015) is: “A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. The desire to eat is a fundamental human right and essential for survival. The constitution of South Africa made the right to sufficient food and water a fundamental human right in the country (du Toit et al., 2011). The inverse of food security is food insecurity. Food insecurity is not only caused by the low availability of food but also the unaffordable food prices, inappropriate and inefficient distribution of food and food waste (Food and Agriculture Organization of the United Nations, 2015). With the rapid population growth, South Africa will not sustain its self-sufficient production status and will have to rely more on imports to meet the demand (du Toit et al., 2011).

To increase food production does not necessarily solve food insecurity and without the right measures in place could perpetuate the food waste problem. The challenges that food security poses stretches across country, society, organisation and individual boundaries. Reducing food waste will directly improve efficiency levels within the supply chain and contribute towards enhanced levels of effectiveness when it comes to food security. Only through identifying the underlying drivers of food waste and its relationship with other food supply chain factors can enterprises adopt interventions to initiate and mitigate food security risk (Irani & Sharif, 2016).

Food waste is not only the waste of a scarce resource but also refers the waste of all other resources used in production such as water, land, energy and other inputs (Eriksson & Spångberg, 2017; Graham-Rowe et al., 2014; Gustavsson et al., 2011; Kaipia et al., 2013; Mena et al., 2011; Vandermeersch et al., 2014). In addition, greenhouse gas emissions and other environmental effects caused by wasted food are considerable side effects to food waste (Gustavsson et al., 2011). Oelofse & Nahman (2013) estimates that the disposal of food waste including other organic waste contributes 4.3% to greenhouse gas emissions in South Africa.

Corrado et al. (2017) highlight the fact that food waste is a significant concern from both an environmental and social point of view. One of the concerns relates to the disposal of food waste in municipal landfills (Oelofse & Nahman, 2013). The disposal of food waste has been outlawed in many countries and is also a priority in South Africa. The literature suggests collaborative ways to utilise waste to increase sustainability and to reduce greenhouse gas emissions (Cabral et al., 2012; Gunasekaran et al., 2015; Jensen et al., 2013; Schöggli et al., 2016). Sustainability is a common theme in supply chain management. Jensen et al. (2013) argue that food waste is a very complex problem for retail groups and waste management will play an increased role in future sustainability.

2.2.2. Trends that influence Food Waste at the Retail Level

Gustavsson et al. (2011) point out the exact drivers of food waste in different parts of the world varies dependent on the specific conditions of a country and the local supply chain members and their relationship with each other. The inefficiencies of the supply chain have received very little attention to date and have left a vacuum of data to analyse and compare.

Mena et al. (2011) conducted a root cause analysis and identified three groups that drive food waste within the supply chain namely: Mega-trends, natural constraints and management causes.

2.2.2.1. Megatrends

Megatrends are any global or industry trends affecting the problem of waste. Elaborating on global trends, Parfitt et al. (2010) identified three inter-related trends are providing an overall structure for characterising drivers that influence food waste:

- Urbanisation and the declining agricultural markets – accelerated population growth and rapid urbanisation has created a higher demand for the extension of food supply chains to feed urban populations. These extended food supply chains require infrastructure improvements on the road, transportation in general and marketing infrastructure while keeping food inflation low (Oelofse & Nahman, 2013). The increased complexity of the supply chain has implications for food waste globally (Parfitt et al., 2010).
- Dietary transition – the dietary patterns of different communities change from starch-based food staples to more differentiated diets as a result of increasing disposable income. A dietary transition can lead to increased consumption of perishables such as

fruit and vegetables (Oelofse & Nahman, 2013). An increased demand for perishable foods and the variety of choice within that category can result in higher stock levels in stores leading to food waste (Gustavsson et al., 2011; Parfitt et al., 2010).

- Globalisation of trade – the increase in exports and imports of food products may pose a threat to food production in domestic markets (Oelofse & Nahman, 2013). As competition increases with the globalisation of trade, the complexity of the food supply chain increases. These complexities include increased transport distances, extended storage of foods and extended food shelf life leading to food waste. (Parfitt et al., 2010).

2.2.2.2. Natural Constraints

Within the retail level of the supply chain, the following factors have been identified as drivers of the food waste (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).

- Food stockholding and displays. Stores tend to overstock products displays to create the effect of abundance, which is believed to increase sales (Gunders, 2012). In addition, retail outlets need to stock a variety of product and sufficient stock to meet the daily demand. The fear of running out of stock to sell and the substantial penalties for loss of sales result in overstocking, over-trimming, and improper stock rotation (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Ready-made food. Ready to eat meals are a trend that is growing in popularity and is based on a global trend in consumer convenience. Ready-made meals aim to utilise off-cut and malformed products but in the process increases cutting waste leading to more significant discards (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Consumer expectation of cosmetic perfection. Customers tend to select specific retail outlets based on the quality of perishables foods (Gunders, 2012). This trend compels retail groups to deliver a superior quality of product with the perfect shape, size, and colour (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011). This trend eliminates a large percentage of perfectly good food produced just because of external cosmetic appearance which leads to food waste that the supplier level of the food supply chain (Gunders, 2012)

- Date labels. In many places, food products that pass their “sell by” dates are required by law to be removed from shelves. “Sell by” and “use by” dates are not necessarily regulated but rather manufacturer suggestions of the ideal time for consumption (Gunders, 2012). Many foods can be safely consumed after their “sell by” and “use by” dates and therefore lead to the prematurely discarding of food that is good to eat (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Packing and packaging size. The food supply chain determines a minimum order quantity according to case size to simplify the ordering and delivery of products. The Inflexible case and unit sizes can lead to a specific store ordering more than they expect to sell (Gunders, 2012). In addition, the bulk packaging of products provides the consumer with more product that can be consumed by one family resulting in the transfer of waste to the end consumer (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Discarded product. Gunders (2012) argues that food waste is more prevalent at the end of promotion or holiday season. The high failure rate for new products launched and packaging that gets damaged in transit can also lead to increased food waste (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- The seasonality of produce. Fresh produce is dependent on the natural environment. Specific products grow in specific seasons of the year. Warm and humid climate has a direct impact on product shelf life and can lead to increased food waste in different levels of the supply chain (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Forecasting difficulties and poor ordering. Within the food supply chain, a variety of forecasting methodologies are in use (Gunders, 2012). Some retail groups use a scientific approach when planning forecasts and orders while others use more informal and ad-hoc methods. Anticipating product demand is a complicated and inherently inaccurate, which makes forecasting and ordering one of the leading culprits of food waste (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).
- Promotions and price. The literature revealed that pricing and promotional activities and mechanics could influence the variability of supply and demand in the food supply chain leading to food waste (Gunders, 2012). Precise measurements and processes are needed to manage promotions in order to limit the unintended consequences of

promotions. Promotions prompt customers to buy abnormally larger quantities of product leading to an increase household food waste. This “forward buying” can lead to waste, mainly when product shelf-life is short (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011).

2.2.2.3. Management Practices

- Performance measurement and management. Research has shown that management emphasis is mainly on cost, efficiency and availability (Gunders, 2012; Mena et al., 2011). Although all these factors have an impact on food waste, food waste itself is usually not a key performance indicator, and it can be sacrificed at the expense of other performance measures (Mena et al., 2011). Lee et al. (1997) and Heydari et al. (2016) argues that the measuring system and incentives for supply chain managers promote the desired behaviour towards a more efficient supply chain.
- Quality management. The retail groups have a strict quality control system which can lead to rejections at the distribution or the retail outlet and can even lead to complete batch recalls. These rejections are an immediate waste factor for the supply chain. The quality of fruit and vegetable as a category of perishables vary quite drastically. While the monitoring of the quality of products is critical, the strict quality control protocol and policies appear to be more critical to the companies than the waste it creates (Mena et al., 2011). Gunders (2012) call for a re-evaluation of the quality and esthetical specification and different quality assurance measures to minimise waste in the supply chain.
- Waste management policies. While some supply chain members have clearly defined procedures and targets for managing waste, many do not have a specific role within the supply chain focusing on food waste (Mena et al., 2011). The data collected does indicate that waste management is handled very differently by different supply chain members and groups. When food waste is not managed and measured in the supply chain, it is likely to lead to increased food waste. Food waste management has become increasingly important for business from a commercial point of view and holistically from a food security and sustainability point of view (Mena et al., 2011). The amount of food waste lost in the supply chain has a substantial financial and commercial implication for the supply chain and warrant a radical action plan to manage food waste better. By measuring the extent of food waste, management can

quantify the commercial impact on the bottom line and emphasise the importance of the food waste problem.

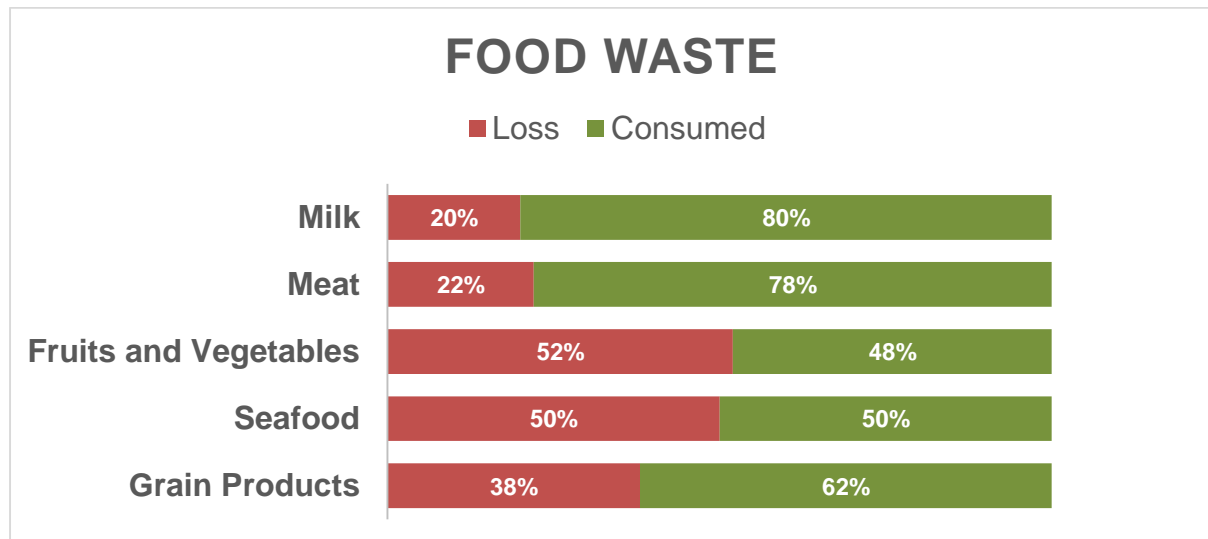
2.2.3. Estimated Food Waste in Supply Chain

The literature agrees that food waste estimates in grocery retail are challenging to produce (Filimonau & Gherbin, 2017; Gunders, 2012; Gustavsson et al., 2011; Oelofse & Nahman, 2013). Parfitt et al. (2010) suggest that this is due to legislation, accounting methodologies, corporate policies, managerial practices and other variables determining data availability.

Previous studies investigated complete supply chain when analysing food waste. They used estimates and percentages of total crop productions for different countries to calculate the extent of the food waste per category and per supply chain level.

Gunders (2012) found that 40% of food produced in America does not get consumed by humans. By breaking produced food down in different commodities, fruits and vegetables have been found to contribute a higher food waste percentage compared to the other categories as seen in Figure 1.

Figure 1 Food Consumed versus Food Wasted



Source (Gunders, 2012)

Gustavsson et al. (2011) proposed a method to estimate food waste by using a percentage of total weight for each food category at each level of the supply chain. These weights were analysed in relation to the production figures for each food group. Gustavsson et al. (2011) compared the results of different areas to each other to show the diverse spectrum and the different challenges facing food waste in each area. He presents the data to include an

estimated percentage of what enters each level of the supply chain for each food category as seen in Table 2.

Table 2 Percentage Food Waste

	Agricultural Production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6%	8%	3.5%	2%	1%
Roots and tubers	14%	18%	15%	5%	2%
Oilseeds and pulses	12%	8%	8%	2%	1%
Fruits and Vegetables	10%	9%	25%	17%	5%
Meat	15%	0.7%	5%	7%	2%
Fish and seafood	5.7%	6%	9%	15%	2%
Milk	6%	11%	0.1%	10%	0.1%
Estimated food waste percentages for each category in each step of the food supply chain for sub-Saharan Africa.					

Source (Gustavsson et al., 2011).

When compared to the percentages of more developed countries it seems that sub-Saharan Africa is not as advanced and efficient regarding its supply chain.

Oelofse & Nahman (2013) used a combination of the methodologies in of Gustavsson et al. (2011) and to replicate the study on food waste for South Africa. Using production data publically available they were able to estimate the extent of waste in each level of the supply chain based on the percentages provided by (Gustavsson et al., 2011). It should also be noted that Oelofse & Nahman (2013) did not use the same conversion rates and therefore it is expected to be slightly higher than presented by Gustavsson et al. (2011).

Oelofse & Nahman (2013) show that in South Africa roots and tubers combined with fruits and vegetables contributes 57% of the overall food waste compared to the 52% of the total fruit and vegetable category presented by Gunders (2012). (Oelofse & Nahman, 2013) concluded that the assumptions made could be conservative and an underestimation but calls for the verification through primary data analysis.

2.3. Drivers of Food Waste in the Supply Chain

The exact causes of food waste in the supply chain varies drastically depending on the specific condition and situation (Gustavsson et al., 2011; Mena et al., 2011).

Mena et al. (2011) tried to identify the root causes of food waste within the supplier – retail interface of the supply chain. Other drivers of food waste are the market economy, resource limitations, legislation, cultural differences, supply chain and consumer behaviour summed up as policy, systems and practices (Parfitt et al., 2010). Many of the food waste drivers identified in the previous discussion align with some supply chain factors and management decisions made in the supply chain.

The supply chain is defined as a set of value-adding activities connecting an industries role players, from suppliers to end customers (Heydari et al., 2016; Sukati, Hamid, Baharun, & Yusoff, 2012). Supply chain management is the management and integration of these value-adding activities throughout the chain (Panda & Mohanty, 2011; Sukati et al., 2012; Vachon & Klassen, 2007; van der Vorst, van Dijk, & Beulens, 2001). Nag, Han, & Yao (2014) argues that the top priority for supply chains management is the procurement, production and distribution of products in partnerships with suppliers and other role players. The goal of these different supply chain partners essentially is to improve the value for the end consumer (Panda & Mohanty, 2011).

Companies dealing with food operates in an ever more complex and dynamic environment and need to be adaptable to changes in the marketplace (Verdouw et al., 2010). As the complexity of the environment increases more and more, role players are contributing to the supply chain, and no single entity controls all the functions. In today's marketplace companies need to realise that they are interdependent organisations are collaborating to better manage and improve the movement of products and information from the primary producer to the end consumer (Verdouw et al., 2010).

Food waste in the downstream supply chain has a devastating effect when considering distortion and significant variance in forecasts and orders it creates for the upstream suppliers in the supply chain (Panda & Mohanty, 2011). This phenomenon is called the bullwhip effect, named after the resemblance to a cracked whip and the variation in reaction down the length of the whip (Panda & Mohanty, 2011).

According to Lee, Padmanabhan, & Whang (1997), the bullwhip effect occurs when the fluctuation in demand, forecasts and order in the supply chain have a knock on effect to each supply chain partner, and the distortion is amplified as it moves up the supply chain. The variability in the information transferred from the one end of the supply chain to the other can

lead to high inefficiencies and severe cost implications to each supply chain partner (Panda & Mohanty, 2011).

Panda & Mohanty (2011) shows that an increased variability in the order process results in an increase in operational capacity to cope with the variability, increase in idle resources that are on standby as well as an increase in inventory holding. As a result, or anticipation of shortages, buyers in the different supply chain levels act defensively and tend to over order resulting in erratic ordering and inflated inventory (Lee et al., 1997).

Lee et al. (1997) identified four main drivers of the bullwhip effect which correlates with the drivers of food waste namely:

- Demand forecasting updating
- Order batching
- Price fluctuation
- Rationing and shortage gaming

Nag et al. (2014) argue that the number of variables and supply chain factors affects the raw material inventory needed to ensure reliable order fill. It is these supply chain factors that are the drivers of food waste with the supply chain.

The theory of constraints (Goldratt & Cox, 2004) states among other that the local optimisation of one sector in the supply chain does not necessarily contribute to the efficiency of the supply chain as a whole. For example, to compensate for shortages, loss of sale, damaged goods, ext. (Gunders 2012), many manufacturers oversupply and retail stores overstock product displays, which result in excess stock in the system. The nature of perishable products might reach their sell-by date and be discarded as waste.

Jensen et al. (2013) call for further research to be done on supply chain innovation to promote collaborations between the different members of the supply chain to reduce inefficiencies and waste to add value as a whole.

2.3.1. Shortages

Based on the short life cycle of perishable product the supply chain traditionally maintain low inventory levels throughout the supply chain (Nag et al., 2014). Variability caused by the actual demand and supply dynamics in the supply chain can have various effects (Lee et al., 1997).

The first is a perfect scenario where the demand and supply are perfectly balanced, and there is just enough inventory to satisfy the demand resulting in zero loss of sale and zero waste. The second scenario is when the supply chain decides to operate at low inventory levels to avoid waste but in turn, run out of stock resulting in loss of sale. The third scenario is when the supply chain decides to hold very high inventory to make provision for all sales resulting excess inventory going to waste. Nag et al. (2014) argue that this demand and supply is dynamic in itself and can result in both shortages and waste simultaneously.

Changes in the supply and demand functions have an aggregated effect of the lead-time placing a time delay between the ordering and the fulfilments resulting in either shortages or waste (Heydari et al., 2016). Every member in the supply chain makes use of forecasting in order to plan raw material, production, stock, scheduling ext. The forecasts usually rely on historical data as well as the member's intuition in projecting the demand patterns based on current observations (Lee et al., 1997).

All demand forecasts are merely estimates based on a series of assumptions and probabilities (Taylor & Fearn, 2009). The attempts to improve demand forecasts usually result in building safety stock and capabilities to detect trends and result in the bullwhip effect (Panda & Mohanty, 2011).

Lee et al. (1997) argue that as the actual orders are being placed by the downstream supply chain member, the upstream member's process that piece of information as a signal for future product demand and adjustments to the forecast and order are being made all across the supply chain. This demand signal by downstream members and the reaction to it by upstream members is the major contributor to the bullwhip effect resulting in either short deliveries or food waste in the different supply chain levels (Panda & Mohanty, 2011).

With perishable food, this process is very dynamic and works on a weekly and daily basis. Therefore, food waste is even more devastating when seen in relation to the loss of sales due to shortages in the same chain. If there is a willing buyer in one store and waste stock for that customer in another store, innovative supply chain solutions must be found to get the right product to the right place at the right time and to reduce waste across the whole supply chain (Jensen et al., 2013).

When demand exceeds supply, suppliers can only supply limited stock on ration called the shortage gaming (Lee et al., 1997). In anticipations of this downstream supply chain members will order more than what is actually required to ensure that they have enough stock (Panda & Mohanty, 2011).

Lee et al. (1997) argue that the effect of shortage gaming is that the customers' orders give little information about the real demand for the product and causes the bullwhip effect to perpetuate the shortage problem for all the supply chain members. The risk is that the over-ordering may result in excess stock in some areas of the supply chain with complete stock-outs in other causing loss of sale as well as food waste (Panda & Mohanty, 2011).

Each member of the food supply chain places an official order with the direct upstream member. There is a disconnect between the accumulation of demand over a period of time versus the fixed order at a specific point in time (Panda & Mohanty, 2011).

Orders cannot be placed unit by unit in line with replenishment and are thus placed in batches for a specific delivery time. Lee et al. (1997) classifies two forms of order batches namely periodic orders and push orders. It is the periodic ordering of the supply chain members that contribute to the bullwhip effect.

The performance measurements within the supply chain have a direct influence on the behaviour of all the role-players (Aramyan et al., 2007; Arif-Uz-Zaman & Ahsan, 2014). The overemphasis of specific performance measures may cause an overreaction to avoid negative management results irrespective of the effects on the broader supply chain (Aramyan et al., 2007). For example, the supply chain performance measures can overemphasise shortages and loss of sales, incentivise buyers to reduce shortages and loss of sales. The way buyers can reduce shortages is to overstate the forecast to allow suppliers to manufacture enough stock and to over-order to which may result in waste.

2.3.2. Promotions and Price

Retail groups use promotions to increase sales and market share (Aramyan et al., 2007). Literature agrees that promotion activities and price fluctuations have a major influence on the level of food waste in retail supply chains (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011; Mourad, 2016). Research has shown that high variability in customer demand for fresh food products is most often self-imposed through promotional activities and policies (Taylor, 2006).

Promotional activities create significant uncertainties and deviation within the supply chain and have a massive impact on the way the supply chain is managed (Hollmann, Scavarda, & Thomé, 2015; Lee, Padmanabhan, & Whang, 1997; Panda & Mohanty, 2011; Taylor & Fearné, 2009). Promotional activity can cause food waste due to low forecast accuracy and inadequate

information sharing between the supply chain managers in the retail outlets and their suppliers (Mena et al., 2011).

Lee et al. (1997) argue that more than 80% of transactions between the supply chain members is made in “forward buying” arrangements which cause variability in demand forecasted. This is evident in some bulk promotion offerings the different retail groups offer the consumer. The research suggested that for perishable foods, that promotional activities and policies are the most common cause of high variability in weekly consumer demand (Taylor & Fearn, 2009).

Price positioning is a function of promotions and can be used to attract customers based on the savings compared to rival retail groups. Food supply chains have high sales targets and use price positioning to drive sales in and out of promotions (Aramyan et al., 2007). Although price is an integral part of promotions, price was therefore evaluated in this research as a separate food waste driver. Panda & Mohanty (2011) argues that consumers buy higher quantities than usual when prices are low causing an artificial variation in demand for product perpetuating the bullwhip effect of food waste. In the fresh produce industry price fluctuation plays a significant role in the dynamics between the weekly fixed prices the retail outlets offer versus the daily fluctuating national market price.

Retail groups have strict sales target and tend to run monthly promotions to push sale volumes (Aramyan et al., 2007; Panda & Mohanty, 2011). All the supply chain members try to capitalise on price fluctuations but with such high variability is often results in some members being on the wrong side of the price advantage. Consumers buy larger quantities than what they require when prices are low causing variability in demand over time perpetuating the bullwhip effect (Panda & Mohanty, 2011). With fresh produce, this hike in demand drives up the price on the national fresh produce market having detrimental effects on the cost price of the product for the upstream supply chain membered especially in the light of the fixed selling price of the retail outlets.

Lee et al. (1997) argue that the superficial high demand for the product in the promotion is not sustainable and customers will buy less than usual to deplete their inventory before the product goes to waste. The lower sales in store coinciding with the inflated demand can cause further markdowns and mostly a waste of product in the retail outlet. When the supply chain is faced with such full swings, the supply chain members have to operate their facilities with overtime in the peak promotional times and be idle off-peak times (Lee et al., 1997). To compensate for overtime suppliers can build up inventory for the promotions can result in food waste if the demand does not meet the supply (Panda & Mohanty, 2011).

Taylor (2006) shows that the consumer demand fluctuation due to promotional activities is low in comparison to the upstream producers due to the demand variability and the bullwhip effect on those producers. Promotions incentivise customers to buy larger than unusual quantities of specific products which can lead to increased household waste (Mena et al., 2011).

The managing the demand for specific products is an art in itself and is recognised as a critical component for the improvement of the efficiencies and the sustainability of the food supply chain (Taylor, 2006). Mena et al. (2011) call for the management of promotions to be part of regular supply chain management practices. Different management policies for promotions drive the promotional activities and mechanics which can affect how much variability is created within the supply chain. These management policies should promote the cooperation and collaboration between supply chain members in order to manage food waste in promotions (Mena et al., 2011).

2.3.3. Shelf Life

Shelf life is among the list of issues that can perpetuate the food waste problem (Gustavsson et al., 2011; Mena et al., 2011; Parfitt et al., 2010). Shelf life dates are designed to help the retail outlet with stock rotation and ensure freshness to the end consumers (Gunders, 2012). Shelf life ranges vary greatly depending on the specific product and due to factors such as weather conditions, warehousing and transport lead times (Liljestrand, 2017).

In many places, it is illegal to sell products with expired shelf life dates, and thus many retailers remove the product from the shelf that is still fit for consumption (Gunders, 2012). Gustavsson et al. (2011) argue that retail stores tend to overstock product displays under the assumption that they will sell more products. In reality, more product does not create more demand for that product, and the result is that the product's shelf life expires before the products are sold resulting in waste.

A lot of different food date labels exists that can be confusing for the store management and the end consumer (Parfitt et al., 2010). The different examples of shelf life dates are "use by" dates, "best before" dates, and "sell by" dates. The meaning of these dates can be confusing, resulting in unsold products and essentially food waste (Parfitt et al., 2010). The customers' perception plays a huge role in their buying patterns when a product is close to the shelf life date on the packaging (Gruber, Holweg, & Teller, 2016).

Perishables by nature are short shelf life products. Mena et al. (2011) have found that products with a shorter shelf life usually have more waste than products with a longer shelf life. With

short shelf life products, the lead time from the farmer to the end consumer plays a crucial part as it influences the number of days the product will stay fresh on the shelf (Kaipia et al., 2013). The shorter the supply chain and the lead time the longer the potential shelf life can be extended. Kaipia et al. (2013) assume that increased shelf life days will increase the number days the retail outlet has to sell that specific unit before it reaches the expiry date reducing the risk of food waste on that product.

2.3.4. Seasonal demand and supply

Seasonality and weather changes have an undoubtedly impact on the high variability in product demand and waste within the supply chain of perishable food (Aramyan et al., 2007; Lee et al., 1997; Mena et al., 2011; Taylor, 2006). Mena et al. (2011) differentiate between the seasonality of demand referring to the demand cycle and seasonality of supply referring to the weather fluctuation of different seasons. The distinction should be made between the seasonal supply side and the seasonal demand side of the food supply chain.

- Seasonal demand.

Variability of end-user demand can be explained by specific trends and patterns referred to as the seasonality of the consumer patterns (Taylor, 2006). Consumer demand seems to increase with month-end shopping, during the holiday seasons and with the Christmas shopping seasons (Lee et al., 1997).

Food supply chains analysis the buying cycles of customers to align the forecast and orders according to the increased demand in specific times. Research has shown that high variability in customer demand caused variability in the supply chain making it difficult to supply precisely in line with the demand. (Taylor, 2006). This fluctuation between demand and supply dynamics and the variability within the supply chain can cause various effects including food waste (Lee et al., 1997).

- Seasonal supply.

The weather changes and the different seasons of the year influence the supply of perishable products and can cause a variability within the supply (Taylor & Fearn, 2009). Gustavsson et al. (2011) argue that waste occurs with the seasonality of the production of specific products to extend to a year-round supply of product. Traditionally the winter and the summer is the two main production seasons with spring and autumn being transition seasons. Product quality

can vary depending on the season particularly in the transition seasons or at the beginning and end of the main production seasons (Mena et al., 2011).

Supply chain members tend to adjust forecast planning and requirements to compensate for the fluctuation in demand and supply fluctuations (Lee et al., 1997). Panda & Mohanty (2011) argues that significant variation in demand and supply within the supply chain due to the seasonality of demand and supply can cause the bullwhip effect within the supply chain.

2.4. Food Waste Conclusion

Through the literature reviewed on food waste in the supply chain, it is clear that food waste is a huge problem both in South Africa and on a global scale. Fruits and vegetables have the highest food waste percentage of all categories analysed and are estimated to be between 52% and 57%.

The retail and distribution level of the supply chain is estimated to have between 8% and 17% food waste for fruits and vegetables with sub-Saharan Africa being the highest of all regions measured. It is not the level with the highest food waste percentage but has a major effect on the supply chain behaviour up and downstream. Food waste, in general, has a negative impact on the world's food security, on the environment and the sustainability of the food supply chain (Parfitt et al., 2010). Inefficiencies in the supply chain resulting in food waste is not a new phenomenon and are commonly known and very extensive (Jensen et al., 2013). Aramyan et al. (2007) found that different performance indicators are used in different links of the supply chain aligned to the companies' different objectives. Jensen et al. (2013) argue that food waste is a very complex problem for retail groups and waste management will play a critical role in future sustainability.

Each role-player in the supply chain has their own goals driven by incentives put in place by the various companies. It is these conflicting goals focusing on the optimisation of each sector that is adding to the complexity that the supply chain role-players face (Aramyan et al., 2007). In reality, each role-player harnesses a strategic priority exclusively within their organisational silos and have trouble working across those internal boundaries (Gulati, 2007).

Literature agrees that assumptions were made to estimate the extent of food waste. These assumptions need to be tested by analysing primary data (Gustavsson et al., 2011; Oelofse & Nahman, 2013).

Panda & Mohanty (2011) argues that the bullwhip effect in the food supply chain can be eliminated through focusing on specific supply chain factors and through effective information

sharing throughout the complete supply chain. By making demand and replenishment data available to upstream members, all partners can calculate their inventory requirements simultaneously based on the same original raw data.

The cooperation and collaboration between the supply chain members are vital to achieve higher efficiencies in the supply chain and to reduce the bullwhip effect of food waste throughout the supply chain (Panda & Mohanty, 2011).

CHAPTER 3. RESEARCH QUESTION AND HYPOTHESES

3.1. Introduction

The purpose of this study is to determine the extent of food waste at the retail level of the supply chain of perishables, and the relationship thereof with the drivers of food waste. Food waste has negative effects on the profitability food supply chain and an adverse effect on the environment and the society as a whole. Previous studies have used specific assumptions to estimate the extent of food waste at different levels in the supply chain. Literature suggests that there are specific drivers of food waste in the supply chain despite limited empirical evidence to support the relationship thereof.

Firstly, this research aims to respond to the call Oelofse & Nahman (2013) made in previous research to validate the assumptions made in calculating the percentage food waste within the food supply chain. This research will focus only to validate the percentages used in the retail level of the supply chain of the fruit and vegetable category of perishables. For this phase of the study, the hypothesis will focus on the question whether the percentage of food waste within the retail level of the supply chain of perishables is equal to the percentage used by Gustavsson et al. (2011) and Oelofse & Nahman (2013).

Secondly, the research will focus on the drivers of food waste highlighted in the literature. For this phase of the study, the hypotheses will focus on the question whether individual drivers have a significant influence on food waste at the retail level of the supply chain. The research also analyses if any combination of drivers has a stronger correlation by testing the significance in a regression model.

All hypothesis testing will follow the basic two-tailed hypothesis principle. First the standard simple linear regression model (Creswell, 2012; Wegner, 2014) is defined as:

$$Y_i = \beta_1 + \beta_2 (X_1) + a$$

Null hypothesis: $H_0: \beta_1 = 0$

Alternate hypothesis: $H_1: \beta_1 \neq 0$

Then the multiple regression model (Creswell, 2012; Wegner, 2014) defined as:

$$Y_i = \beta_0 + \beta_1(X_1) + \beta_2(X_2) + \beta_3(X_3) + \beta_t(X_t)$$

Null hypothesis: $H_0: \beta_1 = 0 \beta_2 = 0 \beta_3 = 0 \beta_t = 0$

Alternate hypothesis: $H_1: \beta_1 \neq 0 \beta_2 \neq 0 \beta_3 \neq 0 \beta_t \neq 0$

Based on the literature support described in the previous chapter the hypotheses that were formulated uses food waste as the dependent variable and the various drivers of food waste as the independent variables.

Through a correlation analysis, the strength of the linear relationship is determined by determining the Pearson's correlation coefficient (Lin, 1989). The regression model was tested for significance by applying a 5% ($\alpha = 0.05$) level of significance with a probability of Type I error (Wegner, 2014).

3.2. Hypothesis 1: Food Waste % of Retail Sales

Research question one (RQ1): What is the extent of food waste in the retail level of the supply chain of perishables?

- **Null hypothesis (H₀1):** Food waste as a percentage of retail sales (Food Waste %) is equal (=) to the percentage used to estimate food waste namely (17%) (Gustavsson et al., 2011; Oelofse & Nahman, 2013).
- **Alternate hypothesis (H₁1):** Food waste as a percentage of retail sales (Food Waste %) is not equal (\neq) to the percentage used to estimate food waste namely (17%) (Gustavsson et al., 2011; Oelofse & Nahman, 2013).

3.3. Hypothesis 2: Shortages

Research question two (RQ2): Can it be predicted with reasonable accuracy, that a relationship exists between the shortages and the extent of food waste?

- **Null hypothesis (H₀2.1):** No significant relationship exists between shortages on shelves (Shortage – Availability Corrected Sales) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁2.1):** A significant relationship exists between shortages on shelves (Shortage – Availability Corrected Sales) and the extent of food waste on the retail level of the supply chain of perishables.
- **Null hypothesis (H₀2.2):** No significant relationship exists between stock out days (Shortage – Availability Business) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁2.2):** A significant relationship exists between stock out days (Shortage – Availability Business) and the extent of food waste on the retail level of the supply chain of perishables.

- **Null hypothesis (H₀2.3):** No significant relationship exists between supplier short delivery (Shortage - Supplier) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁2.3):** A significant relationship exists between supplier short delivery (Shortage - Supplier) and the extent of food waste on the retail level of the supply chain of perishables.

3.4. Hypothesis 3: Promotions and Price

Research question three (RQ3): Can it be predicted with reasonable accuracy, that a relationship exists between the promotions or price and the extent of food waste?

- **Null hypothesis (H₀3.1):** No significant relationship exists between promotions (Promotions) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁3.1):** A significant relationship exists between promotions (Promotions) and the extent of food waste on the retail level of the supply chain of perishables.
- **Null hypothesis (H₀3.2):** No significant relationship exists between price (Price) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁3.2):** A significant relationship exists between price (Price) and the extent of food waste on the retail level of the supply chain of perishables.
- **Null hypothesis (H₀3.3):** No significant relationship exists between the change in price (% Price Change) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁3.3):** A significant relationship exists between the change in price (% Price Change) and the extent of food waste on the retail level of the supply chain of perishables.

3.5. Hypothesis 4: Shelf Life

Research question four (RQ4): Can it be predicted with reasonable accuracy, that a relationship exists between the shelf life and the extent of food waste?

- **Null hypothesis (H₀4):** No significant relationship exists between shelf life (Shelf Life) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁4):** A significant relationship exists between shelf life (Shelf Life) and the extent of food waste on the retail level of the supply chain of perishables.

3.6. Hypothesis 5: Seasonal Supply and Demand

Research question five (RQ5): Can it be predicted with reasonable accuracy, that a relationship exists between seasonality and the extent of food waste?

- **Null hypothesis (H₀5.1):** No significant relationship exists between seasonality (Seasonal Demand) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁5.1):** A significant relationship exists between seasonality (Seasonal Demand) and the extent of food waste on the retail level of the supply chain of perishables.
- **Null hypothesis (H₀5.2):** No significant relationship exists between seasons (Seasonal Supply) and the extent of food waste on the retail level of the supply chain of perishables.
- **Alternate hypothesis (H₁5.2):** A significant relationship exists between seasons (Seasonal Supply) and the extent of food waste on the retail level of the supply chain of perishables.

3.7. Conclusion

Hypotheses have been identified to analyse the extent of food waste and its relationship with selected food waste drivers. The methodology used in this research regarding these hypotheses are discussed in chapter 4.

CHAPTER 4. RESEARCH METHODOLOGY

In support of the hypotheses stated in Chapter 3, the research methodology is designed to measure the extent of food waste in the supply chain of perishables as well as the relationship between food waste drivers and the food waste.

4.1. Research Design

The research used a pragmatic approach to analyse quantitative data analysis in search of useful information and practical solutions towards better understanding what drives food waste (Burns & Grove, 2007). Quantitative research is more deductive in nature (Creswell, 2012) and thus fitting for this research approach. The research hypotheses were deduced from general principles on estimating food waste in the supply chain as well as the drivers of food waste towards more particular and practical solutions using collaborative supply chain frameworks (Creswell, 2012; Saunders & Lewis, 2012; Welman, Kruger, & Mitchell, 2005). The initial theory or principles were either confirmed or amended dependent on the outcome of the research (Saunders & Lewis, 2012).

The object of the research was to evaluate the extent of waste in the supply chain of perishables as well as the relationship between food waste and respective drivers. The research was limited to the retail level of the supply chain of perishable food category within South Africa. The strategy focused on secondary data analysis of private archival documents and administrative records (Saunders & Lewis, 2012).

A cross-sectional timeframe was employed using data for two consecutive financial years 2015/2016 and 2016/2017 respectively. All the data was presented weekly over the same period to obtain a snapshot of the research problem at a specific point in time.

The analysis will make use of linear and multiple regression techniques (Wegner, 2014) to measure correlations between drivers of food waste and the extent of food waste.

4.2. Population

The population or universe for this research focused on retail groups within the South African retail sector that dealt with perishable products. These retail sector of the South African food supply chain consisted of five main retail groups, wholesalers and all independent sellers of fresh produce (Kanter, 2016). The main retail groups in South Africa were found to be the

most appropriate for this study as they represent almost 70% of total food sales (Kanter, 2016). The large retail groups are more likely to have valid historical data on food waste.

Although the population universe is all outlets that supply and sell perishable food, the research was only conducted on a representative sample of the population. This research, however, excludes all catering companies, restaurants and the national market itself due to the unavailability of information. The research only looked at fresh vegetables as a category of perishables. The raw quantitative data was processed and reworked into a format suitable for statistical analysis. All data followed the required authorisation process for the relevant organisations to use for this research.

4.3. Sampling method and size

All data collection followed the frame of a purposive sample as a type of non-probability sampling (Saunders & Lewis, 2012). Because of access within this field, the purposive sampling was conducted (Saunders & Lewis, 2012). A minimum sample sizes are required depending on the different applications of multiple regression (Knofczynski & Mundfrom, 2008). To avoid sampling error by targeting only a subset of the population, the five large retail groups were approached in order to access data for a sufficient number of individual stores. Because of the confidentiality of the data required, only one of the leading retail groups gave authorisation and consent. Since the study used multiple regression for prediction purposes, the minimum recommended sample size was calculated using the number of predicted variables and the squared multiple correlation coefficients (Knofczynski & Mundfrom, 2008). The sample data included 406 individual stores across four different provinces in South Africa exceeding the minimum sample size of 190 individual stores. The sample consisted of weekly data for two consecutive financial years 2015/2016 and 2016/2017 respectively.

4.4. Unit of analysis

This study utilises multiple research tests, and therefore there are multiple units of analysis (Wegner, 2014).

The unit of analysis for each research test are listed below

Research Test	Unit of Analysis
Extent of Food Waste (Food Waste%)	Weekly waste in units as a percentage of total units (sales units + waste units)
Relationship between shortages and food waste (Shortages-Availability (Corrected SU)1)	Weekly corrected sales units as a percentage of actual sales units. $[1 - (\text{sales units} / \text{corrected sales units})] \times 100$
Relationship between shortages and food waste (Shortages-Availability (Corrected SU)2)	Weekly corrected sales units as a percentage of total sales units. $[1 - (\text{corrected sales units} / \text{sales units})] \times 100$
Relationship between shortages and food waste (Shortages-Availability (Business))	Percentage 'out of stock days' on a weekly basis. $[1 - (\text{business availability})] \times 100$
Relationship between shortages and food waste (Shortages-Supplier)	Weekly short deliveries for suppliers as a percentage of total orders. $[1 - (\text{GRN/PO})] \times 100$
Relationship between promotions and food waste (Promotions)	Food waste percentage in promotion weeks versus out of promotion weeks
Relationship between price and food waste (Price)	Food waste percentage in relation to average unit price per week
Relationship between price change and food waste (Price Change)	Food waste percentage in relation to the percentage price change per week. Unit price for $[(\text{Week } x - \text{week } x-1) / \text{week } x-1]$
Relationship between shelf life and food waste (Shelf Life)	Food waste percentage in relation to average shelf life per week
Relationship between seasonality and food waste (Seasonal Demand)	Food waste percentage at the end of month season compared to food waste percentage at the middle of the month season.
Relationship between different seasons and food waste (Seasonal Supply)	Food waste percentage per week in relation to different seasons. Winter, Spring, Summer, Autumn

4.5. Data Collection and Cleaning Process

Quantitative data was collected from secondary data sources (Creswell, 2012; Saunders & Lewis, 2012). Time-series data from June 2015 to May 2017 was collected. The secondary data was gathered from the different retail groups as a collective but also for individual outlets within the retail groups. Data consisted of archived documents of sales, sales in units, short deliveries, waste and business availability (loss of sale) for a period for all the products in the vegetable range.

Some of the products are seasonal and therefore sales as well as waste, only occurs within the specific season. No aggregation was done on these data sets as the significance of the seasonality of the product was measured and thus relevant only specific period tested. In some week there were no sales for out of season products, but faulty shelf life figures still appeared on the system. In the event of no sales, the faulty shelf life was deleted. Both an original and corrected shelf life averages was included in the data set to analyse.

All the products lines in the vegetable category were included in the total of 970 products lines. An average for all the product lines was calculated for each week, and only the averages were used.

4.6. Data Coding

Following the data cleaning process, numerical symbols were assigned to specific labels to permit the transfer of data to the statistical software. A codebook was collated to identify each variable in the study by code name, description and position in the data matrix. A codebook was prepared for this study can be found in Appendix A. Promotions, seasons and seasonality were coded as nominal-scale categorical data.

4.7. Data Analysis

All statistical data were analysed using IBM SPSS Statistics Version 23 software. All tests were conducted at a 95% level of significance.

The approach used for analysing the data consisted of an initial descriptive statistical analysis (Creswell, 2012; Saunders & Lewis, 2012), as to determine a standard error of skewness of the various data sets (Wegner, 2014). When measuring normal distribution, distribution is highly skewed when the skewness value is >1 , moderately skewed when values ranging between 0.5 and 1.0, and relatively symmetrical when values range between 0 and 0.5 (Bulmer, 1979). This step was followed by a bivariate test consisting of a Pearson correlation

analysis conducted between food waste and all drivers of food waste (Wegner, 2014). A combination of various food waste drivers was combined to determine if a stronger correlation with food waste can be modelled.

A linear regression model was used as an extrapolative model to predict the extent of food waste (dependent variable) from the various drivers of food waste (independent variables). Next, multiple regression was used to predict the continuous dependent variable from various independent variables. Multiple regression analyses require that certain assumptions be met before the analyses can be conducted. These assumptions are as follows:

- Adequate Sample size: the minimum sample size for multiple regression was calculated to be at least 19 individual stores (Knofczynski & Mundfrom, 2008). The sample data included 406 individual stores across four different provinces in South Africa.
- No Outliers: Outliers are identified using the residual statistics. The standard deviation for the standard residual should not exceed a value of three standard deviation points (Chan, 2004).
- Independent data points: The Durbin-Watson was used to check for independence (Chan, 2004). Durbin-Watson measures the variables with a range from zero to four. Values hovering around two indicates that the variables are independent (Chan, 2004). Values reaching near zero (0) indicates a strong positive correlation and values reaching near four (4) indicates a strong negative correlation (Chan, 2004; Durbin & Watson, 1951).
- Normally distributed errors: All residuals have to be random normal distributed variables with a mean = 0 with a constant variable (Chan, 2004; Field, 2013). The normal distribution of the residuals was determined by examining the histograms and normal P-P plots.
- Multicollinearity diagnosis: There should be no perfect linear relationship between any two independent variables (Field, 2013). The Variance inflation factor (VIF) measures is a variable has a strong linear relationship with any of the other variables (Field, 2013). The collinearity diagnostics of tolerance and the Variance inflation factor (VIF) were examined with a tolerance level of less than 10. A VIF level close to one indicating the absence of concern for multicollinearity (Field, 2013).

To measure the strength of the relationship between each of the independent variables and the dependent variable the regression coefficients were determined (Wegner, 2014). The coefficient of determination referred to as r^2 , indicated the degree of variance in the dependent variable caused by one or more of the independent variables. The ANOVA was used to determine the effect of the independent variables on the dependent variable (Wegner, 2014). An automatic linear regression model was constructed applying an Akaike Information Criterion (Akaike, 1973; Wagenmakers & Farrell, 2004). This model can be used as a predictive tool for retail groups to forecast food waste percentage based on the specific drivers of food waste. The automatic linear model, remove non-significant variables and trim outliers to build a stronger, more reliable and repeatable information criterion model (Wagenmakers & Farrell, 2004).

4.8. Limitations

The research has various limitations, and it is critical to recognise that the validity of the findings may be affected in specific ways (Creswell, 2012).

- The data available was limited to only two years which limits the research to only a small period.
- It is important to acknowledge the bias of the researcher as well as the data collected from the various retail groups which may guide the research towards the key informants and might hinder the understanding of the broader situation (Myers, 2010). As an active role player in the supply chain of perishables, the researcher maintained a sense of objectivity and attempted to influence the research as little as possible.
- The study was limited to the retail level of the supply chain of perishables in the South African context and therefore limited within this scope and framework. Although applicable, globally the research may have limited application in other areas and sectors. The limited data available for the more extensive supply chain continues to be a limitation for the research as a holistic approach to the whole supply chain.
- The research was limited to only the fruit and vegetable subsection of the perishable category. Food waste stretches over all food categories, and therefore the results may consequently not be generalizable for all perishable or food categories.

- The research findings were based on proposed hypotheses deduced from literature, and it is probable that the findings only represent part of the narrative.
- Time and resources may be a limitation as a lack of time could, therefore, distort the data collection and analysis (Myers, 2013).
- Due to the confidentiality of the data required, only two retail group agreed to supply data for the study. Many retail groups opted not to take part in this research and did not make their data available. The data that was analysed went through the correct authorisation processes to obtain written consent documentation. After preliminary data analysis was conducted, the data set from one of the retailers was eliminated for the final data sample as it was inconsistent with too many errors.
- Secondary data has certain disadvantages that include accessibility of data, knowing the parameters used, original purpose and validity of data (Saunders & Lewis, 2012). Those retail groups that participated captured their data in different ways. Some of the data might, therefore, be inferred and other rendered entirely useless for this study.

4.9. Conclusion

A detailed description of the methodology used in the research was discussed in this chapter. Quantitative research methods were used to analyse secondary data and test the hypotheses. The limitations of this study were explicitly considered and stated.

The following chapter gives a detailed account of the analysis of the data and the results associated with each hypothesis.

CHAPTER 5. RESULTS

5.1. Introduction

This chapter builds on the methodology outlined in the previous chapter by describing the results of the data analysed. The purpose of this study was to determine the food waste percentage of perishable products within the retail supply chain and assess the elements that drive food waste within the supply chain. The data analysis looked at the hypothesised relationships between the dependent variable and the various independent variables namely:

Table 3 List of Variables

Number of Hypothesis	Category	Variables	Variable Name
Hypothesis 1	Food Waste	Dependent Variable	Food Waste %
Hypothesis 2	Shortages	Independent variable 1	Shortages-Availability (Corrected SU)1
		Independent variable 2	Shortages-Availability (Corrected SU)2
		Independent variable 3	Shortages-Availability (Business)
		Independent variable 4	Shortages - Supplier
Hypothesis 3	Price and Promotions	Independent variable 5	Promotions
		Independent variable 6	Price
		Independent variable 7	% Price Change
Hypothesis 4	Shelf life	Independent variable 8	Shelf life
		Independent variable 9	Shelf life (corrected)
Hypothesis 5	Seasonality	Independent variable 10	Seasonal Supply
		Independent variable 11	Seasonal Demand

Source: Own Research

Each individual research question consists of a section describing the correlations between the dependent variable and the relevant independent variables. The correlation section was followed by a simple linear regression model between the dependent variable and each independent variable. This was followed by a multiple regression model. The last section

consisted of the development of a modelling scenario to improve the percentage food waste. An automatic linear modelling scenario builds on multiple regression philosophies was used to strengthen the model by eliminating outliers and taking all variables into account.

5.2. Sample Description

The dataset stretched over 104 weeks and all the data for all the weeks is valid with no missing data. Price change % is working with the delta between two weeks thus only 103 entries.

5.3. Research Question 1: Food Waste %

Normal descriptive statistics was done to determine the extent of food waste of perishables for the specific retail group. The percentage of food waste was determined as a percentage of the total sales plus the total food waste per week.

Table 4 Descriptive Statistics: Food waste %

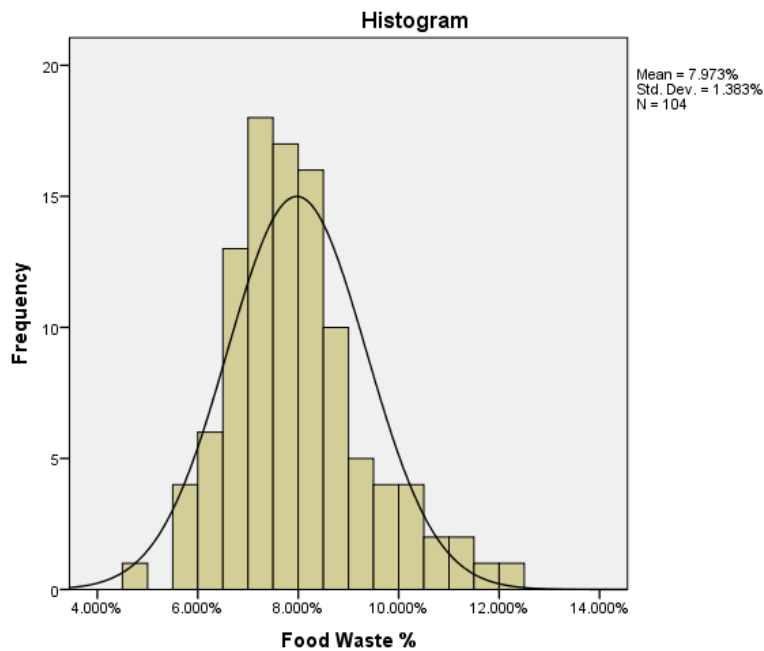
	N	Range	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
Food Waste %	104	7.381%	7.973%	0.136%	1.383%	.685	.237	.664	.469

Source: Own Research

As shown in Table 4 the food waste percentage for the period measured was a mean of 7.381%. A standard deviation of 1.383% indicates that the food waste per week did not deviate far from the mean for the period measured. No significant skewness or kurtosis was detected adding to the validity of the data (Azzalini & Capitanio, 1999). The range of food waste percentage stretches from 4.800% as a minimum for a week to 12.181% as a maximum for a week.

As displayed by the histogram in Figure 2, the data seems to be normally distributed indicating a vast majority of the weeks measured have outcomes that follow a normal pattern.

Figure 2 Normal Distribution Food waste %



Research question (RQ1): What is the extent of food waste in the retail level of the supply chain of perishables?

The null hypothesis (H_0) was Food Waste % equal ($=$) 17% and the alternate hypothesis (H_1) was Food Waste % does not equal (\neq) 17%.

The statistical analysis, therefore, answers the research question and rejects the null hypothesis based on the mean of 7.381% for Food Waste%.

5.4. Research Question 2: Shortages

For this research question of the relationship between shortages and the extent of food waste, four data categories were used namely:

Table 5 Category Shortages

Category	Description
Shortages-Availability (Corrected SU)1	Stock out as corrected sales
Shortages-Availability (Corrected SU)2	Stock out as corrected sales (corrected)
Shortages-Availability (Business)	Stock out as stock available for sales
Shortages - Supplier	Short delivery from suppliers on orders

Source: Own Research

5.4.1. Descriptive Statistics: Shortages

The descriptive statistics for shortages are displayed in Table 6. The mean, median and mode for each category were calculated. All the categories were slightly positively skewed as each skewness level is above 0 and below 1 and can be assumed that the data represents a normal distribution (Wegner, 2014).

Table 6 Descriptive Statistics Shortages

	Shortages- Availability (Corrected SU)1	Shortages- Availability (Corrected SU)2	Shortages- Availability (Business)	Shortages - Supplier
N	104	104	104	104
Mean	8.665%	9.508%	15.674%	5.550%
Median	8.494%	9.282%	15.175%	5.149%
Mode	5.763% ^a	6.115% ^a	11.737% ^a	2.169% ^a
Std. Deviation	1.270%	1.530%	2.273%	2.185%
Skewness	.336	.420	.899	.717
Kurtosis	.122	.243	1.061	-.017

Source: Own Research

5.4.2. Correlations Statistics: Shortages

A Pearson's product-moment correlation was run for all categories of shortages, to assess the relationship between shortages and the extent of food waste.

Table 7 below shows the Pearson correlation and the p-value for each category of shortages. The test complied with all the key assumptions in a Pearson's correlation test confirming that the data is normally distributed.

There was a weak negative correlation between Shortages-Availability (Corrected SU)1 and food waste but with no significance, $p > 0.05$. There was a weak negative correlation between Shortages-Availability (Corrected SU)2 but with no significance, $p > 0.05$. Multicollinearity exists between Shortages-Availability (Corrected SU)1 and Shortages-Availability (Corrected SU)2 as they have a significant correlation with a coefficient of 1 (Field, 2013). Thus they are statistically the same and should not be tested individually.

There were significance and a strong negative correlation between Shortages-Availability (Business), $p < 0.001$, explaining 38% of the variance in food waste. There was significance and a strong negative correlation between Shortages-Suppliers, $p < 0.001$, explaining 34% of the variance in food waste.

Table 7 Correlation Results Shortages

		Food Waste %	Shortages-Availability (Corrected SU)1	Shortages-Availability (Corrected SU)2	Shortages-Availability (Business)	Shortages - Supplier
Food Waste %	Pearson Correlation	1	-.089	-.090	-.376**	-.337**
	Sig. (2-tailed)		.367	.362	.000*	.000*
	N	104	104	104	104	104
Shortages-Availability (Corrected SU)1	Pearson Correlation	-.089	1	1.000**	.357**	.387**
	Sig. (2-tailed)	.367		.000	.000	.000
	N	104	104	104	104	104
Shortages-Availability (Corrected SU)2	Pearson Correlation	-.090	1.000**	1	.361**	.387**
	Sig. (2-tailed)	.362	.000		.000	.000
	N	104	104	104	104	104
Shortages-Availability (Business)	Pearson Correlation	-.376**	.357**	.361**	1	.150
	Sig. (2-tailed)	.000	.000	.000		.129
	N	104	104	104	104	104
Shortages - Supplier	Pearson Correlation	-.337**	.387**	.387**	.150	1
	Sig. (2-tailed)	.000	.000	.000	.129	
	N	104	104	104	104	104

*The correlation is significant at the 0.05 level (2-tailed).

5.4.3. Regression Model Statistics: Shortages

A simple linear regression was calculated to predict food waste based on the different categories for shortages namely Shortages-Availability (Corrected SU)1, Shortages-Availability (Corrected SU)2, Shortages-Availability (Business) and Shortages - Supplier.

All assumptions for regression analyses were met as discussed in chapter 4. All standard residual for the different independent variables was less than the default value of three standard deviation points. The Durbin-Watson values for each independent variable hovered around two showing the independence of the data points. The histograms and normal probability plots were evaluated, and the results confirmed that the data was indeed normally distributed.

Figure 3 Normal Distribution Shortages Availability

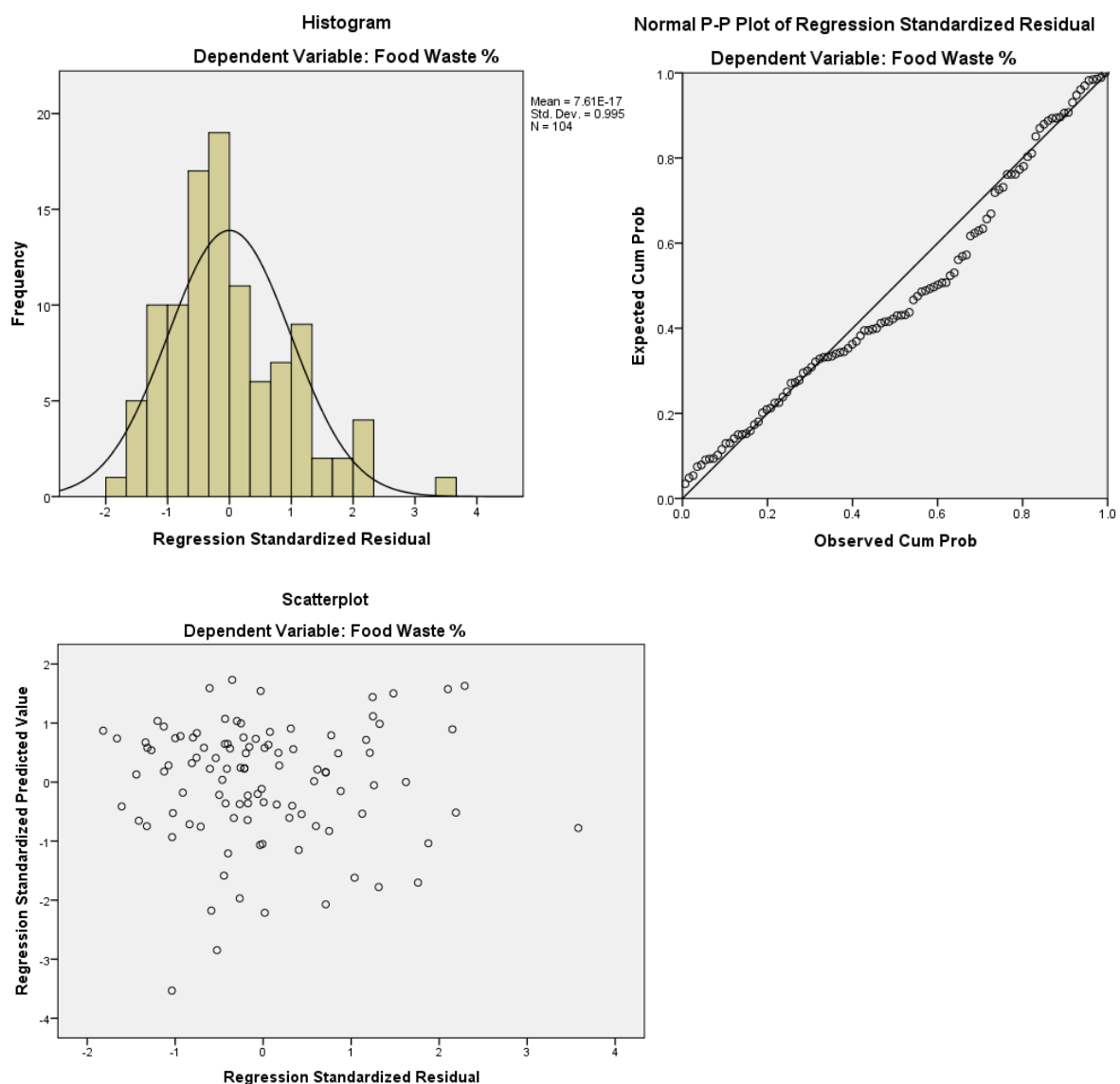


Figure 4 Normal Distribution Shortages Suppliers

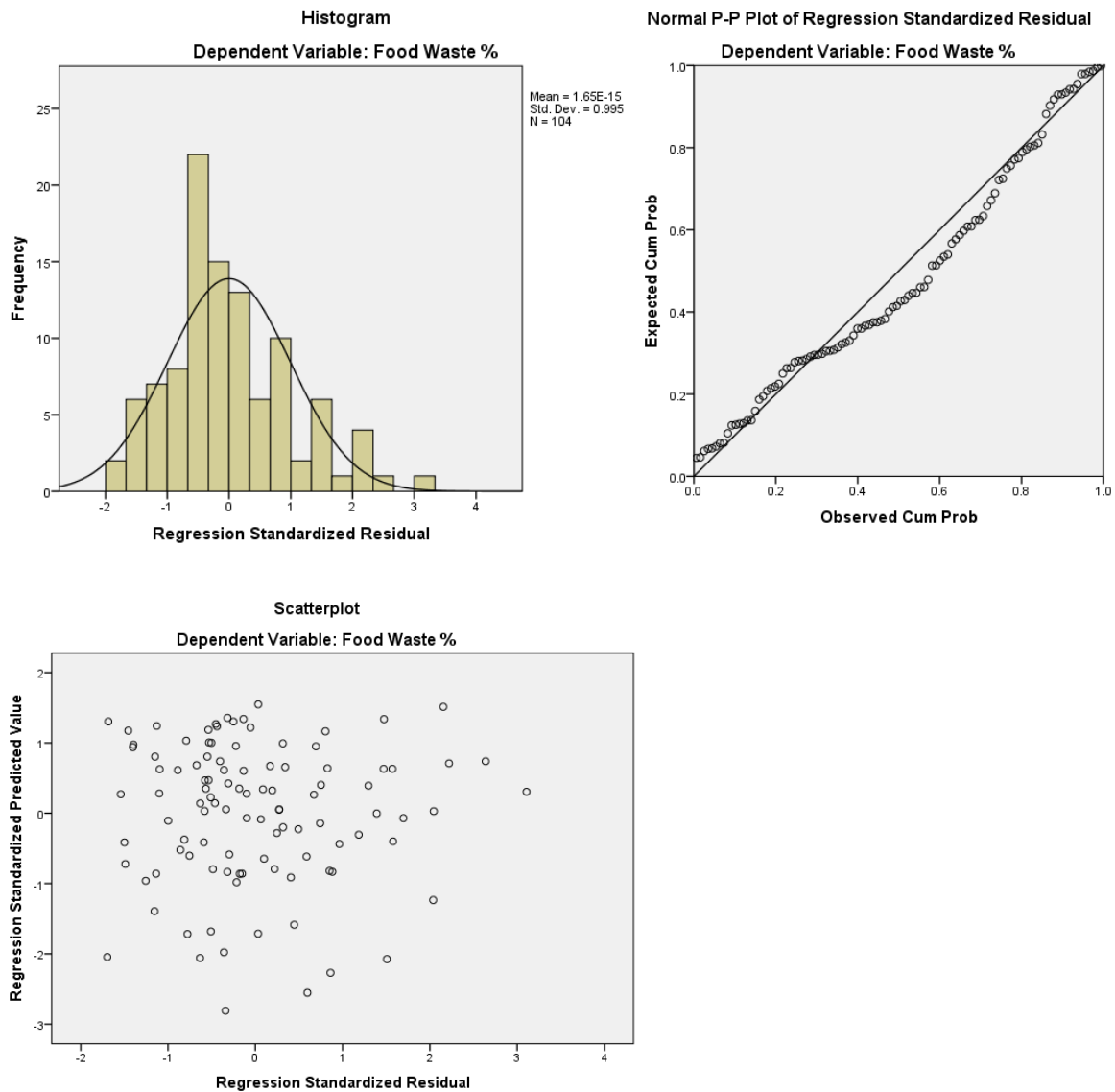


Table 8 below shows the linear regression model for each category of shortages. A significant regression equation was found on Shortages-Availability (Business) ($F = 16.781, p < .001$) with a R^2 of .141. A significant regression equation was also found on Shortages – Suppliers. ($F = 13.075, p < .001$) with a R^2 of .114.

The Shortages-Availability (Corrected SU)1 and Shortages-Availability (Corrected SU)2 linear regression model was not significant since the $p > 0.05$ ($p = 0.367, p = .362$). Therefore a model cannot be generated.

Table 8 Linear Regression Model Results Shortages

	R Square	F Change	Sig.	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Durbin - Watson	VIF
Shortages-Availability (Corrected SU)1	.008	.822	.367	-.097	-.089	1.574	1.000
Shortages-Availability (Corrected SU)2	.008	.840	.362	-.082	-.090	1.575	1.000
Shortages-Availability (Business)	.141	16.781	.000*	-.229	-.376	1.548	1.000
Shortages - Supplier	.114	13.075	.000*	-.213	-.337	1.720	1.000

*The correlation is significant at the 0.05 level (2-tailed). Source: Own Research

Research question (RQ2): Can it be predicted with reasonable accuracy, that a relationship exists between the shortages and the extent of food waste?

The first null hypothesis (H_0 2.1) for this research question states that no significant relationship exists between shortages on shelves (Shortage - Availability) and the extent of Food Waste %. The first alternate hypothesis (H_1 2.1) for this research question states that a significant relationship exists between shortages on shelves (Shortage – Availability Corrected Sales) and the extent of Food Waste %. Shortages on shelves (Shortage – Availability Corrected Sales) had no significant relationship ($F = 0.822$, $p = .367$) with a R^2 of .008 as seen in Table 8. The statistical analysis, therefore, failed to reject the null hypothesis due to lack of evidence to suggest that the null hypothesis is false.

The second null hypothesis (H_0 2.2) for this research question states that no significant relationship exists between stock out days (Shortage –Availability Business) and the extent of Food Waste %. The second alternate hypothesis (H_1 2.2) for this research question states that a significant relationship exists between stock out days (Shortage –Availability Business) and the extent of Food Waste %. Shortages-Availability (Business) had a significant relationship ($F = 16.781$, $p < .001$) with a R^2 of .141 as seen in Table 8. The research question was thus

answered, and the null hypothesis was rejected and the alternative hypothesis accepted at the 95% confidence level.

The third null hypothesis ($H_{02.3}$) for this research question states that no significant relationship exists between shortages on shelves (Shortage - Suppliers) and the extent of Food Waste %. The second alternate hypothesis ($H_{12.3}$) for this research question states that a significant relationship exists between shortages on shelves (Shortage - Suppliers) and the extent of Food Waste %. Shortages-Suppliers had a significant relationship ($F = 13.075$, $p < .001$) with a R^2 of .114 as seen in Table 8. The null hypothesis was therefore rejected and the alternative hypothesis accepted at the 95% confidence level.

5.5. Research Question 3: Promotions and Price

For this research question of the relationship between promotions or price and the extent of food waste, three data categories were used namely:

Table 9 List of Categories Promotions and Price

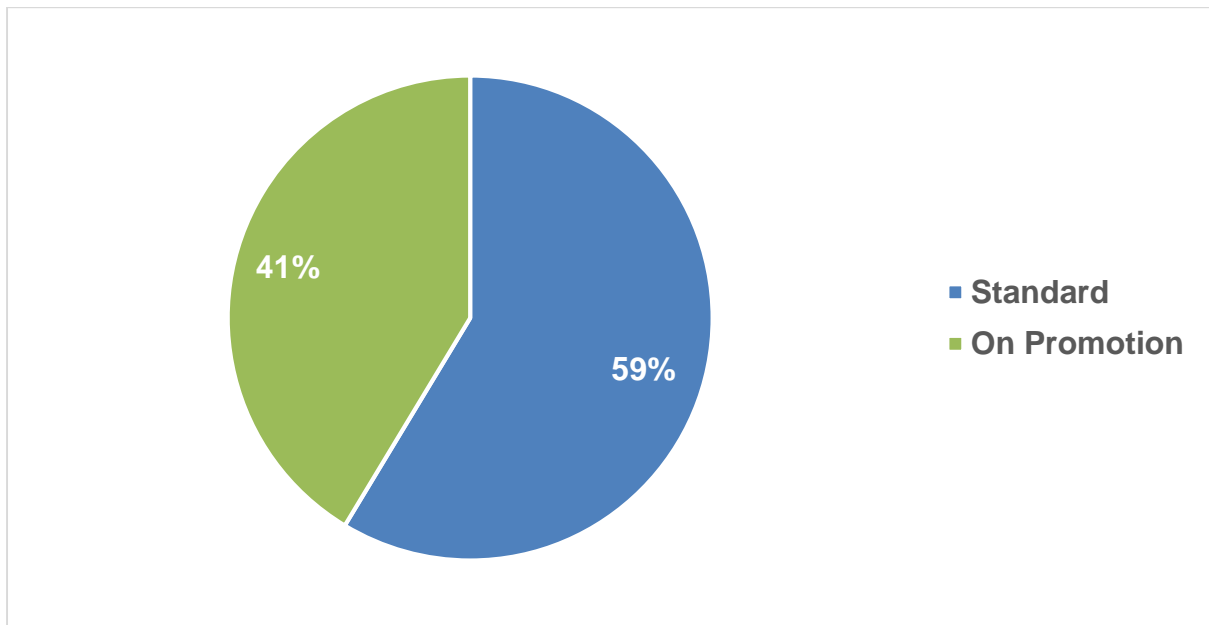
Category	Description
Promotions	In and out of promotions
Price	Average price per week
% Price Change	Percentage change in weekly price

Source: Own Research

5.5.1. Descriptive Statistics: Promotions and Price

The mode (most frequently occurring value) was used to describe promotions as nominal-scaled categorical data. In Figure 5 below Standard out of promotion accounted for 59% of the sample, while promotions represented 41%.

Figure 5 Promotions



The descriptive statistics for Price and % Price Change are displayed in Table 10. The mean, median and mode for each category were calculated. The standard deviation of 5.457% for Price indicates that there was a significant amount of variation from the mean. Regarding normal distribution, Price is slightly negatively skewed. The standard deviation of 28.310% for % Price Change indicates that there was a significant amount of variation from the mean. Regarding normal distribution % Price Change is slightly positively skewed.

Table 10 Descriptive Statistics Price

		Price	% Price Change
N	Valid	104	103
	Missing	0	1
Mean		29.103	4.125%
Median		31.078	0.385%
Mode		21.632 ^a	-40.857% ^a
Std. Deviation		5.457	28.310%
Skewness		-.027	.200
Kurtosis		-1.344	-1.290

Source: Own Research

5.5.2. Correlation Statistics: Promotions and Price

A Pearson's product-moment correlation was run for all categories of promotions, to assess the relationship between promotions and the extent of food waste. Table 11 below shows the Pearson correlation and the p-value for each category of promotions. The test complied with all the key assumptions in a Pearson's correlation test confirming that the data were normally distributed.

There was a weak negative correlation between Price and food waste but with no significance, $p > 0.05$. There was a weak negative correlation between % Price Change but with no significance, $p > 0.05$.

There were significance and a strong negative correlation between Shortages-Availability (Business), $p < .001$, explaining 41% of the variance in food waste.

Table 11 Correlation Results Promotions and Price

		Food Waste %	Promotions	Price	% Price Change
Food Waste %	Pearson Correlation	1	-.411	-.063	-.025
	Sig. (2-tailed)		.000*	.527	.804
	N	104	104	104	103
Promotions	Pearson Correlation	-.411	1	-.177	.134
	Sig. (2-tailed)	.000		.073	.178
	N	104	104	104	103
Price	Pearson Correlation	-.063	-.177	1	-.732
	Sig. (2-tailed)	.527	.073		.000
	N	104	104	104	103
% Price Change	Pearson Correlation	-.025	.134	-.732	1
	Sig. (2-tailed)	.804	.178	.000	
	N	103	103	103	103

*The correlation is significant at the 0.05 level (2-tailed). Source: Own Research

5.5.3. Linear Regression Model Statistics: Promotions and Price

A simple linear regression was calculated to predict food waste based on the different categories for promotions namely Promotions, Price and % Price Change.

All assumptions for regression analyses were met as discussed in chapter 4. All standard residual for the different independent variables was less than the default value of three standard deviation points. The Durbin-Watson values for each independent variable hovered around two showing the independence of the data points. The histograms and normal probability plots were evaluated, and the results confirmed that the data was indeed normally distributed.

Figure 6 Normal Distribution Promotions

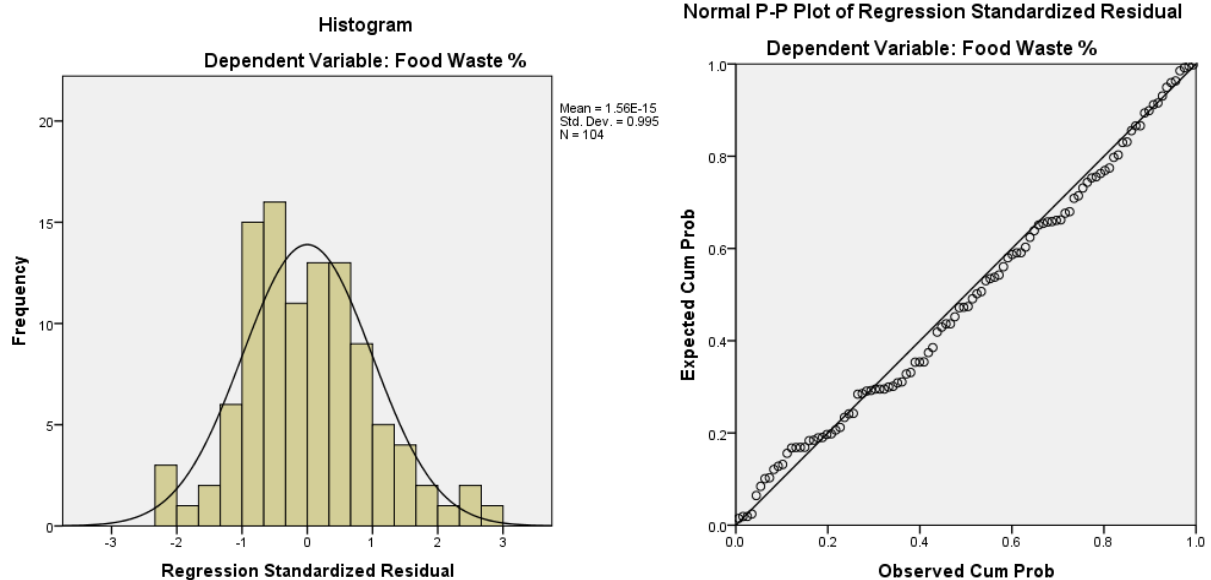


Table 12 below shows the linear regression model for each category of promotions. A significant regression equation was found on Promotions ($F = 20.771$, $p < .001$) with a R^2 of .169.

The linear regression model done for Price and % Price Changes was not significant since the $p > 0.05$ (Price $p = .527$, % Price Change $p = .804$), therefore a model cannot be generated.

Table 12 Linear Regression Model Results Promotions and Price

	R Square	F Change	Sig.	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Durbin - Watson	VIF
Promotions	.169	20.771	.000	-1.150	-.411	1.582	1.000
Price	.004	.403	.527	-.016	-.063	1.514	1.000
% Price Change	.001	.062	.804	-.001	-.025	1.514	1.000

Source: Own Research

Research question (RQ3): Can it be predicted with reasonable accuracy, that a relationship exists between the promotions or price and the extent of food waste?

The first null hypothesis ($H_{03.1}$) for this research question states that no significant relationship exists between promotions (Promotions) and the extent of Food Waste %. The first alternate hypothesis ($H_{13.1}$) for this research question states that a significant relationship exists between promotions (Promotions) and the extent of Food Waste %. Promotions had a significant relationship ($F = 20.771$, $p < .001$) with an R^2 of .169 as seen in Table 12. The research question was thus answered, and the null hypothesis was therefore rejected and the alternative hypothesis accepted at the 95% confidence level.

The second null hypothesis ($H_{03.2}$) for this research question states that no significant relationship exists between price (Price) and the extent of Food Waste %. The first alternate hypothesis ($H_{13.2}$) for this research question states that a significant relationship exists between price (Price) and the extent of Food Waste %. Price had no significant relationship ($p > .05$) with as seen in Table 12. The statistical analysis, therefore, failed to reject the null hypothesis due to lack of evidence suggesting that the null hypothesis is false.

The third null hypothesis ($H_{03.3}$) for this research question states that no significant relationship exists between price (% Price Change) and the extent of Food Waste %. The first alternate hypothesis ($H_{13.3}$) for this research question states that a significant relationship exists between price (% Price Change) and the extent of Food Waste %. % Price Change had no significant relationship ($p > .05$) with as seen in Table 12. The statistical analysis, therefore, failed to reject the null hypothesis due to lack of evidence suggesting that the null hypothesis is false.

5.6. Research Question 4: Shelf Life

For this research question of the relationship between promotions and the extent of food waste, three data categories were used namely:

Table 13 List of Categories Shelf Life

Category	Description
Shelf Life	Average Shelf Life per week
Shelf Life (Corrected)	Average Shelf Life per week (Corrected)

Source: Own Research

5.6.1. Descriptive Statistics: Shelf Life

The descriptive statistics for shortages are displayed in Table 14. The mean, median and mode for each category were calculated. All the categories were moderately negatively skewed.

Table 14 Descriptive Statistics Shelf Life

	Shelf life	Shelf life (corrected)
N	104	104
	0	0
Mean	6.073	5.635
Median	6.353	5.904
Mode	4.778 ^a	4.397
Std. Deviation	0.6118	0.5889
Skewness	-1.649	-1.645
Kurtosis	.771	.766

Source: Own Research

5.6.2. Correlations Statistics: Shelf Life

A Pearson's product-moment correlation was run for all categories of shelf life, to assess the relationship between shelf life and the extent of food waste. Table 15 below shows the Pearson correlation and the p-value for each category of shortages. The test complied with all the key assumptions in a Pearson's correlation test confirming that the data were normally distributed.

There was a weak positive correlation between Shelf Life and food waste but with no significance, $p > 0.05$. There was a weak positive correlation between Shelf Life (Corrected) but with no significance, $p > 0.05$. Multicollinearity exists between Shelf Life and Shelf Life Corrected as they have a significant correlation with a coefficient of about 1 (Field, 2013). Thus they are statistically the same and should not be tested individually.

Table 15 Correlation Results Shelf Life

		Food Waste %	Shelf life	Shelf life (corrected)
Food Waste %	Pearson Correlation	1	.055	.053
	Sig. (2-tailed)		.582	.593
	N	104	104	104
Shelf life	Pearson Correlation	.055	1	.999
	Sig. (2-tailed)	.582		.000
	N	104	104	104
Shelf life (corrected)	Pearson Correlation	.053	.999	1
	Sig. (2-tailed)	.593	.000	
	N	104	104	104

*The correlation is significant at the 0.05 level (2-tailed). Source: Own Research

5.6.3. Regression Model Statistics: Shelf Life

A simple linear regression was calculated to predict food waste based on the different categories for shortages namely Shelf Life and Shelf Life (corrected).

All assumptions for regression analyses were met as discussed in chapter 4. All standard residual for the different independent variables was less than the default value of three standard deviation points. The Durbin-Watson values for each independent variable hovered around two showing the independence of the data points. The histograms and normal probability plots were evaluated, and the results confirmed that the data was indeed normally distributed.

Table 16 below shows the linear regression model for each category of shortages. The Shelf Life and Shelf Life (corrected) linear regression models was not significant since the $p > 0.05$ (Shelf life $p = .582$, Shelf life (corrected) $p = .593$), therefore a model cannot be generated.

Table 16 Linear Regression Model Results in Shelf Life

	R Square	F Change	Sig.	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Durbin - Watson	VIF
Shelf life	.003	.305	.582	.123	.055	1.560	1.000
Shelf life (corrected)	.003	.288	.593	.125	.053	1.559	1.000

*The correlation is significant at the 0.05 level (2-tailed).

Research question (RQ4): Can it be predicted with reasonable accuracy, that a relationship exists between the shelf life and the extent of food waste?

The first null hypothesis (H_0 4.1) for this research question states that no significant relationship exists between shelf life (Shelf Life) and the extent of Food Waste %. The first alternate hypothesis (H_1 4.1) for this research question states that a significant relationship exists between shelf life (Shelf Life) and the extent of Food Waste %. Both Shelf Life and Self Life (Corrected) had no significant relationship ($p > .05$) as seen in Table 16. The statistical analysis answered the research question and failed to reject the null hypothesis due to lack of evidence suggesting that the null hypothesis is false.

5.7. Research Question 5: Seasonal Demand and Supply

For this research question of the relationship between seasonality and the extent of food waste, four data categories were used namely:

Table 17 List of Categories Seasonal Demand and Supply

Category	Description
Seasonal Demand	End of the Month versus Middle of the month
Seasonal Supply	Four different seasons of the year

Source: Own Research

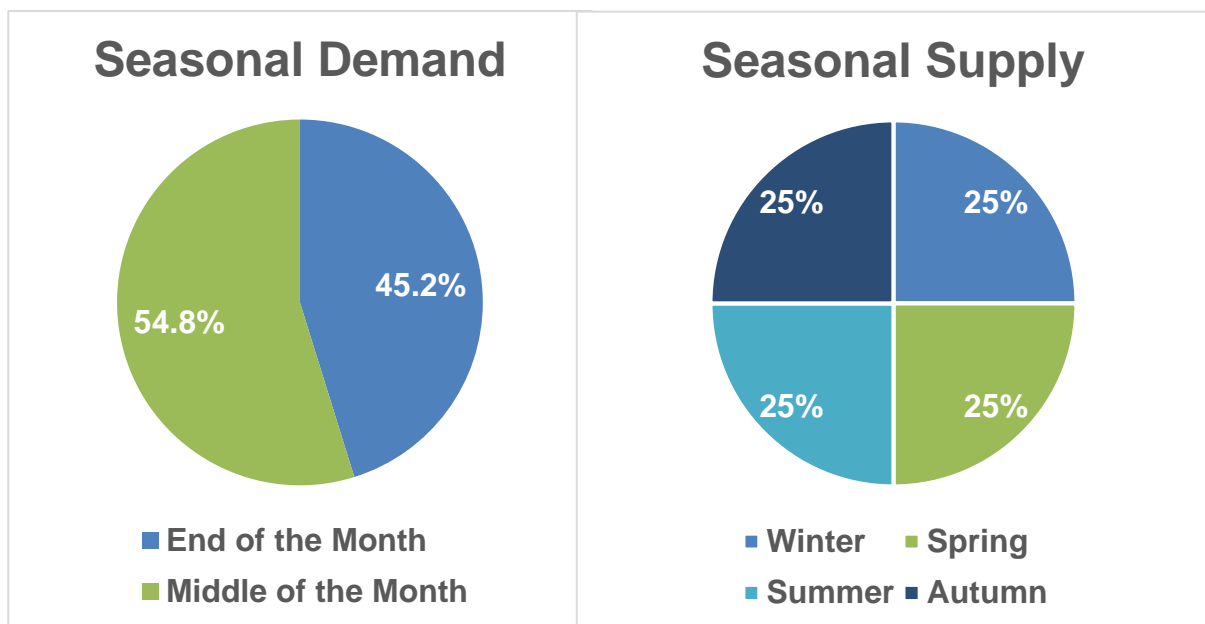
5.7.1. Descriptive Statistics: Seasonal Demand and Supply

The next nominal-scaled categorical data section is seasonal supply. Figure 7 below displays the frequencies and percentages associated with the four different season in a year. The data

is equally represented between Winter (25%), Spring (25%), Summer (25%) and Autumn (25%).

The next nominal-scaled categorical data section is seasonal demand. Figure 7 below displays the frequencies and percentages associated with seasonal demand. The middle of the month period represents (55%) of the data set while the end of the month period represents (45%).

Figure 7 Seasonal Demand and Supply



5.7.2. Correlations Statistics: Seasonality

A Pearson's product-moment correlation was run for all categories of shortages, to assess the relationship between shortages and the extent of food waste. Table 18 below shows the Pearson correlation and the p-value for each category of shortages. The test complied with all the key assumptions in a Pearson's correlation test confirming that the data is normally distributed.

A weak negative correlation between seasonal supply and food waste were found but with no significance, $p > 0.05$.

The study found significance and a strong positive correlation between seasonal demand and food waste, $p = 0.007$, explaining 26% of the variance in food waste.

Table 18 Correlation Results Seasonality

		Food Waste %	Seasons	Seasonality
Food Waste %	Pearson Correlation	1	-.091	.262
	Sig. (2-tailed)		.359	.007*
	N	104	104	104
Seasons	Pearson Correlation	-.091	1	-.026
	Sig. (2-tailed)	.359		.794
	N	104	104	104
Seasonality	Pearson Correlation	.262	-.026	1
	Sig. (2-tailed)	.007	.794	
	N	104	104	104

*The correlation is significant at the 0.05 level (2-tailed). Source: Own Research

5.7.3. Regression Model Statistics: Seasonal Demand and Supply

A simple linear regression was calculated to predict the level of food waste based on the relationship with seasonal demand and seasonal supply.

All assumptions for regression analyses were met as discussed in chapter 4. All standard residual for the different independent variables was less than the default value of three standard deviation points. The Durbin-Watson values for each independent variable hovered around two showing the independence of the data points. The histograms and normal probability plots were evaluated, and the results confirmed that the data was indeed normally distributed.

Table 19 below shows the linear regression model for each category of seasonal demand and supply. A significant regression equation was found on seasonality of demand ($F = 7.491$, $p = .007$) with a R^2 of .068. The seasonal supply linear regression model was not significant since the $p > 0.05$ ($p = 0.359$) therefore a model cannot be generated.

Table 19 Linear Regression Model Results in Seasonal Demand and Supply

	R Square	F Change	Sig.	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Durbin - Watson	VIF
Seasons	.008	.848	.359	-.112	-.091	1.572	1.000
Seasonality	.068	7.491	.007*	.723	.262	1.554	1.000

*The correlation is significant at the 0.05 level (2-tailed). Source: Own Research

Research question (RQ5): Can it be predicted with reasonable accuracy, that a relationship exists between the seasonal demand and supply and the extent of food waste?

The first null hypothesis (H_0 5.1) for this research question states that no significant relationship exists between Seasonal Demand and the extent of Food Waste %. The first alternate hypothesis (H_1 5.1) for this research question states that a significant relationship exists between Seasonal Demand and the extent of Food Waste %. Seasonality had a significant relationship ($F = 7.491$, $p = .007$) with a R^2 of .068 as seen in Table 19. The research question was thus answered, and the null hypothesis was therefore rejected and the alternative hypothesis accepted at the 95% confidence level.

The second null hypothesis (H_0 5.2) for this research question states that no significant relationship exists between seasons (Seasons) and the extent of Food Waste %. The first alternate hypothesis (H_1 5.2) for this research question states that a significant relationship exists between seasons (Seasons) and the extent of Food Waste %. Seasons had no significant relationship ($p > .05$) with as seen in Table 19. The statistical analysis, therefore, failed to reject the null hypothesis as a result of a lack of evidence suggesting that the null hypothesis is false.

5.8. Multiple Regression

Before the multiple regression analyses were conducted, all assumptions for regression analyses were met as discussed in chapter 4. All standard residual for the different independent variables was less than the default value of three standard deviation points. The Durbin-Watson values for each independent variable hovered around two showing the independence of the data points. The histograms and normal probability plots were evaluated, and the results confirmed that the data was indeed normally distributed.

A multiple linear regression was calculated to predict the food waste based on all the categories with a significant correlation namely [Shortages-Availability (Business) and Shortages – Supplier and Promotions and Price and % Price Change and Shelf Life and Shelf Life (Corrected) and Seasonal Demand and Seasonal Supply]. The multiple regression analyses were conducted by entering the control variables in stepwise format to identify the best fit in the model. The results of the multiple regression analyses are displayed in Table 20 below.

From a statistical regression analysis, the Durbin-Watson value tests for autocorrelation in the residuals. The Durbin-Watson as shown in Table 20 is very close to two (DW=1.607) confirming that a very low autocorrelation exists in the model statistic. Durbin-Watson values hovering around two confirms the independence of all the data points, and hence the independence assumption is satisfied (Durbin & Watson, 1951). The Variance inflation factor (VIF) level was close to one indicating the absence of concern for multicollinearity and linear relationships between the variables chosen in this model (Field, 2013). The R square for the multiple regression models was .362 indicating that the food drivers chosen in this model are responsible for 36.2% of the food waste.

Table 20 Multiple Regression Model Result

Model	R Square	Adjusted R Square	Sig. F Change	F Change	Durbin-Watson
1	.169	.161	.000	20.771	
2	.295	.281	.000	18.083	
3	.362	.343	.002	10.404	1.607
a. Predictors: (Constant), Promotions					
b. Predictors: (Constant), Promotions, Shortages-Availability (Business)					
c. Predictors: (Constant), Promotions, Shortages-Availability (Business), Shortages - Supplier					
d. Dependent Variable: Food Waste %					

The multiple regression models can be used as a prediction model:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon$$

$$Y = 12.351 - 1.049 x (\text{Promotions}) - .193 x (\text{Shortages Availability Business}) - .0165 x (\text{Shortages Supplier})$$

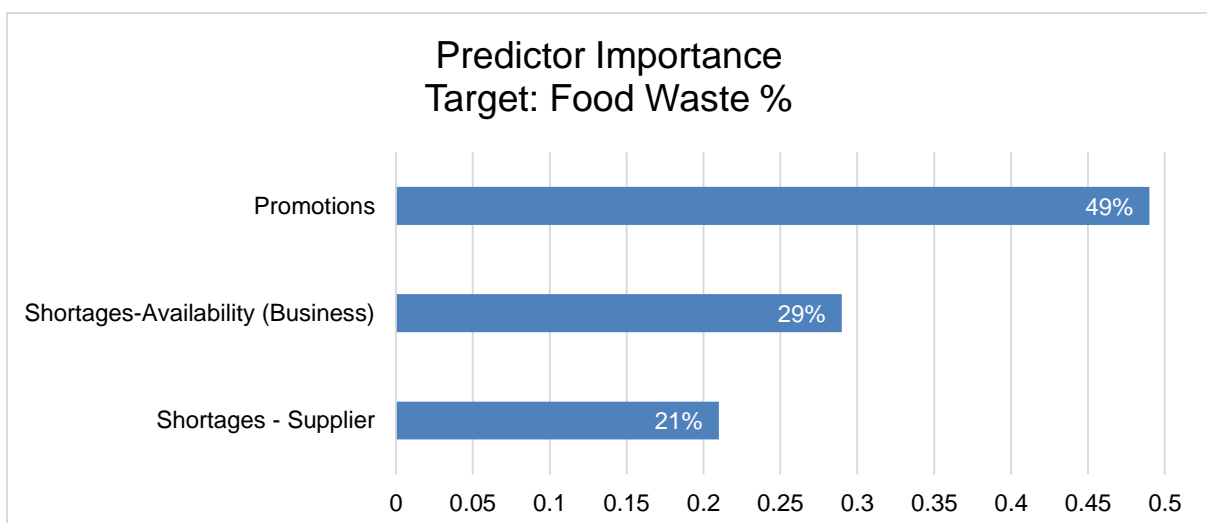
Table 21 Multiple Regression Prediction Model

Model	Coefficients	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
3	(Constant)	12.351		0.000		
	Promotions	-1.049	-0.375	0.000	0.993	1.007
	Shortages-Availability (Business)	-0.193	-0.317	0.000	0.976	1.025
	Shortages - Supplier	-0.165	-0.261	0.002	0.973	1.028
a. Dependent Variable: Food Waste %						

Source: Own Research

To strengthen the model an Automatic Linear Modelling was done. Automatic Linear Modelling used a simple linear regression model applying Akaike Information Criterion as a predictive tool to forecast the extent of food waste based on specific food waste drivers (Akaike, 1973; Wagenmakers & Farrell, 2004). The advantage of using an automatic linear modelling method over the enter or forward stepwise method is the fact that multiple combinations and weighted importance are tested to determine the optimum and best-fit model possible (Akaike, 1973). The Automatic Linear Modelling improved the model to impact 36.4% of food waste.

Figure 8 Automatic Linear Model



5.9. Conclusion

Data analysis was done on based on the research questions and hypothesis. The result was based on research methodology testing the acceptance levels for correlations and assumptions for regression. Once the criteria were met, a modelling scenario was developed to improve the percentage food waste. An automatic linear modelling scenario builds on a multiple regression philosophy was used to strengthen the model by eliminating outliers and taking all variables into account. In chapter 6 the results of the research process are discussed in more detail in relation to existing literature.

CHAPTER 6. DISCUSSION

6.1. Introduction

In the following chapter, the research findings and results of Chapter 5 are discussed in detail and supported by the literature reviewed in Chapter 2. This study aimed to quantify the food waste percentage of perishable products within the retail supply chain and assess the elements that drive food waste within the supply chain. The data analysis looked at the hypothesised relationships between food waste as the dependent variable and the various drivers of food waste as the independent variables.

The way that the food supply chain is managed has a massive impact on the extent of food waste within the food supply chain. The research aims to create a basic model for management within the food supply chain to predict the extent of food waste by focusing on specific food waste drivers.

6.2. Research Question 1: Food Waste %

Naming	Description	Result
Research question (RQ1):	What is the extent of food waste in the retail level of the supply chain of perishables?	Food waste % = 7.381%
Null hypothesis (H₀1):	Food waste as a percentage of retail sales (Food Waste %) is equal (=) to the percentage used to estimate food waste namely (17%)	Reject
Alternate hypothesis (H₁1):	Food waste as a percentage of retail sales (Food Waste %) is not equal (≠) to the percentage used to estimate food waste namely (17%)	Accept

Source: Own Research

From the research it can be concluded that food waste within the retail sector in South Africa is managed more efficiently than initially assumed in the literature. This must be seen in the context that only one retail group participated in the study and thus cannot be fully representative of the sector. The results of the study have found that the food waste percentage per week is on average 7.381% of total product procured and delivered to stores. This is much lower than the 17% food waste for fruits and vegetables used in the research done by Gustavsson et al. (2011) and Oelofse & Nahman (2013).

The 17% was used in the calculation of food waste for fruits and vegetables in sub-Saharan Africa and needs to be explored in more depth. This research only included the data from the retail sector and did not represent the wholesale and informal sectors. Kanter (2016) support this argument by stating that the retail sector in South Africa represents about 70% of the total market which might not be the same for the other sub-Saharan countries.

The percentage of food waste was measured as a percentage of total sales plus total food waste per week for each retail outlet. This level of the food supply chain includes the whole process from the moment a unit is received from the different suppliers to the point of sale to the end consumer. The distribution centres and the transportation and logistics are factored in. This coincides with the description of “distribution” used by Gustavsson et al. (2011), see Table 2.

Food waste percentages per week ranged from 4.800% to 12.181%, indicating a fluctuation which raises the question to the causes of the variation. Looking at the histogram in Figure 2 the data was slightly positively skewed, indicating that the mean is slightly higher than the median. Any inefficiencies within the supply chain related to food waste drivers will increase the possibility of food waste. This suggests that there is a higher possibility of increased food waste than of lower food waste. This supports the call from Jensen et al. (2013) for retail groups to emphasise the need for food waste management for a sustainable food supply chain and food security.

The retail group used for this research have an excellent supply chain management structure in place with strict food waste targets. It is evident in the results that the current food waste management practice and policies are working to stabilise food waste within the food supply chain. Supply chain managers need to understand the drivers of food waste and the impacts they have on the extent of food waste to decrease the percentage of food waste within the food supply chain even further.

The research question regarding food waste percentage has therefore been answered. To determine the extent of food waste within the supply chain of perishable foods in the South African retail industry was therefore achieved.

6.3. Research Question 2: Shortages

Naming	Description	Result
Research question (RQ2):	Can it be predicted with reasonable accuracy, that a relationship exists between the shortages and the extent of food waste?	Yes
Null hypothesis (H₀2.1):	No significant relationship exists between shortages on shelves (Shortage – Availability Corrected Sales) and the extent of food waste on the retail level of the supply chain of perishables.	Fail to reject
Alternate hypothesis (H₁2.1):	A significant relationship exists between shortages on shelves (Shortage – Availability Corrected Sales) and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Null hypothesis (H₀2.2):	No significant relationship exists between stock out days (Shortage – Availability Business) and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Alternate hypothesis (H₁2.2):	A significant relationship exists between stock out days (Shortage – Availability Business) and the extent of food waste on the retail level of the supply chain of perishables.	Accept
Null hypothesis (H₀2.3):	No significant relationship exists between supplier short delivery (Shortage - Supplier) and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Alternate hypothesis (H₁2.3):	A significant relationship exists between supplier short delivery (Shortage - Supplier) and the extent of food waste on the retail level of the supply chain of perishables.	Accept

Source: Own Research

The results of this study show that the corrected sales in units in the supply chain are quite significant with a mean of 8.665% Table 5. Corrected sales are seen as potential sales lost due to stock out on shelves based on the rate of sales for that specific week.

There was a weak negative correlation between shortages on shelves and food waste with no statistical significance. Although there was no statistical significance, the result shows that as shortages on shelf decreased, the percentage food waste increased. This can be explained by supply chain members efforts to limit the loss of sales by overstating the demand factor by over procurement to make provision for loss of sales at the expense of potential food waste (Panda & Mohanty, 2011). The research only looked at the retail level of the supply chain and

did not take into account the bullwhip effect this management behaviour has to the upstream supply chain members or the effect on the consumer (Lee et al., 1997).

A strong positive correlation exists between supplier shortages and corrected sales, with short deliveries from the suppliers explaining 38% of loss of sales. In anticipations of short deliveries from the suppliers, downstream supply chain members will order more than what is actually required to ensure that they have enough stock (Panda & Mohanty, 2011). The overstatement in the orders signals to the upstream supply chain members that there is an increase in the demand. The overstated demand signalled by the reaction to shorts is seen to be the primary contributor to the bullwhip effect resulting in higher shortages and eventually food waste in the different supply chain levels (Panda & Mohanty, 2011).

Business availability is measured in a number of days' sales closes for the day with no stock on shelves. The research shows that each store runs out of stock 15.674% of the time or 1.1 days per week, resulting in lost sales because of stock out. Lee et al. (1997) argue that as the actual orders are being placed, all supply chain member process this information as an indication of current and future product demand. When the stock out occurs in the store at the end of the day, the buyer automatically adds the shortage to the next day's order, signalling an increase in demand. This, in fact, is an overstatement of the demand as loss of sale cannot be made up in the future, resulting in excess stock and potentially food waste.

Loss of sales has a significant commercial impact on the business but has even greater significance when viewed in relation to food waste. It has been argued that the variability in the supply, based on actual supply and demand functions (Lee et al., 1997), can result in simultaneous shortages and waste (Nag et al., 2014). This is potentially devastating for the food chain supply as it results in a combination of loss of sale, and food waste. In reality, this means there is a willing buyer for a specific product in the one store with no stock to buy and at the same time product going to waste in another store. The combined figure of 16.016% (7.381% for food waste Table 4 and 8.665% for corrected sales units Table 6) has a massive commercial implication on the bottom line of the store and the supply chain at large. Jensen et al. (2013) call for innovative supply chain solutions to reduce shortages and waste by getting the right product to the right place at the right time.

The results of this study suggest that supplier shortages and the business viability shortages can predict with significance the extent of food waste. This is a potentially contradicting business dilemma, as the supply chain management have strict targets to reduce both shortages and food waste. This study shows there is an inverse relationship between shortages and food waste resulting in the conflicting results for the efforts made to improve the extent of food waste and shortages.

6.4. Research Question 3: Promotions and Price

Naming	Description	Result
Research question (RQ3):	Can it be predicted with reasonable accuracy, that a relationship exists between the promotions or price and the extent of food waste?	Yes
Null hypothesis (H₀3.1):	No significant relationship exists between promotions (Promotions) and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Alternate hypothesis (H₁3.1):	A significant relationship exists between promotions (Promotions) and the extent of food waste on the retail level of the supply chain of perishables.	Accept
Null hypothesis (H₀3.2):	No significant relationship exists between price (Price) and the extent of food waste on the retail level of the supply chain of perishables.	Fail to reject
Alternate hypothesis (H₁3.2):	A significant relationship exists between price (Price) and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Null hypothesis (H₀3.3):	No significant relationship exists between the change in price (% Price Change) and the extent of food waste on the retail level of the supply chain of perishables.	Fail to reject
Alternate hypothesis (H₁3.3):	A significant relationship exists between the change in price (% Price Change) and the extent of food waste on the retail level of the supply chain of perishables.	Reject

Source: Own Research

Literature agrees that promotion activities have a significant influence on the extent of food waste in the food supply chains (Gunders, 2012; Gustavsson et al., 2011; Mena et al., 2011; Mourad, 2016). This implies that an increase in promotional activities increases the variability in the forecast and actual demand and in turn, increases food waste (Lee et al., 1997; Mena et al., 2011; Taylor & Fearn, 2009). The results of this study show the exact opposite; a strong inverse relationship exists between promotions and the extent of food waste. The percentage food waste decreases on average in promotional periods compared to the periods out of promotions.

It is important to note that the percentage food waste considered all product lines and not only the product lines that are on promotion. Promotions draw the customers to the store, and they do not only buy the promotional products but also need other products and include them in

the basket. Promotions have a more significant bottom line effect than only the products on promotion, and therefore food waste also needs to be viewed from a holistic view.

Panda & Mohanty (2011) argues that promotions have a knock-on effect on out of promotion times. Consumers buy larger quantities than required for promotions because of the price benefit which in turn decreases the demand for that product out of promotion. The supply chain management anticipates the demand for products to return to normal after the promotions while in fact, it drops lower than the normal levels creating potential food waste.

The results of this study do not take into account the bullwhip effect that promotions have on the extent of food waste at the upstream suppliers or the household waste of the consumer.

Price is a function of promotions and was evaluated in this research as a separate food waste driver. Food supply chains have high sales targets and use price positioning to drive sales (Aramyan et al., 2007). Panda & Mohanty (2011) argues that consumers buy higher quantities than usual when prices are low causing an artificial variation in demand for product perpetuating the bullwhip effect of food waste. The results of this study did not find a significant correlation between price and the extent of food waste.

South Africa has a well-functioning national fresh produce market used to a daily price formulation. The retail chain, on the other hand, wants to fix a price for a week in order to accommodate standardised ordering as well as for marketing and promotional purposes. The variability between a fixed retail selling price and a fluctuating cost price could potentially perpetuate the variability in the supply chain resulting in an increase in food waste. The results of this study suggest that price does not have a significant influence on the supply and demand functions to cause big enough variability to result in food waste.

6.5. Research Question 4: Shelf Life

Naming	Description	Result
Research question (RQ4):	Can it be predicted with reasonable accuracy, that a relationship exists between the shelf life and the extent of food waste?	Yes
Null hypothesis (H₀4):	No significant relationship exists between shelf life (Shelf Life) and the extent of food waste on the retail level of the supply chain of perishables.	Fail to reject
Alternate hypothesis (H₁4):	A significant relationship exists between shelf life (Shelf Life) and the extent of food waste on the retail level of the supply chain of perishables.	Reject

Source: Own Research

The results of this study suggest that products with shorter shelf life tend to have a higher percentage food waste (Mena et al., 2011). The assumption made based on the literature is that the extension of shelf life should result in a lower percentage of food waste. The results of this study showed no significant correlation between the length of shelf life and the extent of food waste.

The shelf life extension and reduction is usually determined by shelf life testing and may vary in different seasons and also based on the quality of the product at specific times. The shelf life is used to manage stock rotation and to ensure freshness and safety to the end consumer, and thus the product reaches its shelf life expiry while still perfectly fit for human consumption (Gunders, 2012). Shelf life is therefore linked to the quality and freshness of the product. If the length of the shelf life is not statistically significant, then that eliminates the notion that product needs more time on the shelf to sell. If the product is fresh and of good quality, it will sell long before the shelf life expires. The reverse could then also be true that if the product does not present fresh and of good quality, no amount of shelf life will assist in getting the product sold.

6.6. Research Question 5: Seasonal Demand and supply

Naming	Description	Result
Research question (RQ5):	Can it be predicted with reasonable accuracy, that a relationship exists between seasonality and the extent of food waste?	Yes
Null hypothesis (H₀5):	No significant relationship exists between seasonal demand and the extent of food waste on the retail level of the supply chain of perishables.	Reject
Alternate hypothesis (H₁5):	A significant relationship exists between seasonal demand and the extent of food waste on the retail level of the supply chain of perishables.	Accept
Null hypothesis two (H₀5):	No significant relationship exists between seasonal supply and the extent of food waste on the retail level of the supply chain of perishables.	Fail to reject
Alternate hypothesis two (H₁5):	A significant relationship exists between seasonal supply the extent of food waste on the retail level of the supply chain of perishables.	Reject

Source: Own Research

The literature distinguished between the seasonality of demand and supply (Mena et al., 2011). Lee et al. (1997) argues that certain trends and patterns exist around consumer demand increases, usually with month end, holiday seasons and with Christmas. The results of this study support the notion of seasonality in consumer demand and found that food waste increases in these times.

Seasonal demand has a strong correlation with promotions. This is because most promotions are run with seasonal demand increases such as month end and holidays. Interestingly enough seasonal demand has a positive correlation with low prediction with the extent of food waste while promotions have a negative correlation with high prediction with the extent of food waste. This could be because promotions are carefully monitored and managed while normal seasonal demand fluctuations happen naturally in higher food waste percentage.

The results of this study also show that seasonal demand has a moderate positive correlation with shortages. This seen in relation with the positive correlation with food waste it is clear that the natural influx of demand causes variability in the supply chain resulting in both shortages and waste. Since this is the inverse with regards to promotions, it can be concluded that increase in demand with promotions, the shortages and waste within the supply chain is better

managed than with the natural seasonal increase in demand. This realisation has positive implications for supply chain management.

The results of this study show that seasonal supply does not have a significant effect on the extent of food waste. The perishable industry works with two main seasons namely winter and summer. There are products that are traditionally exclusive winter or summer crops. South Africa is fortunate to have different production areas that enable producers to supply twelve months of the year from the different production areas. Spring and autumn are traditionally more difficult periods as it is seen as a transition period from one primary season to the other. These periods know to be more prevalent for quality and availability issues. Although seasonal supply does not have a significant relationship with food waste, it does have significant relationships with shelf life, shortages from suppliers and shortages on shelf. This indicates that the supply chain manages the variability well. Shelf life is being adjusted with the turn of the seasons as needed to serve the customer better even though it does not affect the extent of food waste. It also shows that specific products have higher variability in specific periods of the year. This is a direct reflection of the way the supply chain manages these variabilities so that it does not translate into an increase in food waste.

6.7. Multiple Regression Model

The results of this study and the literature reviewed have shown that food waste is a very complex problem for the food supply chain as it has multiple drivers and factors influencing the extent of food waste. Aramyan et al. (2007) found that different performance indicators are used in different links of the supply chain to manage inefficiencies and essentially food waste. Food waste management will play an ever more critical role in supply chain management to ensure future sustainability and competitiveness (Jensen et al., 2013).

This study built a multiple regression model to be used by supply chain managers to better manage the extent of food waste by focusing on the efficiencies of specific food waste drivers. The model has found that to focus on all the food waste drivers discussed that will not necessarily result in the best management of the extent of food waste. The results of this study show that the management of promotions, stock out days and supplier shortages can predict a 36.4% reduction in food waste with an accuracy of 95%.

By using the multiple regression prediction model management can predict the effect increased efficiencies of the selected food waste drivers will have on the net extent of food waste.

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon$$

$$Y = 12.351 - 1.049 \times \text{promotions} - .193 \times (\text{stock out \%}) - .0165 \times (\text{supplier short deliveries})$$

For example, in promotion the waste level is **7.631** = 12.351 - 1.049 x 1 - .193 x 15.674 - .0165 x 5.550) versus **8.410** = 12.351 - 1.049 x 0 - .193 x 15.674 - .0165 x 5.550 out of promotion.

By using traditional over forecasting and procurement to bring down shortages to its minimum levels actually increase waste to **8.679** = 12.351 - 1.049 x 1 - .193 x 11.737 - .0165 x 2.169. Food waste is at its worse when shortages is optimise in a period out of promotion **9.728** = 12.351 - 1.049 x 0 - 0.193 x 11.737 - .0165 x 2.169.

6.8. Conclusion

The results of this study show that there is a fluctuation of food waste driven by specific circumstances and factors. The results support the claims by various literature that the drivers of food waste had an effect of and managed to measure the significance of those effects. When supply chain managers focus on specific drivers of food waste they can improve the extent of food waste in the food supply chain. The results show that there are some unintended and inverse consequences on food waste when supply chain management improve efficiencies on specific food waste drivers.

Although shortages in the supply chain cause variability in the supply chain leading to food waste, the results of the study show that by improving shortages food waste increases. This implies that the traditional mechanisms to improve shortages causes have a negative net effect on the supply chain and thus does not improve the overall efficiency.

The multiple regression prediction model developed in this study can assist supply chain managers to essentially predict the effect on food waste based on the improvements made on specific food waste drivers. These predictions can help supply chain managers to create functional methods and targets to manage food waste within the supply chain.

CHAPTER 7. CONCLUSION

7.1. Introduction

The extent of food waste in South Africa and around the world is a significant problem. The literature and the results of this study have shown that there are specific drivers of food waste that can be managed to reduce the food waste in the supply chain. Food waste management has become increasingly important for business from a commercial point of view and holistically from a food security and sustainability point of view.

7.2. Principal Findings

The study aimed to measure the extent of food waste and to test the relationship with specific food waste drivers. In Chapter 1, Table 1 the study set out five objectives to achieve in order to meet its research goals.

Objective	Description
Objective 1	To determine the extent of waste within the supply chain of perishable foods in the South African retail industry.

The principal findings of the study have found that the extent of food waste in South Africa is lower than expected. The study shows that the food supply chain in South Africa for this particular retail group is managed more efficiently than initially assumed in the literature (Oelofse & Nahman, 2013). Although the results are lower than the assumed percentage of food waste, the extent of food waste is still significant when considering the amount of food wasted in the food supply chain.

To measure the extent of food waste is essential to quantify the food waste problem and to raise awareness. The amount of food waste lost in the supply chain has a huge financial and commercial implication for the supply chain and warrant a radical action plan to manage food waste better. The amount of food waste in the supply chain supports Gustavsson et al. (2011) call for drastic action to raise awareness of the food waste problem in an efforts to combat hunger and to advance food security in the world.

The objective to determine the extent of food waste within the supply chain of perishable foods in the South African retail industry was therefore achieved.

Objective	Description
Objective 2	To determine the relationship between shortages and the extent of food waste.

The literature suggests that shortages and food waste in the supply chain has a huge impact on each other and the supply chain and can happen simultaneously (Nag et al., 2014). To supply the demand for product with 100% accuracy is merely impossible as all demand forecasts are based on a series of assumptions and probabilities (Taylor & Fearn, 2009).

The results of this study show that the corrected sales in units in each retail outlet is on average 8.7% of all units sold. This means that the retail outlet effectively experiences 8.7% loss of sales because on insufficient inventory to sell in a particular week.

The results also show that the management of shortages within the supply chain increased food waste. The supply chain's reaction to food waste creates an overstated demand for the product resulting in food waste. This is potentially devastating for the food chain supply as it results in a combination of loss of sale, and food waste of about 16% which has a massive commercial implication on the bottom line of the store and the supply chain at large.

The results of this study suggest that supplier shortages and the business viability shortages can predict with significance the extent of food waste. The objective to determine the relationship between shortages and the extent of food waste in the supply chain of perishable foods in the South African retail industry was therefore achieved.

Objective	Description
Objective 3	To determine the relationship between promotions and the extent of food waste.

The literature suggests that promotional activity can cause food waste due to low forecast accuracy for what the actual uplift in demand will be for a specific promotional week (Mena et al., 2011). Promotional activities and price discounts are used by the retail groups to create an increased demand for the specific product in order to increase sales. The increased demand for a specific time causes variability in the supply chain resulting in shortages and waste in the retail outlet and upstream and downstream supply chain partners (Lee et al., 1997; Mena et al., 2011).

The results of this study show the exact opposite; the percentage food waste decreases on average in promotional periods compared to the periods out of promotions. The study did not find a significant correlation between price and the extent of food waste. From the results it became clear that food waste is more prevalent out of promotion and is better managed in promotional periods. This shows that promotions create a genuine increase in demand for the whole perishable department, but that demand drops lower than average out of promotion creating food waste.

Promotions could have a negative effect on food waste in the period just after the promotion. Panda & Mohanty (2011) argues that promotions have a knock-on effect on out of promotion times. Consumers buy larger quantities than required for promotions because of the price benefit which in turn decreases the demand for that product out of promotion. The supply chain management anticipates the demand for products to return to normal after the promotions while in fact, it drops lower than the normal levels creating potential food waste.

The objective to determine the relationship between promotions and price, and the extent of food waste in the supply chain of perishable foods in the South African retail industry was therefore achieved.

Objective	Description
Objective 4	To determine the relationship between shelf life and the extent of food waste.

The assumption made based on the literature is that the extension of shelf life should result in a lower percentage of food waste (Mena et al., 2011). Other research has found that a lot of different food date labels exists that can be confusing for the store management and the end consumer (Parfitt et al., 2010). The results of this study showed no significant correlation between the length of shelf life and the extent of food waste. This does not mean that the shelf life of the product does not have an essential function in itself.

The objective to determine the relationship between shelf life and the extent of food waste in the supply chain of perishable foods in the South African retail industry was therefore achieved. A qualitative study will have better insights into consumer perception and behaviour and the effect on food waste. In many places, it is illegal to sell products with expired shelf life dates, and thus many retailers remove the product from the shelf that is still fit for consumption

(Gunders, 2012). More considerable effort should be made to change policies in order to utilise expired food for less privileged communities in an effort to combat hunger.

Objective	Description
Objective 5	To determine the relationship between seasonality and the extent of food waste.

Demand and supply for specific products vary drastically depending on the changes in specific condition and situation in the supply chain (Gustavsson et al., 2011; Mena et al., 2011). Seasonal demand alludes to certain trends, and patterns exist around consumer demand increases, usually with month end, holiday seasons and with Christmas. Seasonal demand has a strong correlation with promotions. This is because most promotions are run with seasonal demand increases such as month end and holidays. Seasonal demand does not have the same effects on food waste as promotions. Food waste increases with seasonal demand and thus confirming that demand fluctuations cause both an increase in food waste and in shortages.

The results of this study show that seasonal supply does not have a significant effect on food waste. Different quality and availability issues can be linked to different production seasons. The results of this study show that seasonal supply, therefore, has significant relationships with shelf life, shortages from suppliers and shortages on shelf, although not a significant impact on food waste. This shows that the supply chain possesses effective ways to manage the food waste in relation to the challenges of the different seasons.

The objective to determine the relationship between seasonal demand and supply, and the extent of food waste in the supply chain of perishable foods in the South African retail industry was therefore achieved.

The study has found that specific food waste drivers can explain food waste. From all the driver of food waste that was analysed promotions, stock-outs at the end of the day and short deliveries from suppliers had a significant impact on food waste. The fact that the other food waste drivers did not have a significant relation to food waste does not mean that they do not give valuable information regarding the supply chain management and the management of food waste.

Objective	Description
Objective 6	To determine if a functional model can be developed to reduce food waste using the drivers of food waste.

This study built a multiple regression model to be used by supply chain managers to better manage the extent of food waste by focusing on the efficiencies of specific food waste drivers. The results of this study show that the management of promotions, stock out days and supplier shortages can predict a 36.4% reduction in food waste with an accuracy of 95%. By using the multiple regression prediction model, supply chain managers can predict what the net effect on food waste will be by increasing efficiencies on the promotions, stock-outs and supplier shortages.

7.3. Implications for Management and Business

Food waste is a very complex problem for retail groups, and waste management will play a critical role in future sustainability (Jensen et al., 2013). The literature shows that food waste has a definite effect on the sustainability of the food supply chain and the environment it operates in. Godfrey & Manikas (2012) calls for the integration of sustainability concepts into the management of food supply chains by introducing a triple bottom line approach. The triple bottom line includes performance measures impacting, environmental, economic and social responsibility objectives. Supply chain management emphasis is usually focused on cost, efficiency and availability (Gunders, 2012; Mena et al., 2011). Although food waste has an impact on all the levels of the triple bottom line and the management performance measures, food waste itself is usually not a key performance measure (Mena et al., 2011). Lee et al. (1997) and Heydari et al. (2016) argues that the measuring system and incentives for supply chain managers promote the desired behaviour towards a more efficient supply chain.

The results of this study show that 7.381% of all product entering the retail level of the supply chain goes to waste. Food waste has a huge commercial impact on the business. The financial implication of food waste is reflected on the company's bottom line. By quantifying the extent of food waste management commercial impact on the bottom line and emphasise the importance of the food waste problem.

The study sheds light on the drivers of food waste and how these drivers can assist management to decrease food waste. Mena et al. (2011) argue performance measures, and management practices have a massive impact on the drivers of food waste, but that food

waste is not always a performance measure in itself. The management of efficiencies in one area of the supply chain does not necessarily contribute to the effectiveness of the complete supply chain (Goldratt & Cox, 2004). Performance measures do not always consider the unintended consequences it has on food waste and the effect food waste have on the bottom line (Mena et al., 2011).

Supply chain management needs to re-evaluate performance measures and the impact it has on food waste. Jensen et al. (2013) call for further research to be done on supply chain innovation to promote collaborations between each of the actors in the chain to reduce inefficiencies and waste to add value as a whole. The results of this study show that the way that food waste drivers are managed could have positive and negative effects on food waste. Unrealistic performance measures and targets are useless if managers do not know how to manage food waste drivers towards a more efficient supply chain. Food waste management should play a critical role in supply chain management to ensure future sustainability and competitiveness (Jensen et al., 2013).

This study built a multiple regression model to be used by supply chain managers to better manage the extent of food waste by improving efficiencies on specific food waste drivers. The model has found that to focus on all the food waste drivers discussed that will not necessarily result in the best management of the extent of food waste. By using the multiple regression prediction model management can predict the effect increased efficiencies of the selected food waste drivers will have on the net extent of food waste.

Based on the all the observations made in this study, the following recommendations are proposed to supply chain managers in the South African food supply chain:

- Supply chain management has to make food waste measurements a priority and make it a mandatory key performance indicator. Food waste has to be measured to improve waste management practice toward improving food security and sustainability in South Africa (Oelofse & Nahman, 2013). This study suggests that the ideal food waste target for retail should be between 6 – 8%. The prediction model suggests that any target below 6% is unrealistic to achieve in the current way the supply chain operates. Supply chain managers should monitor the change in food waste with any changes made in the supply chain and use food waste as a strategic outcome for any new project. This supports the call from Jensen et al. (2013) for retail groups to emphasise the need for food waste management for a sustainable food supply chain and food security.

- Shortages and loss of sale should be re-evaluated as a performance measure. Traditional ways of solving shortages and loss of sales have a direct negative effect on food waste and thus a negative effect on the business as a whole. This study shows that the combination of loss of sale and food waste in the supply chain of about 16% which has a massive commercial implication on the bottom line of the store and the supply chain at large. Jensen et al. (2013) call for innovative supply chain solutions to get the right product to the right place at the right time and thus to improve efficiencies and reduces the amount of food waste across the whole supply chain. The study proposes the use of the regression model to find the perfect balance between shortages and waste.
- Promotions can be a useful mechanism to pursue sales targets and manage food waste (Aramyan et al., 2007; Panda & Mohanty, 2011). The results of the study show that the increased demand created by the promotion increases sales across the complete range of perishables, absorbing the increased stock and thus resulting in lower levels of food waste during promotions. Panda & Mohanty (2011) argues that promotions have a knock-on effect on out of promotion times and on the upstream and downstream supply chain partners. Supply chain managers need to be innovative in scheduling promotions for the right periods and the right product ranges.
- This research has developed a multiple regression prediction model to be used by supply chain managers to better manage the extent of food waste by improving the efficiencies on specific food waste drivers. The model has found that to focus on all the food waste drivers simultaneously will not necessarily result in the best management of the extent of food waste. The results show that the management of promotions, stock out days and supplier shortages can predict a 36.4% reduction in food waste. Jensen et al. (2013) promotes the investigation of alternative waste management and handling systems as a combined solution to the food waste problem. To limit and manage waste levels is a high priority for every role player in the supply chain. By using the multiple regression prediction model, supply chain managers can predict what the net effect on food waste will be by increasing efficiencies on the promotions, stock-outs and supplier shortages.

7.4. Limitations of the Research

The research has various limitations, which include:

- The sample of this study was derived from individual stores of a single retail group. The results may consequently not be generalizable to the stores of the other retail groups. It also does not include other wholesalers and smaller independent resellers.
- The data analysed was limited to only two years which limits the research to only a small period.
- The study was limited to the retail level of the supply chain of perishables in the South African context and therefore limited within this scope and framework. The limited data available for the more extensive supply chain continues to be a limitation for the research as a holistic approach to the whole supply chain.
- The research was limited to only the fruit and vegetable subsection of the perishable category. Food waste stretches over all food categories, and therefore the results may consequently not be generalizable for all perishable or food categories.
- The research findings were based on proposed hypotheses deduced from literature. Only a selected number of food waste drivers was selected to analyse. It may be probable that the findings only represent part of the narrative and that additional food waste drivers may exist and have significant results to consider.
- The secondary data analysed has certain disadvantages regarding accuracy and validity. Some of the data might, therefore, be inferred and other rendered entirely useless for this study. Accessibility of data or the lack thereof is a significant limitation to the completeness of the research.

7.5. Recommendations for Future Research

Based on the research limitations and the results of this study, the following areas are recommended for future research:

- The study needs to be conducted on a more extensive sample set. It might be difficult to collect the same data from different sources and analyse together. Therefore, a segmented research approach is suggested, by duplicating the study on different retail

and wholesale groups, and aggregate the results at the end. Oelofse & Nahman (2013) calls for the verification of all levels of the supply chain using primary data analysis. The different sectors and groups could bring an additional perspective to the problem of food waste and the drivers that effect is.

- The data analysed was is limited to only two years which limits the research to only a small period. Gustavsson et al. (2011) point out the extent and drivers of food waste vary depending on specific conditions affecting the food supply chain. A much larger period could be used, which also incorporates negative trends and relationships between food waste drivers and food waste.
- The study was limited by this scope and framework of the retail sector. The literature suggests that the management decisions in one division of the supply chain have a knock-on effect on the upstream members and could cause inefficiencies and food waste in other areas (Goldratt & Cox, 2004; Lee et al., 1997). Research should be conducted on the effects of food waste drivers on the magnitude of food waste in the upstream and downstream levels of the supply chain. It might prove that improvements in one area of the supply chain can lead to negative results in other areas (Goldratt & Cox, 2004). This demand signal by downstream members and the reaction to it by upstream members is the major contributor to the bullwhip effect resulting in either short deliveries or food waste in the different supply chain levels (Panda & Mohanty, 2011). The effects of management decisions on one level of the supply chain need to be tested in order to determine the relationship to food waste in other levels of the supply chain.
- The study was limited to only the fruit and vegetable subsection of the perishable category. Different food categories have different physical characteristics and need to be managed differently in order to achieve the same results. This study should also be conducted on all other categories of food products to better comprehend the food waste problems and the drivers that affect it.
- Only a selected number of food waste drivers was selected for this study. The literature suggests that a number of drivers of food waste exist and vary drastically depending on the specific condition and situation (Gustavsson et al., 2011; Mena et al., 2011). There are so numerous variables within the food supply chain that can be investigated. The search for food waste drivers needs to include areas such as the market economy,

resource limitations, legislation, cultural differences, supply chain and consumer behaviour summed up as policy, systems and practices (Parfitt et al., 2010). Many additional food waste drivers may exist that has a significant effect on food waste. More food waste drivers must be identified and researched to better manage food waste drivers for a more efficient way to manage food waste.

7.6. Conclusion

Food waste is a burning issue for organisations, for the country of South Africa and the world at large. The literature and the results of this study have shown that there are specific drivers of food waste that can be managed to reduce the extent of food waste. Organisations can reduce the extent of food waste in the food supply chain by finding innovative ways to drive efficiencies without causing unintended consequences like food waste in other areas of the supply chain.

Food waste management is a vital component of the modern organisations' competitive advantage and to food security as a whole. The results of this study provided insights into the food waste problem that will encourage conversations and future research in a domain that is critical for a responsible and sustainable food supply chain.

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APPENDIX A CONSISTENCY MATRIX

Hypothesis	Literature Review Sources	Data Collection Tool	Analysis Method
<p>1. Food Waste % Research question (RQ1):</p> <p>What is the extent of food waste in the retail level of the supply chain of perishables?</p>	<ul style="list-style-type: none"> Gunders 2012 Gustavsson et al 2011 Oelofse & Nahman 2013 Parfitt et al 2010 Mena et al 2011 Jensen et al 2013 Kaipia et al 2013 Lee et al 1997 Aramyan et al 2007 Gulati 2007 Sukati, Hamid, Baharun & Yusoff 2012 Panda & Mohanty 2011 	Quantitative data was collected from secondary data sources	Descriptive Statistics Histogram PP Plot
<p>2. Shortages Research question (RQ2):</p> <p>Can it be predicted with reasonable accuracy, that a relationship exists between the shortages and the extent of food waste?</p>	<ul style="list-style-type: none"> Jensen et al 2013 Lee et al 1997 Heydari et al 2016 Aramyan et al 2007 Panda & Mohanty 2011 Nag, Han & Yao 2014 Taylor & Fearn 2009 Arif-Uz-Zaman & Ahsan 2014 	Quantitative data was collected from secondary data sources	Descriptive Statistics Histogram PP Plot Correlations Regression Analysis ANOVA
<p>3. Promotions and Price Research question (RQ3):</p> <p>Can it be predicted with reasonable accuracy, that a relationship exists between the promotions or price and the extent of food waste?</p>	<ul style="list-style-type: none"> Gunders 2012 Gustavsson et al 2011 Mena et al 2011 Lee et al 1997 Aramyan et al 2007 Panda & Mohanty 2011 Taylor & Fearn 2009 Mourad 2016 Taylor 2006 Hollmann, Scavarda & Thome 2015 	Quantitative data was collected from secondary data sources	Descriptive Statistics Histogram PP Plot Correlations Regression Analysis ANOVA
<p>4. Shelf life Research question (RQ4):</p> <p>Can it be predicted with reasonable accuracy, that a relationship exists between the shelf life and the extent of food waste?</p>	<ul style="list-style-type: none"> Gunders 2012 Gustavsson et al. 2011 Parfitt et al. 2010 Kaipia et al. 2013 Mena et al. 2011 Liljestrand 2017 Gruber, Holweg & Teller 2016 	Quantitative data was collected from secondary data sources	Descriptive Statistics Histogram PP Plot Correlations Regression Analysis ANOVA
<p>5. Seasonal Demand and Supply Research question (RQ5):</p> <p>Can it be predicted with reasonable accuracy, that a relationship exists between seasonal demand and supply and the extent of food waste?</p>	<ul style="list-style-type: none"> Gustavsson et al. 2011 Mena et al. 2011 Lee et al. 1997 Panda & Mohanty 2011 Taylor & Fearn 2009 Taylor 2006 	Quantitative data was collected from secondary data sources	Descriptive Statistics Histogram PP Plot Correlations Regression Analysis ANOVA

APPENDIX B CODE BOOK

Items	Coding
Promotions	
Weeks out of promotion	0 = Standard
Weeks on promotion	1 = On Promotion
Seasonal Supply	
Winter (June 1 - August 31)	1 = Winter
Spring (September 1 - November 30)	2 = Spring
Summer (December 1 - February 28/29)	3 = Summer
Autumn (March 1 - May 31)	4 = Autumn
Seasonal Demand	
End of month, holidays and Christmas	1 = End of the month
Middle of the month	2 = Middle of the month

APPENDIX C STATISTICAL ANALYSIS

Descriptive Analysis

	Food Waste %	Shortages-Availability (Corrected SU)1	Shortages-Availability (Corrected SU)2	Shortages-Availability (Business)	Shortages - Supplier
N Valid	104	104	104	104	104
Missing	0	0	0	0	0
Mean	7.972%	8.665%	9.508%	15.674%	5.550%
Std. Error of Mean	.135%	.1245%	.150%	.222%	.2142%
Median	7.813%	8.494%	9.282%	15.175%	5.149%
Mode	4.800% ^a	5.763% ^a	6.115% ^a	11.737% ^a	2.169% ^a
Std. Deviation	1.383%	1.270%	1.530%	2.273%	2.185%
Variance	1.913	1.613	2.343	5.170	4.774
Skewness	.685	.336	.420	.899	.717
Std. Error of Skewness	.237	.237	.237	.237	.237
Kurtosis	.664	.122	.243	1.061	-.017
Std. Error of Kurtosis	.469	.469	.469	.469	.469
Range	7.381%	6.729%	8.160%	11.970%	9.518%
Minimum	4.800%	5.763%	6.115%	11.737%	2.169%
Maximum	12.181%	12.492%	14.275%	23.707%	11.687%
Sum	829.161%	901.177%	988.866%	1630.111%	577.255%

	Price	% Price Change	Shelf life	Shelf life (corrected)
N Valid	104	103	104	104
Missing	0	1	0	0
Mean	29.103%	4.124%	6.073	5.634
Std. Error of Mean	.5351%	2.7894%	.0599	.0577
Median	31.078%	.3852%	6.353	5.903
Mode	21.632 ^a	-40.857% ^a	4.778 ^a	4.397
Std. Deviation	5.457	28.309%	.6117	.5888
Variance	29.781	801.437	.374	.347
Skewness	-.027	.200	1.649	-1.645
Std. Error of Skewness	.237	.238	.237	.237
Kurtosis	-1.344	-1.290	.771	.766
Std. Error of Kurtosis	.469	.472	.469	.469
Range	21.412	95.919%	1.883	1.863
Minimum	21.632	-40.857%	4.766	4.390
Maximum	43.044	55.062%	6.648	6.253
Sum	3026.742	424.869%	631.617	586.026

STATISTICS

		Food Waste %	Promotions	Seasons	Seasonality
N	Valid	104	104	104	104
	Missing	0	0	0	0
Std. Error of Mean		.1356%	.049	.110	.049
Median		7.813%	0.00	2.50	2.00
Mode		4.800% ^a	0	1 ^a	2
Std. Deviation		1.383%	.495	1.123	.500
Variance		1.913	.245	1.262	.250
Skewness		.685	.357	0.000	-.196
Std. Error of Skewness		.237	.237	.237	.237
Kurtosis		.664	-1.910	-1.368	-2.000
Std. Error of Kurtosis		.469	.469	.469	.469
Range		7.381%	1	3	1
Minimum		4.800%	0	1	1
Maximum		12.181%	1	4	2

a. Multiple modes exist. The smallest value is shown

Promotions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Standard	61	58.7	58.7	58.7
	On Promotion	43	41.3	41.3	100.0
	Total	104	100.0	100.0	

Seasons

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Winter	26	25.0	25.0	25.0
	Spring	26	25.0	25.0	50.0
	Summer	26	25.0	25.0	75.0
	Autumn	26	25.0	25.0	100.0
	Total	104	100.0	100.0	

Seasonality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	End of the Month	47	45.2	45.2	45.2
	Middle of the Month	57	54.8	54.8	100.0
	Total	104	100.0	100.0	

Correlations

CORRELATIONS

		Food Waste %	Shortages-Availability (Corrected SU)1	Shortages-Availability (Corrected SU)2	Shortages-Availability (Business)	Shortages - Supplier
Food Waste %	Pearson Correlation	1	-.089	-.090	-.376**	-.337**
	Sig. (2-tailed)		.367	.362	.000	.000
	N	104	104	104	104	104
Shortages-Availability (Corrected SU)1	Pearson Correlation	-.089	1	1.000**	.357**	.387**
	Sig. (2-tailed)	.367		.000	.000	.000
	N	104	104	104	104	104
Shortages-Availability (Corrected SU)2	Pearson Correlation	-.090	1.000**	1	.361**	.387**
	Sig. (2-tailed)	.362	.000		.000	.000
	N	104	104	104	104	104
Shortages-Availability (Business)	Pearson Correlation	-.376**	.357**	.361**	1.000	.150
	Sig. (2-tailed)	.000	.000	.000		.129
	N	104	104	104	104	104
Shortages - Supplier	Pearson Correlation	-.337**	.387**	.387**	0.149	1.000
	Sig. (2-tailed)	.000	.000	.000	.129	
	N	104	104	104	104	104
Promotions	Pearson Correlation	-.411**	-.213*	-.211*	.051	0.075
	Sig. (2-tailed)	.000	.030	.031	.604	.447
	N	104	104	104	104	104
Price	Pearson Correlation	-.063	.080	.079	-.029	.349**
	Sig. (2-tailed)	.527	.420	.428	.771	.000
	N	104	104	104	104	104
% Price Change	Pearson Correlation	-.025	-.177	-.177	-.090	-.024
	Sig. (2-tailed)	.804	.073	.073	.367	.811
	N	103	103	103	103	103
Shelf life	Pearson Correlation	.055	.062	.062	-.631**	.253**
	Sig. (2-tailed)	.582	.534	.531	.000	.010
	N	104	104	104	104	104
Shelf life (corrected)	Pearson Correlation	.053	.061	.061	-.626**	.267**
	Sig. (2-tailed)	.593	.542	.538	.000	.006
	N	104	104	104	104	104
Seasonal Supply	Pearson Correlation	-.091	.259**	.257**	0	.400**
	Sig. (2-tailed)	.359	.008	.008	0.122	.000
	N	104	104	104	104	104
Seasonal Demand	Pearson Correlation	.262**	.199*	.195*	-.028	0
	Sig. (2-tailed)	.007	.043	.047	.777	0.332
	N	104	104	104	104	104

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

CORRELATIONS

		Promotions	Price	% Price Change	Shelf life	Shelf life (corrected)	Seasonal Supply	Seasonal Demand
Food Waste %	Pearson Correlation	-.411**	-.063	-.025	.055	.053	-.091	.262**
	Sig. (2-tailed)	.000	.527	.804	.582	.593	.359	.007
	N	104	104	103	104	104	104	104
Shortages-Availability (Corrected SU)1	Pearson Correlation	-.213*	.080	-.177	.062	.061	.259**	.199*
	Sig. (2-tailed)	.030	.420	.073	.534	.542	.008	.043
	N	104	104	103	104	104	104	104
Shortages-Availability (Corrected SU)2	Pearson Correlation	-.211*	.079	-.177	.062	.061	.257**	.195*
	Sig. (2-tailed)	.031	.428	.073	.531	.538	.008	.047
	N	104	104	103	104	104	104	104
Shortages-Availability (Business)	Pearson Correlation	.051	-.029	-.090	-.631**	-.626**	-.152	-.028
	Sig. (2-tailed)	.604	.771	.367	.000	.000	.123	.777
	N	104	104	103	104	104	104	104
Shortages - Supplier	Pearson Correlation	.075	.349**	-.024	.253**	.267**	.400**	-.096
	Sig. (2-tailed)	.447	.000	.811	.010	.006	.000	.332
	N	104	104	103	104	104	104	104
Promotions	Pearson Correlation	1	-.177	.134	-.005	-.009	.044	-.807**
	Sig. (2-tailed)		.073	.178	.959	.924	.660	.000
	N	104	104	103	104	104	104	104
Price	Pearson Correlation	-.177	1	-.732**	.177	.193	.108	.187
	Sig. (2-tailed)	.073		.000	.072	.050	.274	.057
	N	104	104	103	104	104	104	104
% Price Change	Pearson Correlation	.134	-.732**	1	-.066	-.070	-.028	-.128
	Sig. (2-tailed)	.178	.000		.507	.483	.779	.198
	N	103	103	103	103	103	103	103
Shelf life	Pearson Correlation	-.005	.177	-.066	1	.999**	.424**	.020
	Sig. (2-tailed)	.959	.072	.507		.000	.000	.837
	N	104	104	103	104	104	104	104
Shelf life (corrected)	Pearson Correlation	-.009	.193	-.070	.999**	1	.419**	.023
	Sig. (2-tailed)	.924	.050	.483	.000		.000	.814
	N	104	104	103	104	104	104	104
Seasonal Supply	Pearson Correlation	.044	.108	-.028	.424**	.419**	1	-.026
	Sig. (2-tailed)	.660	.274	.779	.000	.000		.794
	N	104	104	103	104	104	104	104
Seasonal Demand	Pearson Correlation	-.807**	.187	-.128	.020	.023	-.026	1
	Sig. (2-tailed)	.000	.057	.198	.837	.814	.794	
	N	104	104	103	104	104	104	104

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Regression Analysis

SHORTAGES-AVAILABILITY (CORRECTED SU)1

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.089 ^a	.008	-.002	1.384%	.008	.822	1	102	.367	1.574

a. Predictors: (Constant), Shortages-Availability (Corrected SU)1

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.575	1	1.575	.822	.367 ^b
	Residual	195.489	102	1.917		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shortages-Availability (Corrected SU)1

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	8.816	.941		9.374	.000	6.951	10.682		
	Shortages-Availability (Corrected SU)1	-.097	.107	-.089	-.907	.367	-.310	.116	1.000	1.000

a. Dependent Variable: Food Waste %

SHORTAGES-AVAILABILITY (CORRECTED SU)2

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.090 ^a	.008	-.002	1.384279%	.008	.840	1	102	.362	1.575

a. Predictors: (Constant), Shortages-Availability (Corrected SU)2

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.609	1	1.609	.840	.362 ^b
	Residual	195.455	102	1.916		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shortages-Availability (Corrected SU)2

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	8.749	.858		10.196	.000	7.047	10.451		
	Shortages-Availability (Corrected SU)2	-.082	.089	-.090	-.916	.362	-.258	.095	1.000	1.000

a. Dependent Variable: Food Waste %

SHORTAGES-AVAILABILITY (BUSINESS)

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.376 ^a	.141	.133	1.288%	.141	16.781	1	102	.000	1.548

a. Predictors: (Constant), Shortages-Availability (Business)

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27.841	1	27.841	16.781	.000 ^b
	Residual	169.223	102	1.659		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shortages-Availability (Business)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	11.557	.884		13.074	.000	9.803	13.310		
	Shortages-Availability (Business)	-.229	.056	-.376	-4.097	.000	-.339	-.118	1.000	1.000

a. Dependent Variable: Food Waste %

SHORTAGES - SUPPLIER

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.337 ^a	.114	.105	1.309%	.114	13.075	1	102	.000	1.720

a. Predictors: (Constant), Shortages - Supplier

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.390	1	22.390	13.075	.000 ^b
	Residual	174.674	102	1.712		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shortages - Supplier

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	9.157	.352		26.031	.000	8.459	9.855		
	Shortages - Supplier	-.213	.059	-.337	-3.616	.000	-.330	-.096	1.000	1.000

a. Dependent Variable: Food Waste %

PROMOTIONS

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.411 ^a	.169	.161	1.267%	.169	20.771	1	102	.000	1.441

a. Predictors: (Constant), Promotions

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33.340	1	33.340	20.771	.000 ^b
	Residual	163.724	102	1.605		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Promotions

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	8.448	.162		52.079	.000	8.126	8.770		
	Promotions	-1.150	.252	-.411	-4.558	.000	-1.650	-.649	1.000	1.000

a. Dependent Variable: Food Waste %

PRICE

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.063 ^a	.004	-.006	1.387%	.004	.403	1	102	.527	1.582

a. Predictors: (Constant), Price

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.776	1	.776	.403	.527 ^b
	Residual	196.289	102	1.924		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Price

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	8.436	.742		11.376	.000	6.965	9.906		
	Price	-.016	.025	-.063	-.635	.527	-.066	.034	1.000	1.000

a. Dependent Variable: Food Waste %

% PRICE CHANGE

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.025 ^a	.001	-.009	1.394%	.001	.062	1	101	.804	1.514

a. Predictors: (Constant), % Price Change

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.121	1	.121	.062	.804 ^b
	Residual	196.352	101	1.944		
	Total	196.473	102			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), % Price Change

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	7.970	.139		57.402	.000	7.695	8.246		
	% Price Change	-.001	.005	-.025	-.249	.804	-.011	.008	1.000	1.000

a. Dependent Variable: Food Waste %

SHELF LIFE

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.055 ^a	.003	-.007	1.388%	.003	.305	1	102	.582	1.560

a. Predictors: (Constant), Shelf life

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.588	1	.588	.305	.582 ^b
	Residual	196.477	102	1.926		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shelf life

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	7.223	1.364		5.294	.000	4.517	9.929		
	Shelf life	.123	.224	.055	.552	.582	-.320	.567	1.000	1.000

a. Dependent Variable: Food Waste %

SHELF LIFE CORRECTED

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.053 ^a	.003	-.007	1.388006%	.003	.288	1	102	.593	1.559

a. Predictors: (Constant), Shelf life (corrected)

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.555	1	.555	.288	.593 ^b
	Residual	196.509	102	1.927		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Shelf life (corrected)

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	7.270	1.316		5.525	.000	4.660	9.880		
	Shelf life (corrected)	.125	.232	.053	.537	.593	-.336	.585	1.000	1.000

a. Dependent Variable: Food Waste %

SEASONAL SUPPLY

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.091 ^a	.008	-.001	1.384%	.008	.848	1	102	.359	1.572

a. Predictors: (Constant), Seasonal Supply

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.625	1	1.625	.848	.359 ^b
	Residual	195.440	102	1.916		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Seasonal Supply

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	8.252	.332		24.820	.000	7.593	8.912		
	Seasonal Supply	-.112	.121	-.091	-.921	.359	-.353	.129	1.000	1.000

a. Dependent Variable: Food Waste %

SEASONAL DEMAND

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.262 ^a	.068	.059	1.341%	.068	7.491	1	102	.007	1.554

a. Predictors: (Constant), Seasonal Demand

b. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.483	1	13.483	7.491	.007 ^b
	Residual	183.582	102	1.800		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Seasonal Demand

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6.853	.430		15.943	.000	6.000	7.705		
	Seasonal Demand	.723	.264	.262	2.737	.007	.199	1.248	1.000	1.000

a. Dependent Variable: Food Waste %

MULTIPLE REGRESSION MODEL

Model Summary^d

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.411 ^a	.169	.161	1.266942%	.169	20.771	1	102	.000	
2	.543 ^b	.295	.281	1.172551%	.126	18.083	1	101	.000	
3	.601 ^c	.362	.343	1.121502%	.066	10.404	1	100	.002	1.607

a. Predictors: (Constant), Promotions

b. Predictors: (Constant), Promotions, Shortages-Availability (Business)

c. Predictors: (Constant), Promotions, Shortages-Availability (Business), Shortages - Supplier

d. Dependent Variable: Food Waste %

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33.340	1	33.340	20.771	.000 ^b
	Residual	163.724	102	1.605		
	Total	197.065	103			
2	Regression	58.202	2	29.101	21.166	.000 ^c
	Residual	138.863	101	1.375		
	Total	197.065	103			
3	Regression	71.288	3	23.763	18.893	.000 ^d
	Residual	125.777	100	1.258		
	Total	197.065	103			

a. Dependent Variable: Food Waste %

b. Predictors: (Constant), Promotions

c. Predictors: (Constant), Promotions, Shortages-Availability (Business)

d. Predictors: (Constant), Promotions, Shortages-Availability (Business), Shortages - Supplier

Coefficients^a

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1 (Constant)	8.448	.162		52.079	.000	8.126	8.770		
Promotions	-1.150	.252	-.411	-4.558	.000	-1.650	-.649	1.000	1.000
2 (Constant)	11.818	.807		14.652	.000	10.218	13.418		
Promotions	-1.099	.234	-.393	-4.699	.000	-1.562	-.635	.997	1.003
Shortages-Availability (Business)	-.216	.051	-.356	-4.252	.000	-.317	-.115	.997	1.003
3 (Constant)	12.351	.789		15.655	.000	10.786	13.916		
Promotions	-1.049	.224	-.375	-4.681	.000	-1.494	-.604	.993	1.007
Shortages-Availability (Business)	-.193	.049	-.317	-3.925	.000	-.291	-.095	.976	1.025
Shortages - Supplier	-.165	.051	-.261	-3.226	.002	-.267	-.064	.973	1.028