FACTORS INFLUENCING ADOPTION AND PROFITABILITY OF RETURNABLE PLASTIC CRATES AS A FOOD LOSS REDUCING TECHNOLOGY AMONG FRESH TOMATO TRADERS IN LAGOS STATE, NIGERIA

AGHADI CRYSTAL NWABUOGO

A56/9495/2017

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

2019

DECLARATION

This thesis is my original work and has not been presented for an award of a degree in any other university.

Aghadi Crystal Nwabuogo

Reg. No. A56/9495/2017

Signature…… Date……

This thesis has been submitted with our approval as university supervisors

Prof. John Mburu

Department of Agricultural Economics, University of Nairobi

Signature…… Date……

Dr. Mmatlou Kalaba

Department of Agricultural Economics and Rural Development, University of Pretoria

Signature…… Date……

DEDICATION

This thesis is dedicated to my beloved parents, Ven. Dr. and Dr. Mrs. NNPC Aghadi-Ghamzi.

ACKNOWLEDGMENTS

I want to express my deepest gratitude to God for the grace to successfully write this thesis and for his guidance and protection throughout my academic journey. Special appreciation goes to my supervisors, Prof. John Mburu and Dr. Mmatlou Kalaba, whose contributions, and constructive criticisms were immensely helpful and crucial in writing this thesis. I am also grateful to all the lecturers and non-academic staff in the department for their diverse support. I acknowledge my parents, Ven. Dr. and Dr. Mrs. NNPC Aghadi-Ghamzi and my siblings for their moral support which gave me the strength to finish this thesis despite the numerous hurdles faced. I also immensely appreciate the African Economic Research Consortium (AERC) for providing me with the needed financial support and platform to carry out my studies. The inputs of my colleagues, Nimako Solomon, Akrong Rexford, and Adeyanju Dolapo, were beneficial during the development of my proposal. Also, the contributions from Mantey Vida, Akrong Rexford, Tirra Amos, and Mirindi Patrice were valuable and useful to me in discussing my results and proof-reading my work. I also acknowledge the moral support of my friends, Alisah Dozie, Ukwuaba Ikenna, Apam Onyekachi, Nwodo Patience, and Chukwuma Onyinye, who were a source of encouragement to me in the course of this research work. May God bless you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AIC	Akaike's Information Criterion
CNFA	Cultivating New Frontiers in Agriculture
FFV	Fresh Fruits and Vegetables
FGD	Focus Group Discussion
GAIN	Global Alliance for Improved Nutrition
GDP	Gross Development Product
GHG	Green House Gases
KII	Key Informant Interview
LGAs	Local Government Areas
ML	Maximum Likelihood
NBS	National Bureau of Statistics
OLS	Ordinary Least Square
PHL	Postharvest Losses
PLAN	Postharvest Loss Alliance for Nutrition
RUM	Random Utility Model
RPCs	Returnable/Re-usable Plastic Crates
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
USA	United States of America
USD	United State Dollars

ABSTRACT

The tomato traders in Nigeria experience high levels of tomato postharvest losses, which could negatively affect their income and welfare. The Returnable Plastic Crates (RPCs) were introduced into the tomato industry in Nigeria due to their effectiveness in curbing postharvest losses. However, the level of adoption of RPCs in the country remains low, and there is little evidence on the effect of adopting RPCs on the trader's income. The study, therefore, analyzed the profitability of the fresh tomato trade, the factors influencing the adoption and intensity of adoption, and the effect of RPC adoption on the trader's profit margin. The study randomly sampled 245 fresh tomato traders from different tomato markets in Lagos State, Nigeria. Data were collected through focus group discussions, interviews of key informants, and individual trader interviews. A double-hurdle model, endogenous treatment model, t-test and gross margin analysis were used in analyzing the data. The mean gross margins for the fresh tomato traders using RPCs and woven baskets were ₦4,083,200 (approx. 11,342 USD) and ₦1,845,150 (approx. 5,125 USD) per annum respectively. There was a low level of access to credit and participation in training programs and the adoption of RPCs among fresh tomato traders in the study area. The trader's decision to adopt RPCs was significantly affected by the age of the trader, access to radio, group membership, and participation in training programs. Also, the number of income sources, the number of decision-makers, and the trader's profit were factors that significantly affected their intensity of RPC adoption. The study, therefore, concluded that the adoption of RPCs significantly increased the profit of the traders by reducing the level of postharvest losses they encounter. An increase in training programs on the use of RPCs among tomato traders was recommended. The market groups should be actively involved in the intensifying the adoption of RPCs among fresh tomato traders.

CHAPTER ONE

1.0. INTRODUCTION

1.1. Background Information

There has been a global focus on achieving food security and ending poverty, which is reflected in the Sustainable Development Goal (SDG) 1, 2, and 12.3. SDG 1 aims at eradicating poverty in all its forms, while SDG 2 focuses on ending hunger, achieving food security, improved nutrition and sustainable agriculture (United Nations, 2016). SDG 12.3 also advocates for a reduction of food losses along the production and supply chain including postharvest losses by 2030 (United Nations, 2016). Furthermore, the Malabo Declaration of 2014 commits to reducing postharvest losses by at least half by 2025 (NEPAD, 2016). These goals are all directed towards ending hunger, poverty and maintaining a sustainable food chain mostly in developing countries. However, the level of food losses encountered globally is not concurrent with this universal trend. The amount of food loss in the agricultural value chain is estimated to feed about 1.5 billion people annually (Gustavsson *et al.,* 2013). Reducing postharvest losses, therefore, is a global priority to curtail the harmful effects of these losses (Kikulwe *et al.,* 2018).

Food loss and wastage have detrimental consequences to the value chain stakeholders, the country's economy and the environment (Sheane *et al.*, 2008; Lipinski *et al.*, 2013). It also decreases the available food for human consumption. This is worsened by the rising demand for food from consumers, animal feed, biofuel, and other industrial users (Sheane *et al.,* 2008; Rutten, 2013; Natsa, 2015; Kikulwe *et al.*, 2018). Food losses also cause negative externalities to the society through the added cost in waste management, resource wastage, and GHG emission increasing the risk of climate change (Sheane et al., 2008). However, the bulk of concern in this

study lies in the resultant decline in the real income of stakeholders in the agricultural supply chain (Olayemi *et al.*, 2010; Omosomi, 2016). The reduction in the real income of stakeholders adversely affects their welfare and hinders any attempt towards reducing poverty and ensuring a food-secure household. A reduction of these losses through appropriate food loss reducing technologies would go a long way in improving their livelihoods.

Arah *et al.* (2015) define postharvest losses as challenges encountered after harvest by the producers, processors, retailers, and distributors and the exporters in the process of handling the products until it gets to the final consumers. According to Jaspreet and Anita (2013), postharvest losses includes both food losses along the supply chain and food wastage at the consumer level. However, food losses along the value chain are higher in Sub-Saharan Africa (SSA) than food wastage at the consumer level (Table 1). The case is different for European countries which have a larger percentage of food wastage at the consumer level than in the value chain.

Table 1: Estimated Percentage of Fresh Food Losses across Commodities at Different Stages of the Food Supply Chain in Sub-Saharan Africa

Crops: / **Stages:**	**Region**	**Cereals**	**Roots & Tubers**	**Oilseeds & Pulses**	**Fruits & Veg.**	**Meat**	**Fish & Seafood**	**Milk**
Agric. Production	SSA	6	14	12	10	19	5.7	6
	Europe	2	20	10	20	3.2	9.4	3.5
Handling & Storage	SSA	8	18	8	9	0.7	6	11
	Europe	4	9	1	5	0.7	0.5	0.5
Processing & Packaging	SSA	3.5	15	8	25	5	9	0.1
	Europe	10	15	5	2	5	6	1.2
Distribution	SSA	2	5	2	17	7	15	10
	Europe	2	7	1	10	4	9	0.5
Consumption	SSA	1	2	1	5	2	2	0.1
	Europe	25	17	4	19	11	11	7

Source: *Adapted from* Gustavsson *et al.* (2013)

According to Table 1, there was about 5% wastage in Fresh Fruits and Vegetables (FFV) at the consumer level in SSA. The level of losses occurring at the consumer level is significantly lower than the losses at the packaging and distribution stages (25% and 17% respectively) in SSA (Table 1). Tackling FFV losses along the value chain is a priority in African countries as these losses are more precarious than food wastage at the consumer levels (Sheane *et al.*, 2008; Jaspreet and Anita, 2013).

Fresh fruits and vegetables particularly have high levels of postharvest losses mainly due to its perishability and high moisture content making it susceptible to rot and spoilage (Jaspreet and Anita, 2013). The susceptibility of FFVs to deterioration is worsened by the lack of suitable storage, packaging and handling facilities in SSA. These complications have led to higher levels of food losses in FFVs compared to other farm products like cereals, pulses, oilseeds, roots, and tubers (Idah *et al.*, 2007; Ganry, 2009; Aulakh *et al.*, 2013;). The problem of food losses especially in FFVs during supply and sale is, therefore, of utmost concern in SSA. Tomatoes, which belong to the class of FFVs, have more than 80% moisture content and are highly prone to postharvest losses (Babalola *et al.*, 2010).

Tomato is an important crop globally as it accounts for 60% of the total global vegetable production at 177 million tonnes in 2016 *(*Erhie *et al.*, 2018). It is the world's largest and most widely consumed food crop after potato and ranks the highest among canned vegetables in the world (Kimura and Sinha, 2008). In Nigeria, tomato is the most important vegetable after onions and pepper in terms of demand (Orebiyi *et al.*, 2016). It also accounts for about 18% of the daily vegetable consumption in the country (Babalola *et al.*, 2010). Tomato possesses diverse and numerous uses that vary from consumption in its raw form to its usefulness in the preparation of

many dishes across the globe. It also has medicinal and cosmetic purposes and sustains a high demand throughout the year.

The focus on tomato in Nigeria is partly linked to its high production levels, demand, and contribution to the welfare of the stakeholders in the tomato value chain and the Nigerian economy. Nigeria produces about 31% of the total tomato output in SSA and is therefore ranked as the largest producer, with about 4.1 million tonnes produced in 2017 (FAO, 2018). About 70% of the tomato produced in the country originates from the Northern states (Ugonna *et al.,* 2015). However, a larger percentage of the fresh tomatoes goes to major tomato markets in other parts of the country (Babarinsa *et al.,* 2018). Tomato marketing, therefore, forms a major source of livelihood for traders in the tomato supply chain (Ugonna *et al.,* 2015).

The tomato industry in Nigeria possesses the capacity to provide employment, contribute towards food security, poverty reduction and generate a source of foreign exchange for the country (Natsa, 2015). However, the level of tomato postharvest losses along the tomato value chain hampers the growth of the industry. Sibomana *et al.* (2016) noted that Nigeria faces the highest level of postharvest losses along the tomato supply chain in Africa. Ugonna *et al.* (2015) estimated the postharvest tomato losses in Nigeria at 45%. Also, Babarinsa et al. (2018) recorded an estimate of up to 42% postharvest loss, which occurred during the transportation of fresh tomatoes by the wholesalers from the point of purchase in Kano to 'Mile 12' market in Lagos state.

The average annual production of fresh tomato is about 2.2 million tonnes (Erhie *et al.*, 2018). However, with the estimated 45% post-harvest losses, only an estimate of 1.2million tonnes of tomato is left to feed the high demand in the country. The average tomato consumption per capita is estimated at 12kg whereas the annual demand is estimated at 2.3 million tonnes (Erhie *et al.*, 2018). The country is therefore left with a huge tomato demand deficit, which is unable to feed the

fast-growing population. Several factors could contribute to the tomato demand deficit like an increased money supply or reduced interest rate leading to higher demands. However, postharvest tomato losses contribute to a large proportion of the tomato deficit in the country as it reduces the supply of tomatoes in the market (Rutten, 2013). Nigeria, therefore, relies on tomato importation worth up to $60 million annually to meet up with the tomato demand in the country (FAO, 2018).

Postharvest losses are characterized by significant reductions in the shelf-life of the product and other desirable qualities, as observed by Akter and Khan (2012). Qualities like the physical appearance such as color and texture, the firmness and the total soluble solids, and its nutritional benefits (Babatola *et al.*, 2008; Gautier *et al*., 2008; Akter and Khan, 2012). These postharvest losses can also be observed through physical damages, physiological decay or moisture losses in most of the tomato fruit before it gets to the final consumers. The reduction in quality and subsequently quantity, therefore, leads to seasonal fluctuations in supply and prices and becomes a socio-economic loss to the farmers and traders (Odemero and Okoh, 2014).

According to Underhill and Kumar (2014), longer distribution chains in the supply of FFV, and longer supply distances increases the risk of postharvest losses. The tomato losses that occur during the distribution of the tomatoes are linked to the long distances the tomatoes are subjected to in the country (Babarinsa *et al.,* 2018). For instance, Kano, which is one of the largest tomato producing states (Ugonna *et al.,* 2015) in the country, is 998 km away from the wholesale market in Lagos (Babarinsa *et al.*, 2018). The study by Babarinsa *et al.* (2018) showed that up to 42% of the fresh tomatoes harvested in Kano State were physically damaged and unmarketable at arrival in the Lagos markets using the woven basket. However, the same study recorded that these damages were significantly reduced to about 5% with the use of Returnable Plastic Crates (RPCs).

The high level of losses encountered during the packaging and distribution of fresh tomato implies that the way the produced is packaged and distributed could have a great influence on the level of tomato losses. Most of the tomato traders are responsible for the choice of which packaging technology to use in handling and storing the produce for sale (Ugonna *et al.*, 2015). According to Adegbola *et al.,* (2011), there has been a shift from the traditional method of handling and packaging fresh fruits and vegetables to more modern technologies like the use of plastic and cardboard crates in developed countries. However, Nigeria and other developing countries are still making use of old traditional methods thereby incurring more postharvest losses (Babarinsa *et al*., 2018). These methods include the use of woven baskets in Nigeria, wooden crates in Ghana (Arah *et al.*, 2015), and other materials like jute bags, sacks, and polythene bags used in packaging and marketing of fresh tomatoes in African countries. Arah *et al.* (2015) stated that these methods are unsuitable for handling and packaging and lead to higher levels of tomato postharvest losses.

In a bid to reduce tomato losses, the Global Alliance for Improved Nutrition (GAIN) through the Postharvest Loss Alliance for Nutrition (PLAN) project promoted the use of Returnable Plastic Crates (RPCs) in the fresh tomato supply in 2017 (GAIN, 2017). The RPCs are meant to replace woven baskets in the packaging and handling of fresh tomato by the value chain actors in Nigeria. According to Idah *et al.* (2007), the right packaging container should protect the produce from physical damages during handling, storage, transportation, and marketing. However, the woven baskets have sharp edges that cause mechanical injuries to the tomato products and the over-sized nature leads to compression and crushing of the tomatoes especially at the base (Hurst, 2010). Also, the basket is not easily stackable and does not permit sufficient airflow leading to excessive heat that enhances the deterioration of the produce (Hurst, 2010). In contrast, the RPC possesses smooth edges and a reduced depth. It is also easily stackable due to its firmness and allows

sufficient airflow to the produce (Babarinsa *et al.*, 2018). Moreover, it can be reused severally and carries only about 25kg which is the standard quantity a packaging container should take (Naika *et al.*, 2005). According to Adegbola et al. (2011), the plastic crates are more efficient and effective in handling and packaging FFV through all the stages in the supply chain, but its use in the country is very low.

1.2. Problem Statement

The fresh tomatoes sold in Nigeria are packaged and distributed to intermediaries and the processing factories mostly with the use of woven baskets (Ugonna *et al.*, 2015). These baskets cause mechanical injuries and quicker deterioration in the product due to their characteristic features leading to higher levels of tomato postharvest losses (Arah *et al.*, 2015). These losses could be detrimental to the welfare of the wholesalers, retailers and other traders in the tomato supply chain who bears the losses (Adegbola *et al.*, 2011). In contrast, the RPCs introduced into the tomato market in Lagos state, offers more protection to the tomatoes and dramatically reduces the level of losses. Evidence from other countries such as Afghanistan shows that the use of RPCs increased the proceeds gotten by the tomato traders who adopted them and the buyers were willing to pay more for tomatoes sold with RPC (Lipinski *et al.*, 2013). However, a study has not been done in Nigeria, to ascertain the effect of RPC use among the tomato traders. Despite the advantages offered by the use of RPCs and the promotion of its use in the country, the level of adoption of RPCs among tomato traders remains low; hence, this study.

1.3. General Objective

The overall objective of the study was to analyze the factors influencing the adoption and profitability of returnable plastic crates as a food loss reducing technology among fresh tomato traders in Lagos State, Nigeria.

1.4. Specific Objectives

The specific objectives in the study were to;

i. Determine the profitability of the fresh tomato trade in the study area
ii. Analyze the factors influencing the adoption and intensity of adopting RPCs
iii. Analyze the effect of adopting RPC on the profit among the tomato traders

1.5. Hypotheses

i. The fresh tomato trade is not profitable
ii. Socio-economic, institutional and market factors have no influence on the adoption and intensity of adoption of Returnable Plastic Crates among fresh tomato traders
iii. Adoption of Returnable Plastic Crates does not influence the profit of the fresh tomato traders

1.6. Justification of the Study

The information on the factors influencing the adoption of RPCs would help fill the knowledge gap and would also be useful to the public and private sectors like the manufacturing industries and insurance companies. The manufacturing industries of plastic crates would find the information from the research valuable in tailoring the RPCs to best suit the needs of the traders. Additionally, the insurance companies targeting the traders in the tomato supply chain would find

the results useful in developing proper insurance policies towards the reduction of tomato postharvest losses. The policymakers would be able to create better policies and required standards at the Federal and State levels on the use of RPCs with the knowledge of the factors influencing its use. Overall, the understanding of these factors would increase the level of awareness on the use of RPC as a postharvest loss reducing technology in the tomato supply chain.

The results of the effect of RPCs on the trader's profit margin would help in promoting the usability of RPCs among tomato traders. It would contribute to the need for policies regarding the use of plastic crates in place of woven baskets in tomato markets. The information on its effect would also help policymakers in choosing the right policy instrument on policies that would encourage the use of RPCs. The results on the effect of RPC use on the profit margins of the tomato traders would help fill the gap in knowledge and be useful to other researchers on the reduction of tomato losses through the use of RPCs.

1.7. Organization of the Thesis

This thesis is structured in five chapters. The second chapter covers a review of related literature, whereas Chapter 3 is on methodology and constitutes a detailed description of the study area, theoretical and analytical framework and the sampling procedure to be used. Chapter 4 presents the results and discussions, while Chapter 5 constitutes the summary, conclusion, and recommendations from the study.

CHAPTER TWO

2.0. LITERATURE REVIEW

2.1. Definition of terms

Postharvest losses (PHL): is defined as the measurable food losses in quantity and quality along the supply chain from harvesting to its final consumption or other end uses (Hodges *et al.*, 2011). In this study, postharvest losses were measured by the percentage of fresh tomatoes that were unmarketable at the standard price. According to Jaspreet and Anita (2013), postharvest losses include both food losses and food wastage. A report by FAO differentiates between food loss and food waste by stating that food losses occur during the process of production, postharvest, and processing in the supply chain while food waste takes place towards the end of the food chain (Segrè *et al.*, 2014).

Food wastage: Food wastage is the loss of edible food through action or inaction of humans like pouring away spoilt food, delayed consumption until expiry, or dishing out more than the consumable amount (Jaspreet and Anita, 2013).

Food Losses: Food loss is defined as the unintentional loss in the food quantity due to limitations in infrastructure and management along the food value chain. This could directly be from losses in the amount of the produce or indirectly as a result of reduced quality.

2.2. Overview of the Tomato Industry in Nigeria

Tomato is an important produce in Nigeria as it sustains a high demand among the indigenes with a consumption rate of 12kg per capita annually (Adenuga *et al.*, 2013; Erhie *et al.*, 2018). There are about 200,000 tomato farmers in Nigeria, and 90% of these farmers are small and medium-

scale farmers who utilize tomato farming as their major source of livelihood (Adenuga *et al*., 2013; Odemero and Okoh, 2014; Erhie et al., 2018). The tomato industry in Nigeria is high-yielding and economically attractive (Adepoju, 2014). Also, the tomato enterprise has the potential to augment foreign exports and increase the Gross Domestic Product (GDP) in the country. The work of Anang *et al.* (2013) portrayed the tomato industry as one that possesses the capacity to ameliorate poverty among its citizens due to its potential for growth and creation of job opportunities in the country.

The tomato industry is quite essential to Nigeria's agricultural sector and the economy as a whole. The country produces an average of 2.2 million metric tonnes of tomato yearly and is ranked as the 13th largest tomato producing countries in the world (FAO, 2018). Nigeria contributes about 1.3% of the global tomato output and 10.8% of Africa's total tomato output making it the second-largest producer in Africa after Eqypt (FAO, 2018). Tomato is widely cultivated in the country, but the major producing states are located in the North, which includes Kano, Kaduna, Jigawa, Katsina, Gombe, Bauchi, and other states, including Plateau, Benue, and Delta.

Over five years, Nigeria recorded significant growth in tomato output from 1.4 million tonnes in 2011 to 2.2 million tonnes in 2016, indicating a 36% increase in tomato output (FAO, 2018). However, according to the report by Erhie *et al.* (2018), the increased tomato output in Nigeria has been mainly from an expansion in the area of land under cultivation. Moreover, the growth of the tomato industry has been hampered by many challenges in Nigeria. For instance, Adenuga *et al.* (2013) pointed out the reliance of the small-scale producers on rain-fed farming coupled with the lack of irrigation systems. The rain-fed farming subsequently leads to glut during the rainy season and scarcity during the dry season, worsened by the lack of proper storage equipment characterizing the tomato farmers. Moreover, Robinson and Kolavalli (2010) observed the problem of low quality, insufficient produce, the incidence of pest and disease, and the foreign

competition among tomato farmers. However, the issue of postharvest losses along the value chain has been one of the major sources of concern in the tomato industry in recent times.

According to Erhie *et al.* (2018), about 45% of fresh tomato produced in Nigeria is lost through postharvest losses along the value chain which contributes to the demand deficit in the country. The country consumes the largest amount of vegetables in SSA with an estimate of 61.31g/per capita/per day of vegetable consumption (Ganry, 2009; Arifalo and Ogundari, 2013; Kamga, Kouamé, and Akyeampong, 2013). Precisely, the tomato demand is estimated at 2.3 million tonnes annually, with 12kg per capita consumption of tomatoes (Ugonna *et al.*, 2015; Erhie *et al.*, 2018). However, the country has to rely on imported tomato paste to feed the high demand due to insufficient supply of fresh tomato in the market (Erhie *et al.*, 2018).

2.3. The Structure of the Fresh Tomato Supply Chain in Nigeria

According to Andrew *et al.* (2006), the supply chain focuses on the cost and efficiencies of supply and the flow of the produce from the source to the final consumer or destination. Therefore, an efficient supply chain should reduce costs that could arise in the form of postharvest losses or other expenses. The supply chain plays a vital role in the level of postharvest losses that occur in different food products. Studies show that shorter supply chain tends to reduce postharvest losses as was seen in Laos and Fiji, where lower losses were recorder with shorter vegetable supply chains (Underhill and Kumar, 2014; Weinberger et al., 2008). However, as was seen in Cambodia and Vietnam, the losses recorded were higher where the supply chain was longer with more participants like supermarkets, wet market vendors, grocery stores, and street vendors (Weinberger *et al*., 2008).

The tomato supply chain in Nigeria is primarily made up of input suppliers, tomato farmers, processors, and traders at wholesale and retail levels (Figure 1). The input suppliers supply the inputs needed in the nursery and farm cultivation of the tomatoes to the farmers. These inputs include seeds, fertilizer, pesticides, nursery supplies, greenhouse, and auxiliary equipment among others (Ugonna *et al*., 2015). The small, medium, and large scale farmers involved in tomato production make up about 60%, 30%, and 10% of the producers, respectively (Ugonna *et al*., 2015; Erhie *et al*., 2018). The losses that take place at the production stages are majorly due to mechanical damages and spillage during various harvest operations like during harvesting or picking of the fruits. These losses makeup about 0-15% of the total losses and include the rotten tomatoes that are sorted out after harvesting (Jaspreet and Anita, 2013).

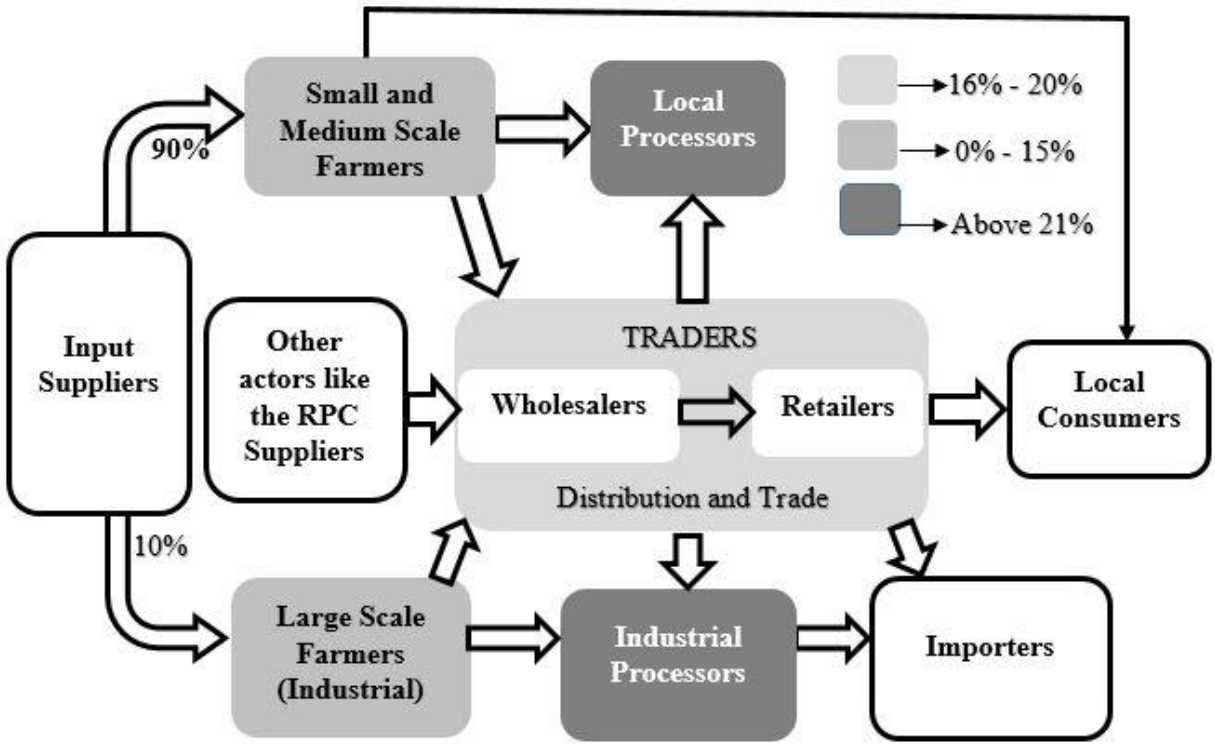

Figure 1: Elements of the Tomato Supply Chain in Nigeria

Source: *Adaptation from* (Erhie et al., 2018)*P*

Both local and industrial processors perform the processing of tomatoes in Nigeria and this stage constitutes the highest percentage of losses in the value chain (Erhie *et al*., 2018). According to Jaspreet and Anita (2013), the losses that occur at this stage are mainly as a result of spillage and degradation during the processing of the fresh tomatoes. The losses also include the products that are considered not suitable to process or wasted during other processes or through accidental spillage.

The distribution and selling phase is divided into three parts (Ugonna *et al*., 2015). The first part is the quantity that is sold directly to end-users in the surrounding areas of the farms. Another part includes the tomatoes sold through the wholesale or retail market, and the third part involves the distribution to the processors either directly from the farmers or the wholesale traders (Figure 1). The losses at this stage include losses and wastage in the market system like the wholesale market, supermarket and wet markets (Jaspreet and Anita, 2013). According to Erhie *et al*. (2018), this stage makes up about 16% - 20% of the total losses along the value chain. The consumers mainly consist of those who consume the products directly, and the losses encountered at these stages are wastage at the household level (Jaspreet and Anita, 2013). However, SSA has a low percentage of food wastage at the consumer level, worth 5% in fresh fruits and vegetables. The 5% wastage at the consumer level is incomparable to the 25% and 17% level of losses occurring at the processing and distribution stage, respectively (Gustavsson *et al*., 2013).

2.4. Role of the Traders in Reducing Losses in the Tomato Supply Chain

The focus on traders is linked to their role in the distribution and sale of fresh tomatoes from the farmers to the processors, traders, and consumers. The packaging and distribution phase accounts for the second-largest level of tomato losses in the supply chain, and the traders are the ones who bear these losses (Gustavsson *et al*., 2013; Erhie *et al*., 2018). These losses are mostly due to a

lack of storage facilities and inadequate packaging technologies (Arah et al., 2015; Izukanne and Chinweota, 2018). The study, therefore, measures the effect of adopting RPCs as a food loss reducing packaging technology on the profit of traders. This is based on the fact that studies have pointed out the numerous benefits of RPCs over woven baskets currently in use in Nigeria by traders (Kitinoja, 2013; Olumuyiwa *et al.*, 2017; Babarinsa *et al*., 2018).

2.5. Review of Empirical Studies on the Profitability of Tomato Trade in Africa

Many studies have measured the profitability of tomato trade in Nigeria either among wholesalers, retailers, or both (Haruna *et al.*, 2012; Odemero and Okoh, 2014; Orebiyi *et al*., 2016; Osuji *et al.*, 2016). The study of Haruna *et al*. (2012) analyzed the economics of the fresh tomato marketers in Bauchi Metropolis of Bauchi State, Nigeria. Farm budgetary techniques, which include gross margin, net income, gross ratio, operating ratio, and fixed ratio, were used to analyze the data of fifty (50) fresh tomato retailers. The study found the fresh tomato marketing to be very profitable with a gross income of ₦80,000 (approx. 222 USD) and a net income of ₦11,330 (approx. 31 USD) for the retailers. This finding correlates with the work of Haruna *et al.* (2012) on the structure, conduct, and performance of tomato marketing in Ghana. The study also found the profit margin of the retailers to be 1,169 Ghana Cedis (approx. 215 USD). The work of Haruna *et al*. (2012) also highlighted the operating ratio, fixed ratio, and gross ratio of the tomato retailers as 0.86, 0.02 and 0.86 respectively. The study of Haruna *et al*. (2012) found the tomato retailers to get 1.2 return/naira invested.

Furthermore, Orebiyi *et al*. (2016) examined the economics of tomato post-harvest losses at the market level in Akwa Ibom State, which is located in the Southern region of Nigeria. Marketing margin was used to analyze the data of One-hundred and thirty-one (131) tomato marketers as a measure of their profit level. The marketing margin was expressed as the purchasing price at the

farm gate subtracted from the selling price by the trader divided by the selling price by the trader and multiplied by 100. The mean marketing margin for the retailers was 98.45, while for the wholesalers, it was 106.8 showing that tomato marketing is quite profitable for both wholesalers and retailers. However, the tomato market is more profitable for wholesalers with a higher marketing margin than for retailers, according to the study. The result of Orebiyi *et al*. (2016) is similar to the work of Wongnaa *et al.* (2014) on the economics of tomato marketing in the Ashanti Region, Ghana. The study showed that the wholesalers had a higher marketing margin of 99.7%, while the retailers had a lesser marketing margin of 75.4%. However, the study highlighted that tomato marketing was profitable for both wholesalers and retailers (Wongnaa *et al.*, 2014). The studies also failed to take the traders who used RPCs into consideration when calculating the profits.

The study of Osuji *et al*. (2016) analyzed the determinants of the factors affecting the net return of tomato in Owerri Metropolis which is located in the South-Eastern region of Nigeria. Gross margin and net return model were used to sample thirty (30) wholesalers and thirty (30) retailers making up a total of 60 tomato traders in the study area. The gross margin was measured as the total revenue minus the total variable cost while the net return was calculated as the gross margin minus the total fixed costs. The gross margin was calculated as ₦22,835 (approx. 26 USD) per day, while the net return was ₦22,728, which sums up to a gross margin of approximately ₦600,000 (1,666 USD) per month for each trader. The profit margin corresponds to the work of Haruna *et al*. (2012), who also found the profit margin for the wholesalers to be about 9,171 (1,693 USD) Ghana Cedis per month.

Some other studies have also highlighted the profitability of tomato marketing by farmers in different African countries (Mango *et al*., 2015; Mutayoba and Ngaruko, 2018). The work of

Mango *et al.* (2015) the tomato value chain competitiveness in selected areas of Malawi and Mozambique. The study found tomato sales to be profitable for small-scale tomato farmers in both countries. However, tomato sale was more profitable for farmers in Mozambique with an average gross margin of 424 USD and a net income of 408 USD while the gross margin and net farm income for Malawi were 207 USD and 176 USD respectively (Mango *et al*., 2015). Also, the study of Masuku and Xaba (2013) which was done in Swaziland, highlighted the annual return per hectare of large-scale tomato farmers to be about 10,714 USD. Furthermore, Mutayoba and Ngaruko (2018) assessed tomato farming and marketing among smallholders in high potential agricultural areas of Tanzania. The study found tomato marketing to be profitable with a net profit of 2,750 Tanzania Shillings (1.2 USD) per bucket of tomato sold. The work of Meliko (2012) done on the efficiency of small-scale agriculture in the Limpopo Province of South Africa also highlights tomato sales to be quite profitable and efficient in the study area. However, there was also no consideration for the traders that sold their tomatoes with the use of RPCs, and the value of the tomato losses was not taken into account in calculating the net returns of the tomato marketers in these studies.

2.6. Review of Empirical Studies on Determinants of Adoption and Intensity of Adoption of Postharvest Technologies

Technology is defined as a design for necessary action that reduces the uncertainty in the cause-effect relationship involved in achieving an outcome (Rogers, 2003). Also, adoption is defined as the degree of use of new technology in long-run equilibrium when a farmer or trader has full information about the new technology and its potential (Feder *et al.*, 1981). The intensity of adoption has been measured in different ways by different authors. It has been measured in terms of a scale, percentage, or number of technologies in use by several authors (Masuki *et al*., 2006;

Paxton *et al.*, 2011; Obuobisa-darko, 2015). Adoption in this study means the use of Returnable Plastic Crates (RPCs) in packaging fresh tomato whereas the intensity of adoption is defined by the percentage of the trader's fresh tomatoes packaged with RPCs.

The socio-economic and demographic characteristics of the farmers or traders like age, income level, sex, household size, education level, and years of experience, among others, have been found to affect adoption and intensity of adoption of postharvest technologies significantly. Elemasho *et al.* (2017) conducted a study on the factors affecting the adoption of post-harvest technologies of selected food crops in Rivers State, Nigeria. The study found out that the age of the farmer, sex, marital status, education, household size, years of experience, and source of information significantly affected the adoption of agricultural postharvest technologies in the study area. Similarly, the work of Tiamiyu *et al.* (2014) found age and education level as significant factors influencing the adoption of on-farm and postharvest technology in the study area. The study was carried out to examine the rate and determinants of the adoption of improved rice quality-enhancing technologies in Niger state.

The work of Bokusheva *et al*. (2012) studied the factors determining the adoption and impact of postharvest storage technology. The study found the household socio-economic characteristics to be significant factors that influenced their adoption of postharvest storage technology. Furthermore, Obayelu *et al.* (2016) worked on the determinants of the perceived effects of the adoption of selected improved food crop technologies among smallholder farmers along the value chain in Nigeria. Some of the technologies that were examined in the study includes the cabinet dryer, chipping machine, fermentation tank, flash dryer, rotary dryer, sifter, de-stoner, grading machine and others. The study also found household socio-economic and demographic factors like

household size, years of schooling, age of household head, and years of experience to significantly affect the farmer's decision to adopt postharvest technologies on cassava and grains in Nigeria.

There is limited evidence from literature to show the effect of socio-economic and demographic factors on the intensity of adoption of postharvest technologies. However, some studies show that socio-economic and demographic factors also affect the intensity of adoption of agricultural technologies. Obuobisa-darko (2015) studied the socio-economic determinants of intensity of adoption of cocoa research innovations in Ghana. Part of the cocoa research innovations included some postharvest innovations like proper and timely fermentation, drying and packaging of cocoa in sacks for sale. The study found age, household size and education to significantly influence the intensity of adopting the cocoa research innovations in the study area.

Institutional factors and support services available in the area of study were significant factors found to determine the level of adoption of postharvest technologies. Group membership, credit accessibility, extension contact, training and electricity are primary support services and institutional factors that have been found to affect the adoption of postharvest technologies significantly. Akangbe *et al.* (2014) carried out a study on tomato farmer's adoption level of postharvest value addition technology and its constraints in the Surulere Area of Oyo State, Nigeria. Membership to a co-operative society, extension contact, and availability of electricity were support services that affected the adoption of postharvest value addition technologies in the study area (Akangbe *et al.*, 2014). In addition, the work of Tiamiyu *et al.* (2014) highlighted access to credit and membership to cooperatives as major factors that influenced the adoption of improved rice quality-enhancing technologies.

The study of Obuobisa-darko (2015) found credit access, membership to an association, and frequency of extension visits to significantly affect the adoption and intensity of adoption of cocoa

research innovations. Similarly, the work of Ali (2012) found that the vegetable farmers who used credit services and sold their produce in a regulated market had higher probabilities of adopting good postharvest practices. Bokusheva *et al*. (2012) highlighted the farmer's ability to finish their training course and the availability of basic infrastructures to be significant factors that influence the adoption of postharvest storage technologies.

Other factors also influenced the adoption and intensity of adoption of postharvest technologies. Adegbola *et al.* (2011) also carried out a study on the factors influencing the adoption of re-usable plastic vegetable crates in Kano State, Nigeria. However, this study was done before the introduction of the RPCs in the tomato value chain and focused on the perceived factors responsible for the non-use of plastic crates by vegetable farmers in the study area. The farmers highlighted the high cost of plastic crates, the difference in measurement, unavailability and low awareness on the existence of plastic crates as the major factors responsible for its non-use. Another factor that influenced the adoption of postharvest technologies was the perception of the respondent towards that technology (Adegbola *et al.*, 2011; Elemasho *et al.*, 2017b).

2.7. Review of Empirical Studies on the Effect of Returnable Plastic Crates (RPCs) on Welfare

The Postharvest Education Foundation performed a cost/benefit analysis on the use of RPC in comparison to other single-use packaging containers in the USA. The results showed that the use of RPCs yielded the highest amount of net profit as compared to fiber-board cartons, sacks, and baskets which generated the lowest net profit (Kitinoja, 2013). Likewise, Rapusas and Rolle (2009) discovered that plastic crates had the lowest cost per kg compared to the bamboo baskets and wooden crates. The finding on the reduced cost per kg of RPCs was drawn from a cost analysis

performed on different bulk packaging containers for tomatoes, mangoes, and lettuce in the Philippines (Rapusas and Rolle, 2009). The reduction in cost was mainly due to the ability of the RPCs to be re-used multiple times, which ultimately decreases its cost per use. The study also showed that the use of RPCs increased the value of a kilogram of FFV by up to 16% of the total market price (Rapusas and Rolle, 2009).

The high cost of RPCs has been highlighted as one of the major barriers hindering the use of RPCs as this may seem to have a negative influence on the user's profit and welfare (Adegbola *et al.*, 2011). However, Kitinoja (2013) argued that the use of RPC is cost-effective as the costs involved in the use of RPC are mostly lower than the gains from the reduction of losses. Likewise, Babarinsa *et al*. (2018) stated that although RPCs are costlier than the woven baskets used in Nigeria, the level of losses prevented by the plastic crates makes up for its high cost. The study found out that the use of RPCs reduced the level of losses incurred by the traders by more than 80% (Babarinsa *et al.*, 2018). However, the study failed to examine the effect of the use of RPCs on the profit of the users of RPCs.

A case study on the use of RPCs by farmers in Afghanistan showed that the RPCs reduced transportation spoilage of fresh tomatoes from 50% to 5% (CNFA, 2006). This finding is similar to the work of Babarinsa *et al*. (2018) in Nigeria who also showed that the transportation losses reduced from above 45% to below 5% with the use of RPCs. Reduced food losses would lead to higher income for the user, increased marketability of the produce and decreasing costs, as shown by the case study in Afghanistan (CNFA, 2006). The report by CNFA (2006) showed that the incomes of the farmers increased by a total of 75,000 USD through reduced losses. The study further showed that the buyers were willing to pay 33% more for the tomatoes packaged with RPCs due to its relatively higher quality and reliability (CNFA, 2006).

2.8. Review of Empirical Methods on Adoption and Intensity of Adoption of Agricultural Technologies

There are quite several approaches that have been used to model the determinants of adoption and intensity of adoption of agricultural technology. The adoption decision in regards to a particular technology is binary and can be modeled separately using a Binary Logit or Probit Regression model. However, the farmer or trader does not stop at the adoption decision but goes ahead to decide on the intensity of usage after the decision to adopt has been taken (Obuobisa-darko, 2015). It is, therefore, important to also analyze the factors that determine the intensity of adoption of that technology. According to Teklewold *et al.* (2006), the decision to adopt and the decision on the intensity of adoption are mostly assumed to be determined by the same stochastic processes, which are not always the case. This decision to adopt and the intensity of adoption can be determined jointly or separately (Gebremedhin and Swinton, 2003). In cases where the factors that affect the decision to adopt and those that affect the intensity of adoption are the same, then the conventional Tobit model or any other straightforward binary or censored model can be used (Green, 1993).

Past studies have applied the Censored Tobit model to analyze the determinants of the intensity of adoption of a technology (Wanjiku *et al.*, 2003; Kaguongo *et al.*, 2012; Akangbe *et al.*, 2014). However, it is not always the case that the two decisions are affected by the same number of factors in the same manner. One reason for the failure of this assumption is that there may be a percentage of the target population who would never adopt the technology for strong reasons (Teklewold *et al.*, 2006). The double-hurdle model is, therefore, more suitable in circumstances where the decision to adopt and the intensity of adoption are not jointly made (Green, 1993). The double-hurdle model can be seen as a parametric generalization of the Tobit model in which two separate stochastic processes are employed to determine the decision to adopt and the intensity of adoption

of a particular technology (Teklewold *et al*., 2006). In the double-hurdle model, both hurdles incorporate the effects of the characteristics and circumstances of each respondent, and such variables may be seen at both stages or either of them (Teklewold *et al.*, 2006). Moreover, those explanatory variables may have opposite effects in the two steps, and therefore, the double-hurdle model accounts for this. Hence, the choice of the double-hurdle model in the analysis of the factors influencing the intensity of adoption of RPC in the study area.

The method used to analyze the intensity of adoption of a particular technology primarily depends on the way the intensity of adoption is calculated in the study. The intensity of adoption has been measured in several ways by different authors according to the type of technology or the nature of their research and respondents. In the case of land cultivation, the intensity of adoption was measured as the number of hectares cultivated with the improved seed or the level of input applied per hectare (Nkonya *et al.*, 1997). Obuobisa-darko (2015) made use of a scale from one (1) to five (5) in measuring the intensity of adoption of cocoa research innovations. The intensity of adoption has been measured in some studies as the number of that technology in use (Masuki *et al*., 2006; Paxton *et al*., 2011). The outcome variable on the intensity of adoption would become a count variable if the author captures the intensity of adoption as the number of technology in use by the respondent. A Poisson Count Regression is, therefore, employed in cases where a count variable is used to measure the intensity of adoption (Ali, 2012; Obuobisa-darko, 2015).

However, defining the intensity or extent of adoption as just the number of that new technology in use seems to be limiting and misleading as it does not give an accurate picture of the extent to which the technology has been adopted. For example, Farmer A, who has a total of 100 hectares of land, might decide to use 50 hectares, which is half of his farmland, for cultivating the improved variety (the new technology in focus); whereas Farmer B, who has a total of 500 hectares of

farmland might decide to use 100 hectares, which is just one-fifth of his farm for cultivating the improved variety. Using only the number might lead the audience to think that Farmer B is a higher adopter than Farmer A due to the larger number of hectares cultivated, which may not be the case. This study, therefore, has adopted the use of percentages in measuring the intensity of adoption which goes a step further to consider the other areas that are not in use by the technology. Other studies also made use of the same strategy in measuring the intensity or extent of adoption (Teklewold *et al*., 2006; Nchinda *et al.,* 2010; Asfaw *et al.*, 2011; Kaguongo *et al*., 2012). In this study, the intensity of adoption was measured as the percentage of fresh tomato that is packaged with the use of Returnable Plastic Crates (RPCs) and the double-hurdle model was used to measure this decision process.

2.9. Review of Empirical Methods used to analyze the Effect of Adoption on Profit

Several models may seem suitable to examine the effect of an adoption decision on the profit margin of the respondents. One of them involves a simple comparison using t-tests, chi-square, or proportional test of comparison. Also, a regression-adjusted comparison could be used in comparing the profits of the adopters and non-adopters. However, the results of these comparisons may be misleading and reflect an omitted variable bias. There are several areas where the omitted variable bias could arise. One of which includes the unobserved and uncontrolled differences in some of the profit-making ability between the two sets. Furthermore, a simple OLS regression can be considered for analyzing the effect of adoption on profit, which is a continuous variable. However, according to Cerulli (2014), the OLS estimation assumes a joint normality of errors. It also assumes the same causal effects in the sample for both adopters and non-adopters. The use of the OLS regression model would, therefore, lead to inconsistent and inefficient estimates due to the presence of selectivity bias.

Selectivity bias emanates from a set of unobservable factors in the disturbance term, which is present in the regression model. The set of unobservable factors would likely induce a non-zero correlation with the adoption decision of the traders. The reason for the correlation is because the decision to adopt RPCs by the trader is typically random and not observable. We would, therefore, observe the effect of adoption for only the adopters which are non-random sub-samples. However, there exist some systematic differences in the observed and unobserved characteristics of both adopters and non-adopters. Also, selectivity bias could arise from the inclusion of an endogenous dummy variable (the decision to adopt or not to adopt) among the regressors in the model. The Endogenous Treatment Regression Model was, therefore, chosen to address the issue of selectivity bias in the model.

2.10. Theoretical Framework

Technology was defined by Rogers (2003) as a design for instrumental action, which reduces the uncertainty in the cause-effect relationship involved in achieving a particular outcome. Adoption was also defined as the degree of use of new technology in the long-run when the individual has full information about the new technology and its potential (Feder *et al.*, 1981). There are quite some theories that have been used to explain the adoption of technologies in different sectors. Some of the theories, as outlined by Obuobisa-darko (2015), include the theory of reasoned action, the theory of planned behavior, diffusion innovation theory and unified theory of acceptance and use of technology. However, this study is anchored on the random utility model (RUM) which assumes that the decision-maker has perfect discrimination ability (Brooks *et al.*, 2011).

In selecting any of the adoption options, the trader deliberates on the costs and benefits related to these adoption decisions and how they will derive maximum utility from it subject to external factors. If the costs that are related to continued adoption of RPCs are more than the benefits, the

trader will not be encouraged to start or continue using it, thus, choosing the next best alternative. To maximize their expected utility, a trader can decide to adopt RPC. The tomato traders are expected not to adopt or decrease the intensity of adoption of RPC if the satisfaction from not adopting or decreased intensity of adoption is greater than adoption or increased intensity of adoption. The utility of the trader depends on maximum profit attained through cost minimization and productivity optimization (Feder *et al.*, 1981). It is assumed that the decision made by the trader is a function of technology, institutional and socio-economic characteristics. The utility of adopting or increasing the intensity of adoption is a latent (unobserved) variable and can only be observed through the decision made by the trader. Let U_j^n, U_j^a and U_j^d represent the utility in the state of non-adoption (n), adoption (a), and increased intensity of adoption (d) of RPCs respectively. The trader chooses to change from the position of non-adoption to that of adoption of RPC if: $U_{ij}^* = U_{ij}^a - U_{ij}^d > 0$ and choose to increase the intensity of adoption if $U_{ij}^* = U_{ij}^d - U_{ij}^a > 0$. Where U_{ij}^* is the unobserved net benefit of adopting or increasing the intensity of adoption (Lancsar and Savage, 2004). Therefore, the decision made by the trader to adopt or increase the intensity of adoption can be determined by:

$$U_{ij}^* = X_{ij}\beta + \mathcal{E}_{ij} \quad \text{……………………………………………………………………. i}$$

Where X_{ij} is a vector of observable trader i characteristics for adopting and β represents a vector of estimated parameters and $\mathcal{E}_{ij}$ is the random error term which represents unobserved characteristics that influence the decision made by the trader (Lancsar and Savage, 2004). In other words, it represents uncertainty, since it is assumed that the trader does not have perfect information. For instance, in the current study, the trader who is the decision-maker chooses to increase the intensity of adoption to achieve some level of utility, U_{ij}^* . The model assumes that

the trader will choose the option that gives him maximum satisfaction (Lancsar and Savage, 2004). The deterministic part (X_{ij}) of the model is a linear combination of observable explanatory variables such as age, education and household size.

CHAPTER THREE

3.0. RESEARCH METHODOLOGY

3.1. Conceptual Framework

The conceptual framework showing the linkages between the profitability and adoption of RPCs is represented in Figure 2. The decision on adoption and intensity of adopting RPCs by fresh tomato traders is dependent on the trader's expected utility from its adoption of increased intensity of adoption. The expected utility of the trader is further influenced by several factors which influences the trader's decision on adoption of the technology (Teklewold *et al.*, 2013). These factors are grouped into institutional, socio-economic/demographic and other factors as shown in Figure 2.

Institutional factors comprise factors such as group membership, credit access, and training programs. Market groups and associations are vital platforms that could encourage the adoption of relevant innovations and technologies. A trader's membership in an association affects their probability of adopting new and relevant technologies like RPCs (Akangbe *et al.*, 2014). The ability to access credit services would affect the trader's willingness to adopt RPCs as the RPCs are costlier than other conventional packaging technologies in use (Adegbola *et al.*, 2011). Training programs are also very crucial to the traders in their adoption decisions for the acquisition of relevant information, which promotes technology adoption. Training programs also help to influence the trader's awareness and perception of the use of new technology. Increased awareness and perceptions of postharvest technology increases its probability of adoption (Elemasho *et al.*, 2017b; Olumuyiwa *et al.*, 2017).

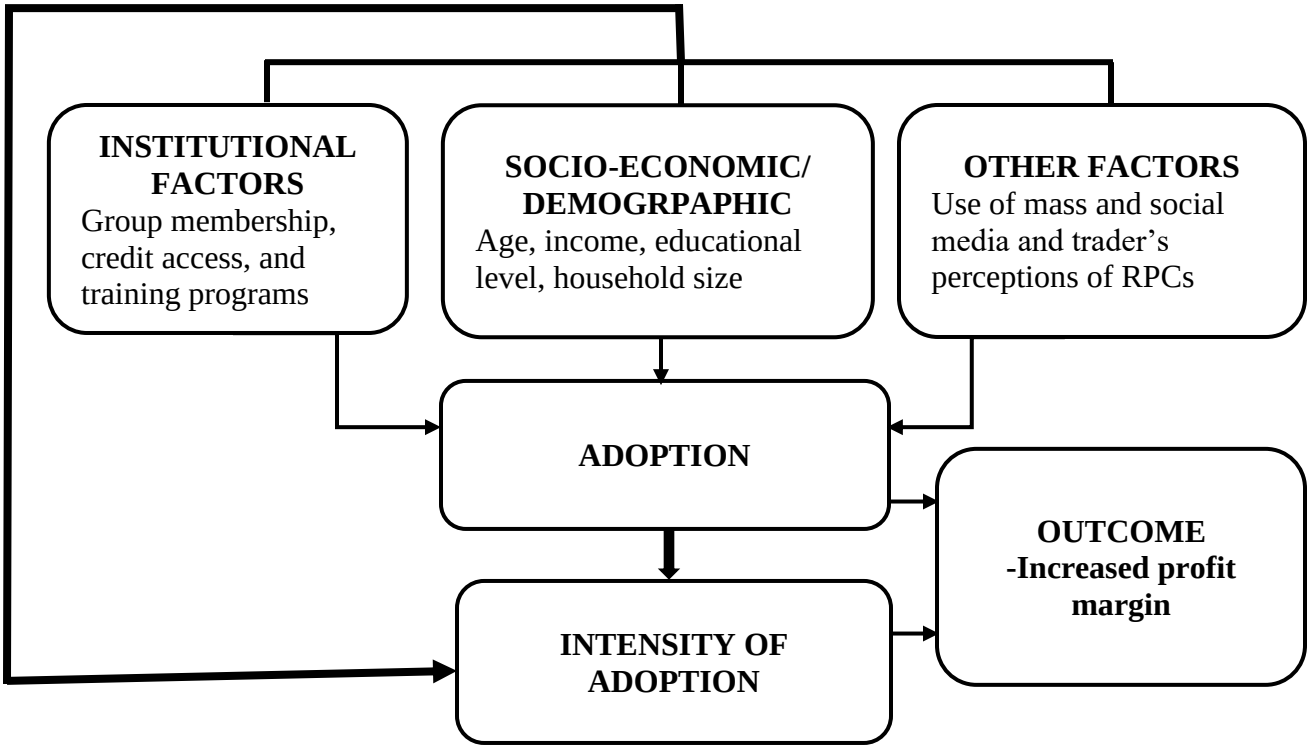

Figure 2: Conceptual Framework showing the Linkages in Profitability and Adoption of Returnable Plastic Crates

Source: *Author's conceptualization (2019)*

Socio-economic and demographic factors such as age, income, years of schooling, household size among other factors affect the adoption behaviors of the traders. The use of RPCs in the tomato market is a new innovation and the younger traders are more receptive to new innovations. The work of Elemasho *et al.* (2017a) showed that the younger respondents in the study had higher probabilities of adopting posharvest technologies in the study area. The trader's income level influences the trader's adoption decision as a higher income level would promote the adoption of

RPCs which is more cost-effective. Adegbola *et al.* (2011) discovered that the inability to afford the RPCs was the major reason for the unwillingness to adopt RPCs. Therefore, an increased income level would promote more financial resources to afford the use of RPCs. Household size is also an essential socio-economic factor which has been found to affect adoption behaviors towards a new technology (Doss, 2006; Obuobisa-darko, 2015; Elemasho *et al.*, 2017).

The level of education a trader has is expected to influence their adoption decision of new technology. Traders with higher levels of education are expected to have more knowledge and exposure and are, therefore, more receptive to innovations. Higher levels of education among farmers and traders have been found to increase their probability of adopting agricultural technologies (Obuobisa-darko, 2015; Elemasho *et al.*, 2017a). The trader's household size is another socio-economic factors that influence the trader's adoption decision. Although larger households could be advantageous to farmers due to the manual labor supply, it is expected to be disadvantageous to the traders because the tomato trade is not labor-intensive. Also, larger households could increase the expense and reduce their probability of adoption (Obuobisa-darko, 2015).

There are other factors like the trader's perceptions of RPCs and the use of mass and social media, which also influences the trader's adoption decision. The work of Elemasho *et al.* (2017b) emphasized the crucial role that the perceptions of farmers/traders towards a postharvest technology have in their adoption decision. The traders who have a positive perception of RPCs are more likely to adopt RPCs than those who have a negative perception. Also, the use of social and mass media by the fresh tomato traders was expected to influence their adoption of RPCs. Mass and social media have been discovered as powerful tools for accessing and disseminating

useful agricultural information, which positively affects the trader's adoption decision (Masuki *et al.,* 2006; Obidike, 2011).

The trader's adoption decision would lead them to either become adopters or non-adopters of RPCs. Furthermore, the adopters were expected to make decisions on the intensity of adoption, which is also affected by the highlighted factors in Figure 2. The adoption of RPCs would significantly influence the trader's profit margin and lead to other outcomes. The effect of the adoption of RPCs on the profit margin was expected to shape their future adoption decisions and intensity of adoption subsequently.

3.2. Description of the Study Area

The study was done in Lagos State, which is a megacity located in South-Western, Nigeria. The city has latitudes of 6° 23¢N and 6°41¢N and longitudes of 2°42¢E and 3°42¢E (Obayelu *et al.*, 2014). It is bordered in the north and east by Ogun State, in the west by the Republic of Benin and the south by the Atlantic Ocean, as shown in Figure 3. The last census in 2006 stated that about 9.1 million people were living in Lagos State making it the second-largest populated state after Kano State (NBS, 2011). Although Lagos has the second largest population in the country, it is the smallest in terms of landmass, as it covers an area of only 3,671 square kilometers (NBS, 2011). The population density of the state is estimated at 4,193 persons per square km (Obayelu *et al.*, 2014). Lagos State is the wet equatorial type influenced by its nearness to the equator and the Gulf of Guinea (Obayelu *et al.,* 2014). The state experiences two rainy seasons with the annual rainfall at about 1300mm (NBS, 2011). Lagos State has consistently high temperatures with the yearly mean temperature ranging from about 24^0C – 33^0C, and the annual mean relative humidity at 1500GMT is 70% (Iwugo *et al.*, 2003; NBS, 2013).

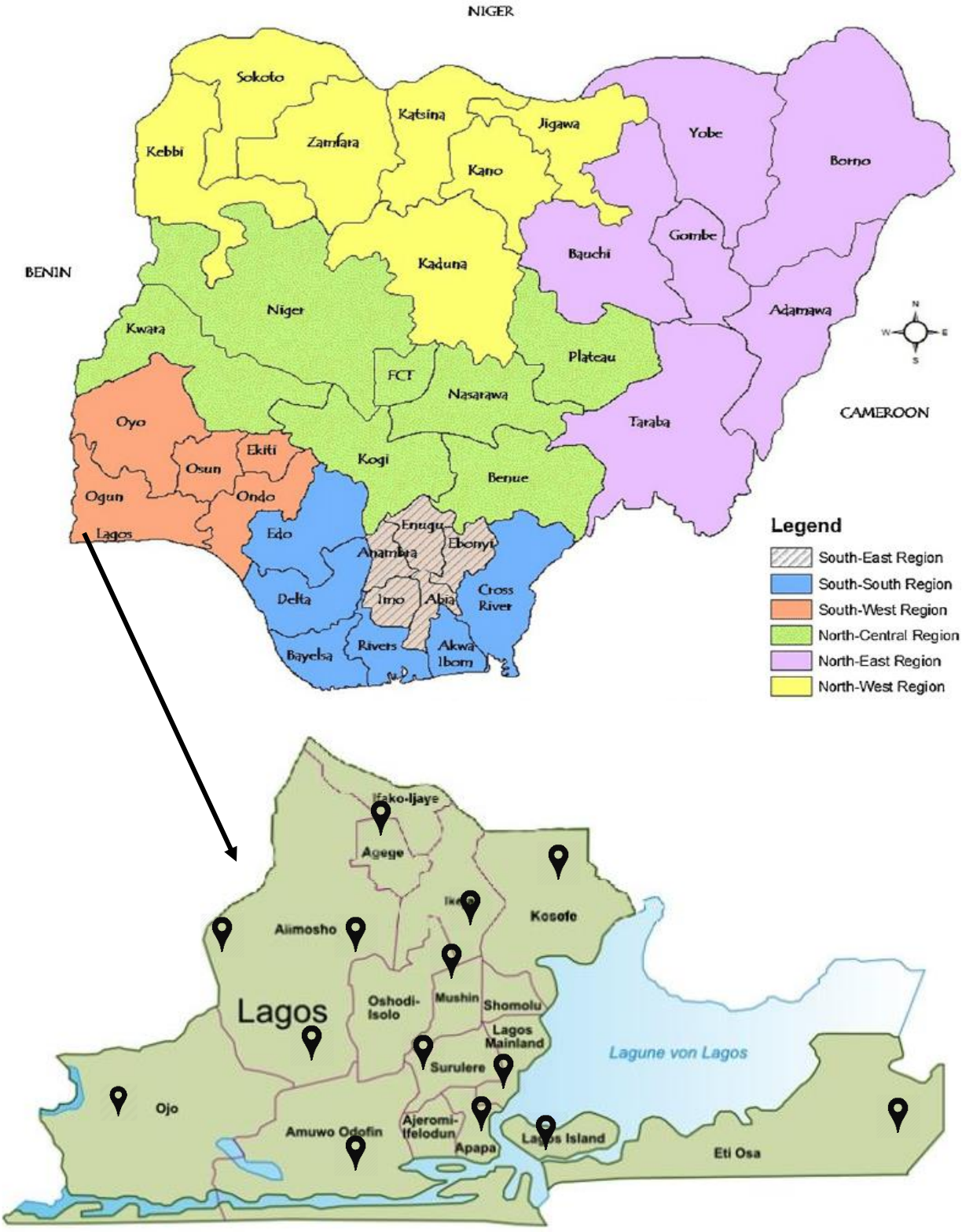

Figure 3: The Map of Nigeria and Lagos State showing Sampling Locations
Source: *Akinwale et al. (2013)*

Lagos state has high economic importance to Nigeria as it is the country's largest urban setting and contributes the largest share to the GDP. The state is highly industrialized and has a direct connection to seaports. It was also the previous capital territory of Nigeria before Abuja. According to Ekundayo (2013), the state is a major financial center and would be the fifth-largest economy in Africa if it were to be a country. The total generated revenue of Lagos State in 2017 was about ₦334 billion (approx. 920 million USD) growing by 10.43% annually (NBS, 2017). The people who live there are involved in different kinds of businesses.

Lagos State holds the largest tomato markets in Nigeria, and most of the fresh tomatoes gotten from the farm go straight to the markets in Lagos (Babarinsa *et al*., 2018). More than five of the biggest tomato processing industries are also located in Lagos (Ugonna *et al.,* 2015). Therefore, the farmers find it more advantageous to deliver the fresh tomatoes directly to Lagos due to the presence of the processing factories and large fresh tomato markets. Fresh tomato retailers from different parts of the country prefer to buy fresh tomatoes from Lagos due to its abundance and lower prices. The use of Returnable Plastic Crates in the fresh tomato market was introduced in Lagos due to the presence of sizeable fresh tomato markets (Babarinsa *et al*., 2018).

3.3. Research Design

The study made use of cross-sectional and descriptive research designs due to its ability to capture the data needed for analyses. Qualitative and quantitative approaches were employed to collect data on the adoption and profitability of the Returnable Plastic Crates (RPCs) among fresh tomato traders. The quantitative research approach was used to obtain cross-sectional data on the sampled tomato traders at a specific time. The quantitative data were collected through a semi-structured questionnaire, which was administered to the fresh tomato traders and used for the empirical data analysis.

3.4. Sampling Procedure and Data Collection

3.4.1. Sampling Procedure and Sample Size

A multi-stage sampling procedure was used in the selection of the respondent to be interviewed for the study. The first stage involved the purposive selection of Lagos State, where about 70% of the tomatoes produced in the country are directly distributed (Babarinsa *et al.*, 2018). In the second stage, a purposive sampling technique was used to select fourteen large tomato markets in different Local Government Areas (LGAs) of Lagos State. These markets were selected through the help of key informants and tomato market association leaders. Furthermore, 267 fresh tomato traders were randomly selected in the third stage using a simple random sampling technique. However, 12 traders were dropped due to their inability to complete the survey, and only 245 were used for the data analysis. The sample size was determined with a sample size determination formula developed by Cochran (1963) because of the inability to ascertain the population size. Cochran's formula is used to yield a representative sample for proportions of an unknown population (Singh and Masuku, 2014). The formula is given as:

$$n = \frac{Z^2 pq}{e^2}$$

Where *n* is the desired sample size, and *Z* is the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level is 95%). The value for Z is found in statistical tables that contain the area under the normal curve and is 1.96 for the 95 percent confidence interval in this case. The *p* is given as the estimated proportion of an attribute (fresh tomato traders) that is present in the population, *q* = (1-p), whereas the *e* is the desired level of precision (6 percent).

The resulting sample size was, therefore, calculated as:

$$n = \frac{1.96^2 \times 0.5 \times 0.5}{0.06^2} = 267$$

3.4.2. Data Collection Methods

The cross-sectional data was collected through focus group discussions, interviews of key informants, and the use of a semi-structured questionnaire in the study area. The Focus Group Discussions (FGD), Key Informant Interviews (KII) and pre-testing of questionnaire were carried out in one of the biggest fresh tomato markets in Nigeria (*Mile 12 market*). The FGD and KII were carried out for four days. This involved tomato market association leaders and representatives from different stages of the tomato value chain (farmers, wholesalers, retailers, handlers, carriers, distributors and consumers). The purpose of the FGD and KII was to acquire insights on the fresh tomato trade and the use of RPCs. The pre-testing of the questionnaire was carried out on the last day of the FGD. The KII, FGD, and pre-testing of questionnaire were helpful in re-structuring the questionnaire to be administered to the fresh tomato traders. Similar questions were merged, irrelevant questions were deleted while other questions were rephrased accordingly. Other perceived important variables from the results of the pre-testing, FGD, and KII were inputted in the questionnaires. The questionnaires were administered with the help of five trained enumerators who were selected based on qualification, data collection experience, and communication skills. The semi-structured questionnaire was used in collecting primary data from fresh tomato traders. This took a total of 12 days. Data were collected on the socio-economic characteristics of the respondents, the factors affecting their use of Returnable Plastic Crates, and the effect of the use of RPC on their profitability.

3.5. Data Analysis

Data were analyzed using descriptive and inferential statistics (econometric analysis). STATA software was used to analyze the data.

3.5.1. Analysis of the Profitability of Fresh Tomato Trade

The study used the Gross Margin (GM) analysis to determine the profitability of the fresh tomato trade for RPC and baskets users. The GM model was specified from the angle of estimating total costs and total revenue within a month. It was calculated as total sales revenue minus the total variable cost. The gross margin depicts the level of total revenue that the trader holds after incurring the variable or direct costs. Variable costs are expenses that are paid and differ with the quantity of tomatoes sold (Nunoo *et al.*, 2014). The total variable cost in this study included the cost of packaging containers, market fees, transportation costs, and other miscellaneous daily expenses. Total Revenue was computed as the total number of containers of tomatoes sold minus the losses multiplied by the price of each container (Equation ii)

a. Gross Margin (GM); GM = TR – TVC---------- ii
b. Operating Ratio (OR); OR = TVC/TR ---------- iii
c. Percentage Profit = TR – TC /(TC * 100) ---------- iv

TR = Total Revenue (Q.Py); TVC = Total Variable Cost; TC = Total Cost

Q = Quantity of tomatoes sold in a basket/crate; Py = Unit Price of tomatoes in a basket/crate

The operating ratio is also known to be the operating cost ratio or operating expense ratio and is expressed as a ratio or percentage. It was computed by dividing the operating expenses (which is the total variable cost of the trader in this case) by the net revenue over a particular period, which is a month in this study. The basic components as seen in Equation (iii), include the total variable

cost and the total revenue. Some non-operating expenses like fixed costs, interest charges, and others are not included in the computation. The operating ratio is used to measure the operational efficiency of the management and indicates the profit ratio of the business. It shows whether or not the cost component in the sales is within the normal range. Therefore, a low operating ratio means a high net profit ratio (which is more operating profit), while a high operating ratio signifies a lower net profit ratio. However, the profit percentage shows how well the business uses its income. A high percentage shows that the business generates a lot of profit for every ₦1 of revenue, whereas a lower profit percentage indicates that the business's high costs reduce the profit for every ₦1 of revenue.

3.5.2. Analysis of the Factors affecting Adoption and Intensity of Adoption of RPCs

The study used a double-hurdle model to analyze the factors influencing the adoption and intensity of adoption of RPC among fresh tomato traders. According to Teklewold *et al.* (2006), the double-hurdle model can be seen as a parametric generalization of the Tobit model in which two separate stochastic processes are employed to determine the decision to adopt and the intensity of adoption of a particular technology. The adoption decision was analyzed in a binary form whereby 0 was recorded for the non-adopters and 1 for the adopters. The adopters were defined as those fresh tomato trades who were currently making use of the RPCs in packaging and selling the fresh tomatoes. The definition of the intensity of adoption, as given by Feder *et al.* (1981), is the level of adoption of a given technology. In this study, the intensity of adoption is given by the percentage of fresh tomatoes packaged with the use of Returnable Plastic Crates (RPCs).

The intensity of adoption = % RPC (Percentage of fresh tomatoes packaged with the use of RPC by fresh tomato trader)

$$\%RPC = \frac{Amount\ of\ fresh\ tomatoes\ packaged\ with\ RPC\ (kg)}{Total\ amount\ of\ fresh\ tomatoes\ bought\ (kg)} \times 100 \ldots\ldots\ldots\ldots\ldots v$$

The model was originally developed by Cragg (1971) and has been extensively applied in several studies (Gebremedhin and Swinton, 2003; Teklewold *et al.*, 2006; Obuobisa-darko, 2015). The model was defined by Cameron and Trivedi (2009) as a modified Tobit model, which contains two processes, one generating the zeros and one generating the positive values. The two models to be used are not constricted to be the same. The decision to adopt or not to adopt the RPC technology is binary which may lead to the generation of several zeros for the non-adopters. Also, having decided to adopt, the trader may choose to intensify the usage, and the factors affecting both decisions may be different; hence, the choice of the double-hurdle model (Obuobisa-darko, 2015). The concept behind the model is that the initial binary outcome determining if the variable is zero or has a positive value is governed by the binomial probability model (Binary Logit/Probit). Therefore, if the value is observed to be positive, then it is said that the 'hurdle is crossed" and a truncated regression model governs the conditional distribution of the positive values.

According to Obuobisa-darko (2015), the double-hurdle model shows a two-stage decision-making process, and each process is a model of one decision, and they are functionally independent. The Maximum Likelihood (ML) estimation of the hurdle was, therefore, achieved by individually maximizing the two terms in the likelihood where one is for the zeros and the other for the positive values. The first part makes use of the entire sample while the second uses positive continuous variables only. The double-hurdle model is helpful in the analysis of an event that may or may not take place, and when it does, it takes on continuous positive values.

The first stage was analyzed using a binary logit model, whereas the second stage would make use of a truncated regression.

Teklewold *et al.* (2006) specified the model as follows (Equation vi);

$D_i = 1$ if $D_i^* > 0$

$D_i = 0$ if $D_i^* \leq 0$

$D_i^* = \alpha' Z_i + \mu_i$ ---------- vi

D is adoption, and D^* is a latent variable that takes the value 1 if the farmer adopts RPC and 0 otherwise. Z is a vector of household's characteristics, and α is a vector of parameters

They specified the intensity of adoption (Y) as (Equation vii);

$Y_i = Y_i^*$ if $Y_i^* > 0$ and $D_i^* > 0$

$Y_i = 0$ otherwise

$Y_i^* = \beta' X_i + V_i$ ---------- vii

Where Y_i is the observed answer to percentage tomatoes packaged with RPCs and X is a vector of individual characteristics, and β is a vector of parameters.

The error terms, μ_j, and V_i are distributed as follows (Equation viii):

$\mu_i \sim N(0,1)$
$V_i \sim N(0,\sigma^2)$ } ---------- viii

Hypothesized Variables affecting Adoption and Intensity of Adoption of RPCs

Age of the trader: The age of the traders was collected as a continuous variable in years. The effect of the age of the trader on the adoption and intensity of adopting RPCs was hypothesized to be negative (Table 2). This is because the younger population is more open and willing to try innovations and has been observed to be less risk-averse (Teklewold *et al*., 2006; Elemasho *et al*., 2017a). Elemasho *et al*. (2017a) also found out that the younger respondents were more likely to adopt post-harvest technologies than the older ones.

Household size: Household size was collected as a continuous variable in terms of the number of people living and feeding in the same household. The effect of household size on the adoption of agricultural technologies has shown different patterns in literature. Larger household size has increased the adoption of agricultural technologies (Obuobisa-darko, 2015; Elemasho *et al*., 2017a). It has also decreased the adoption and intensity of adoption (Doss, 2006; Akangbe *et al*., 2014). A larger household could increase the monthly expenses of the trader but could also be an additional source of income and labor for the trader. The household size was, therefore, hypothesized to either have a negative or positive effect on the adoption and intensity of adoption..

The number of income sources: It is expected that the higher the number of income sources a trader has, the more diversified and open they are to new technologies. It was found that farmers with secondary occupations had higher adoption levels (Olaoye *et al.*, 2017). Also, it is expected that a higher number of income sources would signify a larger amount of income, which would provide the trader with the financial resources to adopt RPCs. According to Adegbola *et al.* (2011), the number one reason, identified by 100% of the respondents, for not adopting the RPCs was due to its cost and the inability to afford it. A higher number of income sources were, therefore, hypothesized to increase the adoption and intensity of adopting RPCs.

Table 2: Variables included in Double-Hurdle Model and Expected Signs

Variable	Description	Expected signs on	
		Adoption	Intensity of adoption
Age	Age of the trader in years	-	-
HHsize	Household size	-/+	-/+
Income	Number of income sources	+	+
HHead	Being the household head (Yes =1, No = 0)	+	+
Education	Years of formal education	+	+
AssocMem	Number of market associations a trader belongs to	+	+
Media	Access to television and radio (Yes = 1, No access = 0)	+	+
Credit	Access to credit (Yes = 1, No access = 0)	+	+
Training	Participation in training programs (Yes = 1, No access = 0)	+	+
Perceptions	Perceptions of the traders towards RPCs. (Negative perception = 0, Positive perception = 1)	+	+
DecMakers	Number of people involved in decision making	+/-	+/-
Profit	The profit margin of the tomato trader		+

Household head: The effect of being the household head on the adoption and intensity of adoption is hypothesized to be either positive or negative as it could either increase or decrease the level and intensity of adoption of RPCs. The household heads are in charge of decision making, and this could hasten the process of RPC adoption. However, the household heads also have a higher number of dependants, which could reduce their real income and affordability of RPC technology.

Education: A higher level of formal education was expected to increase the adoption and intensity of adoption of RPCs among the fresh tomato traders. Studies have shown that those with higher education possess more knowledge and exposure, which leads to higher probabilities of adopting postharvest technologies (Akangbe *et al*., 2014; Tiamiyu *et al.*, 2014; Elemasho *et al.*, 2017a). The level of education has also been observed to influence the intensity of adoption of agricultural technologies (Wanjiku *et al.*, 2003; Obuobisa-darko, 2015).

Membership to market associations: It was expected that traders who belong to market groups and associations have access to relevant information on new technologies in the tomato market. Studies have found out that membership to associations has increased the adoption of agricultural postharvest and value-addition technologies (Akangbe *et al.*, 2014; Tiamiyu *et al*., 2014). Obuobisa-darko (2015) found out that membership to farmer's associations also increases the intensity of adopting agricultural technologies. Therefore, membership to market associations was hypothesized to have a positive effect on the adoption and intensity of adopting RPCs among tomato traders.

Access to media (radio and television): Access to media (television and radio) was hypothesized to influence the adoption and intensity of adopting RPCs positively. Access to media by tomato traders is expected to enhance the level of awareness and perception of postharvest technologies and lead to an increase in the probability and intensity of RPC adoption. Access to radio and television has been highlighted as a powerful tool for obtaining information on agricultural technologies (Obidike, 2011; Elemasho *et al*., 2017a). Also, the work of Masuki *et al.* (2006) emphasized the importance of an agricultural information pathway in increasing the adoption of agricultural technologies.

Access to credit: The effect of access to credit by the tomato traders was expected to be positive in the adoption and intensity of adopting RPCs. It was expected that traders who have access to credit were able to obtain more financial resources that would enable them to afford the RPC technology. Studies have also found access to credit to significantly increase the likelihood of adopting agricultural technologies (Teklewold *et al.,* 2006; Tiamiyu *et al.*, 2014; Obuobisa-darko, 2015).

Training programs: The trader's participation in training programs were hypothesized to have a positive effect on the adoption and intensity of adopting RPCs. The training programs help to increase the trader's level of awareness, knowledge, and perceptions of postharvest technologies. Studies have found that an increased level of awareness increases the adoption of RPCs (Adegbola *et al.,* 2011; Olumuyiwa *et al.,* 2017).

Perceptions of traders: Positive perceptions by the traders towards RPCs were expected to increase the adoption and intensity of adoption of RPCs. Studies have shown a positive perception towards a particular agricultural technology would significantly increase its likelihood of adoption (Adegbola *et al.,* 2011; Asfaw *et al.,* 2011; Elemasho *et al.,* 2017b).

The number of decision-makers: The number of decision-makers involved in the tomato trade is hypothesized to positively or negatively affect the adoption and intensity of adoption. It is expected that a larger number of decision-makers could slow down decision making in technology adoption. However, a larger number of decision-makers who are more exposed or educated could also increase the likelihood of adopting a new technology leading to increased profit margins (Adhikari *et al.,* 2009).

Profit: The profit of the trader is hypothesized to increase the intensity of adoption of RPCs conditional on adopting. It was expected that a higher profit margin would provide more financial resources, which would increase the adoption and intensity of adoption. Olaoye *et al.* (2016) found out that a higher profit margin significantly increased their adoption of improved agricultural technologies in the study area.

3.5.3. Analysis of the Effect of Adopting RPCs on the Fresh Tomato Traders

An Endogenous Treatment-Effect Regression model was used to analyze the effect of RPCs on the profit of fresh tomato traders in the study area. The use of 'treatment effect' is suitable when analyzing the causal effect of a binary variable on any outcome variable that could be of interest scientifically or in policy-making decisions. Some examples include the analysis of the effect of particular government intervention or any other binary individual choice. The decision to adopt the technology is a binary one where the trader decides to adopt or not to adopt the RPCs. The outcome variable is the profit of the trader which is a continuous variable. The Endogenous Treatment Effects model was, therefore, chosen to be suitable in estimating the effect of adoption on the trader's profit to yield an unbiased and consistent estimate.

The purpose of the Endogenous Treatment Effects model is to estimate the effects of undergoing treatment while accounting for its endogeneity and selection bias (Vella, 2011). To control for the possibility of endogeneity and selection bias, the control function makes use of a two-stage estimation process. The model would make use of the predicted probability of adopting the RPC technology obtained from the first stage in Equation (ix) to estimate the effect on the trader's profit in Equation (x). The decision to adopt is estimated as a selection equation in Equation (ix) in the first stage to construct the control function. The control function is then included as one of the independent variables representing the predicted probability of adopting RPC in the second stage

shown in Equation (x). A binary Probit model was used to estimate the first stage, while the second stage was regressed using the predicted value gotten from the first stage.

The first stage is specified as follows;

$A_i = \gamma C_i + \mu_i$ ---------- ix

A_i is a binary-treatment variable that is assumed to emanate from a set of unobservable latent variables. Where C_i represents socio-economic and other characteristics hypothesized to affect the trader's decision to adopt the RPC technology based on literature.

The decision to adopt is based on the following rule;

$$A_i = \begin{cases} 1, if\ A_i > 0 \\ 0, otherwise \end{cases}$$

Where the μ and ε in equation (ix) and (x) are bivariate normal with covariance matrix;

$$\begin{bmatrix} \sigma^2 & \rho\sigma \\ \rho\sigma & 1 \end{bmatrix}$$

The second stage which is the major regression we are interested in will be specified as follows;

$P_i = \beta S_i + \alpha A_i + \delta M_i + \varepsilon_i$ ---------- x

Where P_i denotes the profit of trader *i*, which depends on their socio-economic characteristics captured by S_i, some market factors captured by M_i and the trader's adoption of RPC denoted by A_i. The β in Equation (x) is a vector of the associated coefficient in the equation for the independent variable S_i, and it is assumed to have no form of correlation with the error term, ε_i. It is worth noting that interactions between S_i and A_i are allowed in Equation (x).

3.6. Diagnostic Tests of the Endogenous Treatment Regression Model

3.6.1. Heteroscedasticity test

Heteroscedasticity is the variance of the error term varying across observations and results in inefficient estimators, incorrect confidence interval and incorrect *t*-statistics in linear regression (Wooldridge, 2015). The Breusch-Pagan/ Cook-Weisberg test was used to test for the presence of heteroscedasticity in the Endogenous Treatment Regression model. The null hypothesis of homoscedasticity/constant variance meant that the variance was constant across the observation.

3.6.2. Multicollinearity Test

Multicollinearity occurs when there is a high linear relationship among the independent variables used in the models. Severe collinearity between the explanatory variables in the model would lead to large standard errors leading to wider confidence intervals, acceptance of the 'zero null hypotheses' (i.e., the true population coefficient is zero) more readily. The t-ration of one or more coefficient tends to be statistically insignificant (Damodar and Porter, 2004). The variance inflation factor (VIF) which is computed for each of the explanatory variables, was used to check for multicollinearity. The computation of the VIF involved the estimation of the variables with an OLS regression and using the command 'VIF' to get the variance inflation factors. The VIF for each of the variable was computed as follows:

$VIF = 1/1\text{-}R_i^2$

Where R^2 is for the auxiliary regression, and $_i$ represents each of the independent variables. According to Damodar and Porter (2004), a variable should not be included in an econometric model if the VIF of the variable exceeds ten. A Pearson correlation matrix was performed to ascertain if there was a strong linear relationship between the explanatory variables.

CHAPTER FOUR

4.0. RESULTS AND DISCUSSION

4.1. Descriptive Statistics of the Fresh Tomato Traders

This section discusses the socio-economic, demographic, and support services that characterized the fresh tomato traders in the study area. These factors are represented in Table 3 and Table 4. Table 3 and Table 4 also show the mean and standard deviation of the sampled population, adopters and non-adopters of RPCs. Only 81 (33%) out of 245 sampled tomato traders had adopted RPCs. This shows a low percentage of RPC adoption in the study area, which is in line with other studies that have also highlighted the low adoption of RPCs and other postharvest technologies (Elemasho *et al.*, 2017b; Olumuyiwa *et al.*, 2017). However, the result is an improvement from the study of Adegbola *et al.* (2011), where none of the respondents made use of RPCs in packaging their fresh tomatoes.

4.1.1. Socio-economic and Demographic Characteristics

The results in Table 3 show that the male and female sex were almost equal in number with a mean of 0.49, which shows a good representation of the male and female sex in the tomato trade. However, the males were slightly higher in number than the females, which is similar to the findings of Adeoye *et al.* (2009), where the male sex constituted a higher percentage of the tomato traders. The higher number of males in the tomato trade is in contrast to other studies, where the majority of the tomato traders were females (Odemero and Okoh, 2014; Osuji *et al*., 2016). There was also a significant difference between the adopters and non-adopters of RPCs in terms of their sex. The result shows that the adopters had a higher number of males compared to the non-adopters. This could stem from the less time spent by men at home to cater for the children and more time spent with their co-traders from which they can gather more information about RPCs.

This finding is in line with the work of Teklewood *et al.* (2006), where the male household heads had a higher probability of adopting agricultural technologies.

Table 3: Socio-economic and Demographic Characteristics of the Fresh Tomato Traders

Variables	Max	Min	Pooled (n = 245) Mean (SD)	Adopters (n = 81) Mean (SD)	Non-adopters (n = 164) Mean (SD)	t-value
Sex (Female = 1)	1	0	0.49 (0.50)	0.22 (0.41)	0.63 (0.48)	6.44***
Age of the trader	72	15	38 (9.35)	36 (9.64)	39 (9.04)	2.66***
Household size	20	1	5.56 (3.22)	5.50 (3.3)	5.59 (3.19)	0.19
Marriage (1 = married)	1	0	0.87 (0.34)	0.85 (0.36)	0.87 (0.33)	1.18
Years of schooling	16	0	8 (4.64)	6 (5.23)	9.17 (3.97)	5.03***
Years of experience	60	1	13 (8.97)	13 (7.7)	14 (9.55)	0.79

**** refers to the statistical significance at 1%*

Source: Field survey, 2019

Table 3 shows that the mean age of the tomato traders was 38 years, with a standard deviation of 9.35. This result could be indicative of the fact that traders within this age range are able and willing to take risks associated with the tomato trade and bear the physical labor it entails. The result is similar to other studies, which have shown that a larger percentage of the tomato traders were between the age bracket of 31 – 40 years (Adeoye *et al.*, 2009; Haruna *et al.*, 2012; Osuji *et al.*, 2016). There was also a significant difference between the adopters and non-adopters of RPCs in terms of their age. The adopters had a lower mean age of 36 years when compared to the non-adopters, whose mean age was 39 years. The lower mean age of the adopters could be a pointer to the fact that the younger traders are more likely to adopt new technologies than the older ones, as other studies have shown (Obuobisa-darko, 2015; Elemasho *et al.*, 2017a).

According to the results in Table 3, the mean household size was 5.56 with a standard deviation of 3.22. This shows that most of the traders had about six people living and feeding in the same household. The result is similar to other studies that have also found that the largest percentages of fresh tomato traders had household sizes between 5 and 10 (Haruna *et al.*, 2012; Obayelu *et al.*, 2014; Osuji *et al.*, 2016). Furthermore, the mean of the marital status for the sampled traders was 0.87, with a standard deviation of 0.34. This shows that the majority of the fresh tomato traders were married which could be because married people have more responsibilities to carry and would stay in the tomato trade as long as it remains profitable. The studies of Adeoye *et al.* (2009), Osuji *et al.* (2016), and Haruna *et al.* (2012) similarly found out that the majority of the tomato marketers were also married. There was no significant difference between adopters and non-adopters in terms of household size and marital status. This could be because the household size and marital status have no significant influence on the adoption of RPCs in the study area.

The mean years of formal education among the tomato traders were 8years, which is at the junior secondary school level with a standard deviation of 4.64. This shows that a larger percentage of the sampled traders had primary and secondary school education. This result indicates an averagely high level of literacy and corresponds with the findings of Adeoye *et al.* (2009) and Osuji *et al.* (2016), where the highest proportion of tomato traders had attained primary and secondary school education respectively. However, it is in contrast to the study of Obayelu *et al.* (2014), where the majority of the traders had no formal education. There was also a significant difference (at a 1% significance level between the adopters and non-adopters regarding their years of formal education. The non-adopters had a higher mean year of formal education. One reason for this might be because the adoption and use of RPCs do not require as much technical knowledge as other agricultural technologies.

The mean years of experience of tomato traders according to Table 3 was 13 years with a standard deviation of 8.97. The high mean years of experience are indicative of the fact that most of the tomato traders are well-experienced and tend to stay in the tomato trade for long periods possibly due to its rewarding benefits. The result aligns with other studies that also found the majority of the tomato traders to be well-experienced (Haruna *et al.,* 2012; Obayelu *et al.,* 2014; Orebiyi *et al.,* 2016; Osuji *et al.,* 2016). There was no significant difference between the adopters and non-adopters of RPCs in terms of their years of experience in the tomato trade (Table 3).

4.1.2. Institutional Factors and Support Services

The results in Table 4 show a generally low level of credit access with a mean of 0.09 and a standard deviation of 0.29. The table shows a low level of access to credit among adopters and non-adopters of RPCs, and there was no significant difference between the two categories according to the T-test. However, there was a slight difference between the adopters and non-adopters as a higher percentage of the adopters had more access to credit than the non-adopters. The low level of credit access among the tomato traders could be one of the reasons for the low adoption of RPCs. The findings correspond with the study of Obayelu *et al.* (2014)**,** where up to 18% of the sampled traders identified a lack of access to credit as the major barrier they face in the tomato trade.

Study findings in Table 4 also show that there was a very low level of participation in training programs among the sampled tomato traders as the mean was 0.03, with a standard deviation of 0.17. The mean level of participation was higher for the adopters than for the non-adopters. This shows that a higher percentage of the adopters had participated in training programs. There was a significant difference between the adopters and the non-adopters in terms of their participation in training programs.

Table 4: Institutional Factors and Support Services Characterizing Fresh Tomato Traders

Variables	Max	Min	Pooled (n = 245) Mean (SD)	Adopters (n = 81) Mean (SD)	Non-adopters (n = 164) Mean (SD)	t-value
Access to credit (1 = access)	1	0	0.09 (0.29)	0.11 (0.31)	0.09 (0.28)	-0.65***
Training programs (1 = participation)	1	0	0.03 (0.17)	0.07 (0.26)	0.01 (0.08)	-7.65***
Group membership (1 = member)	1	0	0.6 (0.49)	0.89 (0.32)	0.45 (0.5)	-0.24**

*** and **** refer to the statistical significance at 5% and 1% respectively*

Source: Field survey, 2019

There was an averagely high level of group membership among the tomato traders in the study area with the mean of 0.6 and a standard deviation of 0.49, as shown in Table 4. There was also a significant difference between adopters and non-adopters of RPCs in terms of their group membership. The results in Table 4 show a significantly (at a 1% significance level) higher number of adopters compared to non-adopters belonged to a market group. This result is in line with studies that have found out that most adopters of agricultural postharvest and value-addition technologies are members of associations (Akangbe *et al.*, 2014; Tiamiyu *et al*., 2014).

4.1.3. Source of Market Information among Fresh Tomato Traders

The results in Figure 4 show the major sources of market information outlined by the fresh tomato traders in the study area. It was revealed that the majority (72%) of the traders sourced their market information from fellow traders. Also, up to 21% of the traders indicated that their major source of information was the media (21%). This result shows that interpersonal interactions, mass, and social media are vital sources of information for the traders. The finding is in line with other studies where the major sources of information on agricultural technologies were highlighted as interpersonal communication and mass media (Obidike, 2011; Nwabeze *et al*., 2013; Elemasho *et al*., 2017a). A lower percentage of the tomato traders sourced their market information from family (3%), friends (3%), buyers (0.5%) and training programs (0.5%).

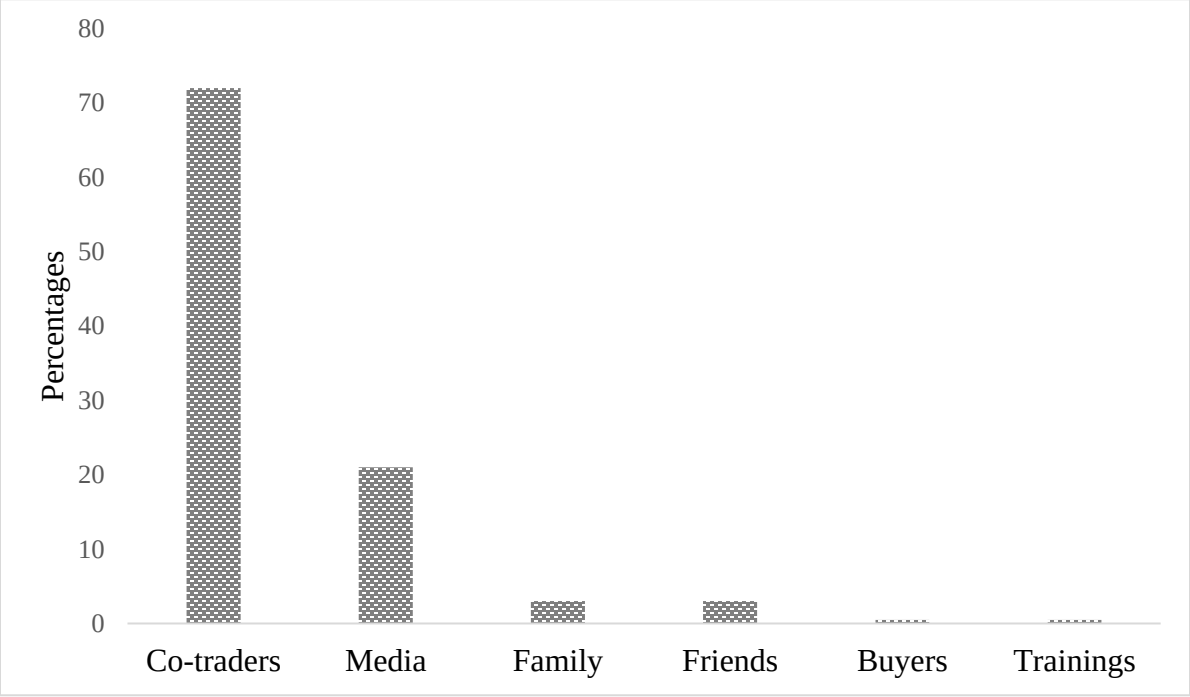

Figure 4: Major Sources of Information among Fresh Tomato Traders

Source: Field survey, 2019

4.1.4. Perceptions of Tomato Traders towards Returnable Plastic Crates (RPCs)

The results in Figure 5 show the perceptions of fresh tomato traders towards different characteristics of RPCs. A higher percentage of traders disagreed with the statement that the RPCs are widely known. This result shows a low level of awareness of the use of RPCs in Nigeria, as portrayed by Olumuyiwa *et al*. (2017), where a low level of RPC awareness was also discovered. A larger percentage of the traders also disagreed with the fact that the RPCs were widely available and affordable. This result is similar to the study of Adegbola *et al.* (2011), where unavailability and the high cost of RPCs were major reasons for the non-adoption of RPCs.

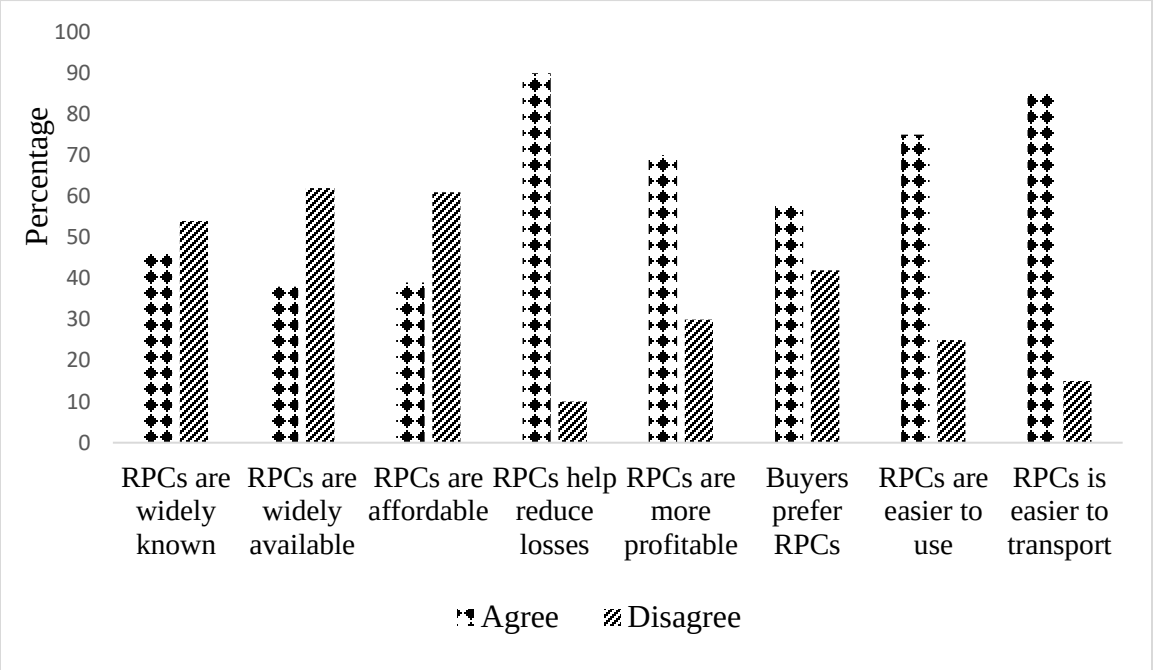

Figure 5: Description of Fresh Tomato Trader's Perceptions of RPCs

Source: *Field survey, 2019*

The majority of the fresh tomato traders agreed that RPCs greatly help in reducing postharvest losses and are more profitable than the use of woven baskets. This result is in line with the study of Olumuyiwa *et al*. (2017), where the traders accepted that the use of RPCs would increase their

income. Also, a higher proportion of the traders indicated that the tomato buyers prefer the RPCs to the woven baskets. This finding is in line with the case study in Afghanistan, where buyers were willing to pay 33% more for the tomatoes packaged with RPCs due to its relatively higher quality and reliability (CNFA, 2006). A larger percentage of the traders also accepted that RPCs are easier to use and make transportation of the fresh tomatoes easier. This finding is in line with other studies which have also discovered that RPCs greatly reduces the level of tomato transit losses and ease transportation of the fresh tomatoes (Babarinsa *et al.*, 2018; CNFA, 2006).

4.1.5. Major Constraints Faced by the Fresh Tomato Traders

The constraints faced by the tomato traders in the course of their tomato trade are presented in Table 5. Up to 41% of the traders identified low access to funds and capital as the major challenge they face in the tomato trade. This finding tallies with the study of Obayelu *et al.* (2014), where lack of access to credit was identified by 18% of the sampled tomato traders as the major challenge they faced in the tomato trade. Also, the large population of traders in the tomato trade leading to high levels of competition was further identified as a major constraint faced by up to 14% of the respondents.

The inability to access adequate market for the produce was highlighted by about 12% of the traders. High postharvest losses resulting from tomato diseases, inadequate storage facilities, and other associated risks were highlighted as another major constraint faced by up to 11% of the tomato traders. This constraint was also pointed out in the study by Obayelu *et al.* (2014), where 29% of the fresh tomato traders mentioned a lack of storage facilities as one of their major challenges. Also, the issue of lack of storage facility leading to high losses was pointed as a threat in the fresh tomato market by Haruna *et al.* (2012).

Table 5: Major Constraints Faced by the Fresh Tomato Traders

Constraints	Percent (%)
Low access to funds and capital	41
Large population and high competition among traders	14
Inability to access adequate market for the produce	12
High postharvest losses (resulting from tomato diseases, lack of adequate preservation and other associated risks)	11
Lack of adequate training and knowledge about the tomato market	7
High taxes and excessive fees charged to the tomato traders	4
Bad road networks and long distance from the farm to market	3
Non-uniform pricing in the tomato market	2
Shortage of fresh tomatoes especially during dry seasons	2
Theft and inadequate security	2
The high cost of transport	2
Total	**100**

Source: *Field survey, 2019*

Other constraints include lack of adequate training and knowledge about the tomato market, high taxes and excessive fees charged to the tomato traders, bad road networks and, long distances from farm to the market. Also, the traders highlighted non-uniform pricing, shortage of fresh tomatoes especially during the dry seasons, high cost of transportation, theft and inadequate security as other constraints they face in the tomato market.

4.1.6. Barriers Hindering the Adoption of Returnable Plastic Crates (RPCs)

The results in Table 6 show the barriers indicated by the traders, which hinder their adoption of Returnable Plastic Crates (RPCs) despite their willingness to adopt this technology, as portrayed by Olumuyiwa *et al.* (2017). Up to 29% of the respondents reported the inability of the RPCs to contain as many fresh tomatoes as the woven baskets to which they were accustomed. The RPCs can only contain about 25kg of fresh tomatoes whereas the baskets can contain up to 40-59kg of tomatoes (Kitinoja, 2013). This result is in line with the work of Babarinsa *et al*. (2018), where the respondents complained that the truck was unable to transport as much as fresh tomatoes with the use of RPCs than with the use of baskets.

Table 6: Barriers Hindering the Adoption of RPCs among Fresh Tomato Traders

Barriers	**Percentage (%)**
Inability to contain as many tomatoes as the baskets	29
The high cost of RPCs	25
Familiarity associated with the use of baskets	18
Low cost of obtaining baskets	10
Insufficient knowledge on the use of RPC	7
Unavailability of RPC	4
The difference in the unit of measurement	4
Buyer's preference for baskets	3

Source: *Field survey, 2019*

Furthermore, the high cost of RPCs was indicated as a significant barrier to RPC use by up to 25% of the respondents, while the low cost of obtaining the baskets was indicated by 10% of the traders. These barriers are related to the inability to afford the new technology as a result of the differences in the costs of RPCs and woven baskets. The expensive nature of RPCs and lack of funds to purchase them have also been identified as major barriers hindering the use of RPCs and other value addition and postharvest technologies (Adegbola *et al*., 2011; Akangbe *et al*., 2014; Izukanne and Chinweota, 2018).

The results in Table 6 further indicate that up to 18% of the fresh tomato traders highlighted the familiarity associated with the use of woven baskets as the major barrier hindering the adoption of RPCs. Up to 4% of the traders also indicated that the RPCs have a different unit of measurement from what they are used to, and this poses a major barrier to its usage. This result is in line with the study of Adegbola *et al.* (2011), where up to 18% of the respondents recorded that the inability to change old habits was one of the major factors for the non-use of RPCs in the study area. Other factors include insufficient knowledge on the use of RPCs, its unavailability and the buyer's preference for the woven baskets. Although these barriers constituted only 4%, 2%, and 2% respectively, it cannot be overlooked as it still poses as a barrier towards the adoption of RPCs. Also, unavailability and insufficient knowledge on the use of RPCs were highlighted by other studies as factors hindering the adoption of RPCs and other postharvest technologies (Adegbola *et al*., 2011; Akangbe *et al*., 2014).

4.2. Profitability of Fresh Tomato Trade

The average costs, returns, gross margins, percentage profits, and operating ratios of the tomato traders who use RPCs and those who use baskets are presented in Table 7 and Table 8 respectively.

Table 7: Costs and Returns of RPC Users among Fresh Tomato Traders

	Wholesalers		**Retailers**		**Total**
	Unit Cost/ Qty	**Yearly Cost/Qty**	**Unit Cost/ Qty**	**Yearly Cost/Qty**	
Selling price (₦)	3,200		5,000		
Selling days		180		252	
Quantity sold	36		4		
Percentage loss	0.05		0.08		
Quantity sold minus losses	34.2		3.68		
Total Revenue		19,699,200		4,636,800	
Total Cost		12,829,800		3,339,800	
Gross Margin		6,869,400		1,297,000	4,083,200
Operating Ratio		0.65		0.72	0.69
Profit Percentage		54%		39%	46.5%

1 USD = ₦360

Source: *Field Survey, 2019*

Table 7 shows that the tomato trade was profitable for the traders who made use of RPCs with an average gross margin of ₦4,083,200 per annum (approx. ₦340,266 per month), the operating ratio of 0.69 and profit percentage of 46.5%. Table 8 shows that the tomato trade was also profitable for the tomato traders who made use of baskets with an average gross margin of ₦1,845,150 (approx. ₦153,762 per month), the operating ratio of 0.85 and profit percentage of 18%. However, the tomato trade was discovered to be more profitable for the wholesalers than for the retailers, as shown by the higher gross margin and profit percentage and lower operating ratio. This finding is

in line with the work of Wongnaa *et al.* (2014), who found the tomato trade to be more profitable for the wholesalers than for the retailers with a higher marketing margin.

Table 8: Costs and Returns of Basket Users among Tomato Traders

	Wholesalers		**Retailers**		
	Unit Cost/ Qty	**Yearly Cost/Qty**	**Unit Cost/ Qty**	**Yearly Cost/Qty**	**Total**
Selling price (₦)	4,900		7,300		
Selling days		180		252	
Quantity bought	30		3		
Percentage loss	0.25		0.30		
Quantity sold minus losses	22.5		2.1		
Total Revenue		19,845,000		3,863,160	
Total Cost		16,716,000		3,301,860	
Gross Margin		3,129,000		561,300	1,845,150
Operating Ratio		0.84		0.85	0.85
Profit Percentage		19%		17%	18%

1 USD = ₦360

Source: *Field Survey, 2019*

The average gross margin and operating ratio for the retailers (basket and RPC users) were estimated at ₦929,150 (approx. ₦77,430 per month) and 0.79, respectively. This finding is similar to the work of Haruna *et al.* (2012), where the monthly gross income and an operating ratio of the tomato retailers were found to be approximately ₦80,000 and 0.86 respectively. Also, the retailers were observed to incur higher losses than the wholesalers. The reason for this could be that the retailers mostly buy from the wholesalers and take a longer time to sell off their tomatoes.

The results in Table 7 and Table 8 show that the tomato trade is more profitable for the traders that make use of RPC than for the basket users. This is indicated by the difference in gross margin,

profit percentage, and operating ratio for the RPC and crate users. The average gross margin and profit percentage for the tomato traders who made use of RPCs were higher than the gross margin for the traders who made use of baskets. Also, the operating ratio which is an indicator of the cost component for the crate users was lower than the operating ratio for the basket users. One primary reason for this difference is that the losses encountered by the traders who use baskets are significantly higher than the losses faced by the RPC users. This result is in line with other studies that have similarly found the use of RPCs to be more profitable than other packaging technologies (CNFA, 2006; Kitinoja, 2013).

4.3. Factors influencing the Intensity of Adopting RPCs among Fresh Tomato Traders

Table 9 shows the result of the diagnostic test of the double-hurdle model against the Tobit regression model. The Likelihood Ratio (LR) test resulted in a test statistic of 15.939 and a significant p-value of 0.00035 using the log-likelihood values of the two estimated models. The test statistic (Γ=15.939) exceeds the critical value of the χ2 distribution. The use of the double-hurdle model, therefore, results in a statistically significant improvement in model fit. The Akaike's Information Criterion (AIC) was also used to test for the fitness of the model, and the double-hurdle model which had the lowest AIC was preferred. The result of the AIC shows that the decision to adopt RPC and the decision on the intensity of adoption is governed by different processes and further confirms the fitness of the double-hurdle model.

Table 9: Diagnostic Test of the Double Hurdle Model

	Probit Regression	**Truncated Regression Y(Y>0)**	**Combined (Double-hurdle)**	**Tobit Regression**
Wald χ^2	166.70	41.00	92.79	227.82
Prob > χ^2	0.00***	0.00***	0.00***	0.00***
Log Likelihood	-72.13	-370.66	-442.03	-449.99
Number of observations (n)	245	81	245	245
AIC (-LOG-L+k)/n	0.45	9.00	3.72	3.58
	0.31	1.59	1.86	1.89
X^2-Test Double Hurdle versus Tobit: p = Pr[$X \geq 15.939$] = 0.0003***				

, ** and * refers to the statistical significance at 10%, 5% and 1% respectively*

Table 10 shows the estimated marginal effects of the factors influencing the adoption and intensity of adoption of RPCs. The trader's decision to adopt RPC was significantly and positively influenced by group membership, the number of income sources, the use of radio, participation in training programs and the perceptions of the traders. Similarly, the number of income sources, the

number of decision-makers and the trader's profit were factors that positively and significantly influenced the intensity of RPC adoption. However, the age of the traders negatively influenced RPC adoption and the trader's perception similarly influenced the intensity of adoption negatively.

Results in Table 10 show that the age of the trader had a negative significant (at a 10% significance level) effect on the adoption of RPCs. The result showed that an increase in the age of a trader reduces their probability of adopting RPCs by 0.4%. This indicates that younger traders are more likely to be potential adopters of RPCs than the older traders. A possible explanation is that younger traders are more open and willing to try innovations and are less risk-averse (Teklewold *et al.*, 2006; Elemasho *et al.*, 2017a). This finding is similar to other studies that have also found out that the younger population is more likely to adopt post-harvest technologies (Bokusheva *et al.*, 2012; Elemasho *et al.*, 2017a).

Group membership showed a positive significant (at 1% significance level) effect on the adoption of RPCs. This indicates that the tomato traders who belong to a market group or association have a higher probability (14%) of adopting RPCs than the traders who do not belong to any market group. This finding shows that market groups play a vital role in the adoption of postharvest technologies through information dissemination and other mechanisms. These findings are in line with other studies that have also found group membership and networking to increase the probability of adopting postharvest significantly and other agricultural technologies (Masuki *et al.*, 2006; Akangbe *et al.*, 2014; Tiamiyu *et al.*, 2014; Obuobisa-darko, 2015).

The number of income sources had shown a positive and significant effect on the probability of RPC adoption and the intensity of adoption at 1% and 5% significance level respectively. This means that an additional income source obtained by the trader increases their probability of adopting RPC by 24% and increases the intensity of adoption by 12%. One reason for this is that

a higher number of income sources increase the amount of income the trader has. Also, the traders who have more sources of income or secondary occupations are more diverse and open-minded to innovation. This result is in line with the work of Olaoye *et al.* (2017), were farmers with a secondary occupation had a higher probability of adopting agricultural innovations.

Table 10: Marginal Effect of the Factors affecting Adoption and Intensity of Adoption

Variables	Probability of Adoption		Intensity of Adoption	
	Marginal Effect	**Robust SE**	**Marginal Effect**	**Robust SE**
Age of the trader	-0.004*	0.014	-0.561	0.474
Household size	-0.003	0.033	-0.170	1.284
Group membership	0.141***	0.277	0.522	9.258
Number of income sources	0.236***	0.568	19.658**	11.714
Years of schooling	0.014	0.175	-0.297	4.682
Access to radio	0.267***	0.352	-	-
Access to television	-	-	-9.050	12.084
Perceptions of the trader	0.119***	0.123	20.563***	6.878
Participation in training programs	0.180***	0.465	1.654	2.373
Number of decision makers	-0.022	0.379	12.156**	9.066
Being the household head	0.127***	0.311	4.943	11.304
Access to credit	0.068	0.382	10.654	10.216
Trader's profit	-	-	42.038***	18.624
Constant	-0.260	0.845	71.991**	29.989
Sigma	27.286***	1.756		

, ** and * refers to the statistical significance at 10%, 5% and 1% respectively*

Source: Field Survey, 2019

Access to radio significantly (at 1% significance level) and positively influenced the adoption of RPCs. The result showed that those who had access to radios had approximately 27% higher probability of adopting RPCs compared to those who had no access to radio. The traders who have access to the radio can obtain vital information and are more open and willing to adopt new technologies. Radio has been highlighted by different studies as a powerful tool for getting information on postharvest technologies and other useful information for stakeholders in the agricultural value chains (Obidike, 2011; Elemasho *et al*., 2017a). Also, Masuki *et al.* (2006) emphasized the importance of an agricultural information pathway in the adoption of agricultural technology.

The perception of the traders towards RPCs was observed to positively influence the adoption and the intensity of adopting the RPCs at a 1% significance level. This means that the traders who have a positive perception towards RPCs have approximately 12% higher probability of adopting RPCs. Positive perception towards RPCs also increases the trader's intensity of RPC adoption by 20% conditional on adoption. This shows the importance of the trader's perception towards any new technology in the adoption of that technology by the trader. The trader is more likely to adopt new technology if they perceive it to be better than their current one in terms of the properties they consider relevant to them. Other studies have also emphasized the vital role that the perception of the farmer plays towards the adoption of postharvest and other agricultural technology (Adegbola *et al.,* 2011; Asfaw *et al.,* 2011; Barua *et al.*, 2017; Elemasho *et al.,* 2017b).

Participation in training programs related to the tomato trade positively and significantly affected RPC adoption at a 1% significance level. Those who participated in training programs had an 18% higher probability of adopting RPCs than those who had not. Participation in training programs helped increase the trader's awareness and knowledge of the use of new technologies. Also, an

increase in the level of awareness and sensitization on postharvest technologies has been found to increase its adoption (Adegbola *et al*., 2011; Elemasho *et al*., 2017a).

The number of decision-makers in the tomato trade positively and significantly influenced the intensity of adoption at a 5% significance level. This implies that an increase in the number of decision-makers increased the intensity of RPC use by 12%. More decision-makers who are exposed and educated would influence an increase in the intensity of RPC use if they observe it to be more profitable. The finding corresponds to the work of Adhikari *et al.* (2009) who found out that a higher number of decision-makers in the agricultural enterprise significantly contribute to its profitability and growth.

Being a household head significantly and positively influenced the decision to adopt RPCs at a 1% significance level. The result in Table 10 shows that being the household head increases their probability of adopting RPCs by approximately 13%. This could be because the household heads are in charge of decision making which could hasten the process of RPC adoption in the first stage. This finding is similar to the work of Teklewold *et al.* (2006), who found being a male household head to significantly and positively influence the decision to adopt an agricultural technology.

The trader's profit was observed to be positively and significantly influence the intensity of RPC adoption at a 1% significance level. This implies that an increase in the profit increases the trader's intensity of RPC usage by 42% conditional on earlier adoption of RPCs. An increase in the profit for a trader who has already adopted RPCs have more incentives and financial resources to increase the intensity of RPC usage. This finding corresponds with the study of Olaoye *et al.* (2016) who found out that the respondent's profit from the previous year significantly increases their adoption of improved agricultural technologies in the study area.

4.4. Effect of Adopting Returnable Plastic Crates (RPCs) on Tomato Trader's Profit

Table 11 shows the result of the endogenous treatment regression on the effect of RPC adoption on the profit of the fresh tomato traders. Table 11 also gives the lambda, rho, sigma, Wald χ^2 and the Prob > χ^2 used in evaluating the fitness of the model. The lambda is significant at 1% and shows that there was an endogeneity bias, which has been corrected. Also, the rho at 77% indicates that the decision to adopt RPCs and the effect of RPC adoption on profit are highly correlated and were not fit to be modeled individually. The Wald χ^2 is 366.19 and significant at 1%, showing that the model is fit and the variables together explain the variation in the trader's profit.

Table 11: The Effect of Adopting RPCs on the Profit of the Fresh Tomato Traders

Variables	**Co-efficient**	**Standard Errors**	
Use of RPCs (predicted)	0.4961***	(0.0356)	
Sex (female = 1)	0.0752***	(0.0218)	
Years of schooling	-0.0008	(0.0023)	
Number of income sources	-0.0889*	(0.0458)	
Log of monthly expenses	-0.0176***	(0.0057)	
Television use (Use = 1)	0.0117	(0.0233)	
Number of decision makers	0.0231	(0.0246)	
Lambda	-0.1211***	(0.0243)	
Rho	-0.7744	Wald χ^2	= 366.19
Sigma	0.1564	Prob > χ^2	= 0.000

, and * refers to the statistical significance at 10%, and 1% respectively*

Source: *Field survey*

According to Table 11, the adoption of RPCs has a positive effect on the trader's profit at a 1% significance level. It shows that the use of RPC would increase the trader's profit by 49%. This could be because the adoption of RPCs significantly reduces the level of tomato postharvest losses that the trader faces, thereby increasing their profit margin. This finding is in line with other studies which have found that the use of RPCs in the tomato value-chain significantly reduces losses and also increases the real income of the users (Adegbola *et al.,* 2011; Kitinoja, 2013; Olumuyiwa *et al.*, 2017; Babarinsa *et al.,* 2018; Erhie *et al.,* 2018;).

Table 11 also shows that the sex of the trader has a positive and significant effect on the trader's profit margin showing that the profits of females are 7% higher than the males. Also, an increase in the number of income sources a trader has significantly reduced the trader profit from the tomato trade by 8%. This could be because other sources of income in the form of another occupation or trade take up more of the trader's resources, which should have been diverted towards the trader's tomato business. An increase in the trader's monthly expenses also significantly reduces the trader's profit by 1.7%. This could probably be because an increase in expenses reduces the financial capacity of the trader.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The study analyzed the profitability of the tomato trade for the fresh tomato traders in Lagos State, Nigeria. The study also examined the factors influencing the adoption and intensity of adopting RPCs and the effect of adopting RPCs on the trader's profit margin. The tomato trade was profitable for the fresh tomato traders in the study area. However, the tomato traders, who had not adopted RPCs as a food loss reducing technology, incurred higher levels of tomato postharvest losses and increased costs. The use of RPCs by the fresh tomato traders was effective in reducing the costs incurred by the traders. The tomato traders, who had adopted the use of RPCs, therefore, had a higher profit margin than other tomato traders in the study area

The likelihood of adopting RPCs by the tomato traders was significantly higher for the traders, who belonged to a market association and who participated in training programs and had access to radios. The study shows that market associations, training programs, and radios are vital tools that encourage the adoption of RPCs in the study area. An increased number of income sources and a higher profit margin strongly influenced the trader's decision to intensify the use of RPCs. The way the traders perceived the usefulness, availability, and accessibility of RPCs was very pivotal in their decision to adopt RPCs and to intensify its use. However, the study showed that the younger traders were more likely to adopt RPCs than the older traders.

5.2. Recommendations

5.2.1 Policy Recommendations

The following recommendations have been made based on the findings of the study. The study recommends that training and sensitization programs on the importance of the RPCs should be made intensified among the traders. These training programs should indulge market association leaders and make use of radio in the dissemination of the training and sensitization programs. Policies should focus on strengthening the effectiveness of the tomato market associations to help intensify the adoption of RPCs. The policy-makers should adopt a bottom-top approach in formulating policies regarding the RPCs and the tomato traders as their perceptions are very essential in their adoption of RPCs.

Public and private institutions should help provide other sources of income for the traders to enable them to afford the use of RPCs. Also, the RPCs should be subsidized and made more available and accessible to the fresh tomato traders. The tomato traders should also be educated on the advantages gotten through the use of RPCs and the positive effect it has on their profit margin. The government and non-governmental programs focused on the adoption of RPCs should also indulge more young people as they are more likely to respond favorably than the older traders. The study recommends that a multi-stakeholder approach should be adopted in policies regarding the use of RPCs, which would include the leaders of the market associations and the tomato traders.

5.2.2. Recommendations for Further Research

Further research should look into other actors in the fresh tomato value chain like the handlers, distributors, and their respective roles in the adoption of Returnable Plastic Crates (RPCs). Consumer's preference and acceptability for fresh tomato packaged with the use of RPCs should also be researched on.

REFERENCES

Adegbola, A., Bamishaiye, E. I., & Olayemi, F. (2011). Factors Affecting the Adoption of the Re-Usable Plastic Vegetable Crate in Three Local Government Areas of Kano State , Nigeria. *Asian Journal of Agricultural Sciences*, *3*(4), 281–285.

Adenuga, A. H., Muhammad-Lawal, A., & Rotimi, O. A. (2013). Economics and Technical Efficiency of Dry Season Tomato Production in Selected Areas in Kwara State, Nigeria. *Agris On-Line Papers in Economics and Informatics*, *5*(1), 11–19. Retrieved from https://search.proquest.com/openview/7fc50ac1bead77c21d4daf722fcdaf95/1?pq-origsite=gscholar&cbl=436323

Adeoye, I. B., Odeleye, O. M. O., Babalola, S. O., & Afolayan, S. O. (2009). Economic Analysis of Tomato Losses in Ibadan Metropolis, Oyo State, Nigeria. *African Journal of Basic & Applied Sciences*, *1*(56), 87–92. Retrieved from https://idosi.org/ajbas/ajbas1(5-6)09/1.pdf

Adepoju, A. O. (2014). Post-harvest losses and welfare of tomato farmers in Ogbomosho, Osun state, Nigeria. *Journal of Stored Products and Postharvest Reseach*, *5*(2), 8–13. https://doi.org/10.5897/JSPPR2014.0160

Adhikari, A., Mishra, A. K., & Chintawar, S. (2009). Adoption of Technology and Its Impact on Profitability of Young and Beginning Farmers: A Quantile Regression Approach. *Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia*, 1–22. Retrieved from https://ageconsearch.tind.io/record/46830/files/Adoption_mishra_edits.pdf

Akangbe, J. A., Ogundiran, T. J., Komolafe, S. E., Ifabiyi, J. O., & Ajibola, B. O. (2014). Tomato Farmers Adoption Level of Postharvest Value Addition Technology and its Constraints in Surulere Area of Oyo State, Nigeria. *Journal of Agriculture and Social*

Research (JASR), *14*(1), 91-97–97. Retrieved from https://www.ajol.info/index.php/jasr/article/view/166704

Akinwale, O., Lekan John, O., Adejoh, P., Adeneye, A., Adeneye, A., Musa, A., … Sulyman, M. (2013). Survey of Hypertension, Diabetes and Obesity in Three Nigerian Urban Slums. *Iranian Journal of Public Health*, *42*, 972–979.

Akter, H., & Khan, S. A. (2012). Effect of Gamma Irradiation on the Quality (Colour, Firmness and Total Soluble Solid) of Tomatoes (Lycopersicon Esculentum Mill.) Stored at Different Temperature. *Asian Journal of Agricultural Research*. https://doi.org/10.3923/ajar.2012

Ali, J. (2012). Factors Influencing Adoption of Postharvest Practices in Vegetables. *International Journal of Vegetable Science*, *18*(1), 29–40. https://doi.org/10.1080/19315260.2011.568998

Anang, B. T., Zulkarnain, Z. A., & Yusif, S. (2013). Production Constraints and Measures to enhance the Competitiveness of the Tomato Industry in Wenchi Municipal District of Ghana. *American Journal of Experimental Agriculture*, *3*(4), 824–838. https://doi.org/10.9734/ajea/2013/4373

Andrew, F., Shunk, D., & Callarman, T. (2006). Value Chains versus Supply Chains. *BP Trends*. Retrieved from www.bptrends.com

Arah, I. K., Kumah, E. K., Anku, E. K., & Amaglo, H. (2015). An Overview of Post-Harvest Losses in Tomato Production in Africa: Causes and Possible Prevention Strategies. *Journal of Biology*, *5*(16).

Arifalo, S. F., & Ogundari, K. (2013). Determinants of Household Demand for Fresh Fruit and Vegetable in Nigeria: A Double Hurdle Approach. In *Quarterly Journal of International*

Agriculture (Vol. 52). Retrieved from https://www.researchgate.net/publication/260640308

Asfaw, S., Shiferaw, B., Simtowe, F., & Haile, M. G. (2011). Agricultural technology, seed access constraints and commercialization in Ethiopia. Journal of Development and Agricultural Economics,. *Journal of Development and Agricultural Economics*, *3*(9), 436–447.

Aulakh, J., Regmi, A., Fulton, J., & Alexander, C. (2013). Estimating Post-Harvest Food Losses: Developing a Consistent Global Estimation Framework. *Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting*. Retrieved from https://ageconsearch.umn.edu/bitstream/150363/2/AAEA_Poster_Post-harvest.pdf

Babalola, D. A., Makinde, Y. O., Omonona, B. T., & Oyekanmi, M. O. (2010). Determinants of post harvest losses in tomato production: a case study of Imeko – Afon local government area of Ogun state. *Journal of Life and Physical Science*, *3*(2), 14–18.

Babarinsa, F. A., Ogundele, R. B., Babarinsa, O. A., & Omodara, M. A. (2018). Evaluation of plastic crate as replacement for raffia basket to prevent in-transit damage of packaged tomatoes. *Journal of Postharvest Technology*, *06*(3), 70–79. Retrieved from http://www.jpht.info

Babatola, L. A., Ojo, D. O., & Lawal, O. I. (2008). Effect of Storage Conditions on Tomato (Lycopersicon esculentum Mill.) Quality and Shelf Life. *Journal of Biological Sciences*, *8*(2), 490–493. https://doi.org/10.3923/jbs.2008.490.493

Barua, S., Singh, P., Mridiula, D., Gupta, R. K., Satyapriya, & Tomar, B. S. (2017). Attitude Assessment of Farmers Towards Post-harvest Technologies and Value Addition of Horticultural Crops in Punjab. *Journal of Human Ecology*, *59*(2–3), 164–168.

https://doi.org/10.1080/09709274.2017.1305611

Bokusheva, R., Finger, R., Fischler, M., Berlin, R., Marín, Y., Pérez, F., & Paiz, F. (2012). Factors Determining the Adoption and Impact of a Postharvest Storage Technology. *Food Security*, *4*(2), 279–293. https://doi.org/10.1007/s12571-012-0184-1

Brooks, S., Gelman, A., Jones, G., & Meng, X. (2011). *Handbook of markov chain monte carlo*. Retrieved from https://books.google.com/books?hl=en&lr=&id=qfRsAIKZ4rIC&oi=fnd&pg=PP1&dq=Brooks,+S.,+Gelman,+A.,+Jones,+G.,+%26+Meng,+X.+L.+(Eds.).+(2011).+Handbook+of+markov+chain+%09monte+carlo&ots=Rcy99U-d2W&sig=7BFuB2JieHURFSZLggK3jyJQfbc

Cameron, A. C., & Trivedi, P. K. (2009). *Microeconometrics Using Stata* (Vol. 23). Retrieved from www.stata.com

Cerulli, G. (2014). Ivtreatreg: A command for fitting binary treatment models with heterogeneous response to treatment and unobservable selection. *Stata Journal*, *14*(3), 453–480. https://doi.org/The Stata Journal

CNFA. (2006). *Afghanistan: Longer Shelf-Life for Tomatoes Drastically Improves Incomes*.

Cochran, W. G. (1963). *Sampling Techniques* (2nd ed.). New York: John Wiley & Sons Inc.

Cragg, J. G. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. *Econometrica*, *39*(5), 829. https://doi.org/10.2307/1909582

Damodar, G., & Porter, D. C. (2004). *Basic Econometrics* (Fourth Edi). Editura McGraw-Hill.

Doss, C. R. (2006, May 1). Analyzing technology adoption using microstudies: Limitations,

challenges, and opportunities for improvement. *Agricultural Economics*, Vol. 34, pp. 207–219. https://doi.org/10.1111/j.1574-0864.2006.00119.x

Ekundayo, J. M. O. (2013). *Out of Africa: Fashola: Reinventing Servant Leadership to Engender Nigeria's Transformation*.

Elemasho, M. K., Alfred, S. D. Y., Aneke, C. C., Chugali, A. J. C., & Ajiboye, O. (2017a). Factors affecting Adoption of Post-harvest Technologies of Selected Food Crops in Rivers State, Nigeria. In *International Journal of Agricultural Economics and Extension* (Vol. 5). Retrieved from www.internationalscholarsjournals.org

Elemasho, M. K., Alfred, S. D. Y., Aneke, C. C., Chugali, A. J. C., & Ajiboye, O. (2017b). Farmers ' Perception of Adoption of Post-harvest Technologies of Selected Food Crops in Rivers State, Nigeria. *International Journal of Agricultural Resource, Innovation and Technology*, *7*(1), 22–26.

Erhie, E., Agbeyi, E., Oyaniran, T., Nevin, A., Oladipo, O., & Adegunle, E. (2018). *X-raying the Nigerian Tomato Industry: Focus on Reducing Tomato Wastage*. Retrieved from https://www.pwc.com/ng/en/assets/pdf/nigeria-tomato-industry.pdf

FAO. (2018). FAOSTAT Database. Retrieved January 13, 2018, from Food and Agriculture Organization of the United Nations website: http://www.fao.org/faostat/en/#rankings/countries_by_commodity_imports

Feder, G., Just, R., & Silberman, D. (1981). *Adoption of agricultural innovations in developing countries: A survey World Bank staff working paper no. 444*. Retrieved from http://www.journals.uchicago.edu/t-and-c

GAIN. (2017). *PLAN Nigeria Crating Workshop Report*.

Ganry, J. (2009). Current Status of Fruits and Vegetables Production and Consumption in Francophone African Countries- Potential Impact on Health. *Acta Horticulturae*, (841), 249–256. https://doi.org/10.17660/ActaHortic.2009.841.30

Gautier, H., Diakou-Verdin, V., Bénard, C., Reich, M., Buret, M., Bourgaud, F., … Génard, M. (2008). How Does Tomato Quality (Sugar, Acid, and Nutritional Quality) Vary with Ripening Stage, Temperature, and Irradiance? *Journal of Agricultural and Food Chemistry*, *56*(4), 1241–1250. https://doi.org/10.1021/jf072196t

Gebremedhin, B., & Swinton, S. M. (2003). Investment in soil conservation in northern Ethiopia: The role of land tenure security and public programs. *Agricultural Economics*, *29*(1), 69–84. https://doi.org/10.1016/S0169-5150(03)00022-7

Green, W. H. (1993). *Econometric Analysis* (2nd Editio). New York: Macmillian.

Gustavsson, J., Cederberg, C., Sonesson, U., & Emanuelsson, A. (2013). The Methodology of the FAO study: Global Food Losses and Food Waste - extent, causes and prevention. In *Swedish Institute for Food and Biotechnology*. Retrieved from http://www.diva-portal.org/smash/get/diva2:944159/FULLTEXT01.pdf

Haruna, I., Nkegbe, P. K., & Ustarz, Y. (2012). Structure , Conduct and Performance of Tomato Marketing in Ghana. *Journal of Economics and Sustainable Development*, *3*(10), 156–163. Retrieved from http://www.udsspace.uds.edu.gh/handle/123456789/427

Haruna, U., Sani, M. H., Danwanka, H. A., & Adejo, E. (2012). Economic Analysis of Fresh Tomato Marketers in Bauchi Metropolis of Bauchi State, Nigeria. *Nigerian Journal of*

Agriculture, Food and Environment, *8*(3), 1–8.

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest Losses and Waste in Developed and Less Developed Countries: Opportunities to Improve Resource Use. *The Journal of Agricultural Science*, *149*(S1), 37–45. https://doi.org/10.1017/S0021859610000936

Hurst, W. C. (2010). *Harvest, Handling and Sanitation Commercial Tomato Production. Handbook B 1312*. Retrieved from http://extension.uga.edu/search.html?q=Harvest%2C+Handling+and+Sanitation+Commercial+Tomato+Production&refinement=publications

Idah, P. A., Ajisegiri, E. S. A., & Yisa, M. G. (2007). Fruits and Vegetables Handling and Transportation in Nigeria. In *AU Journal of Technology* (Vol. 10). Retrieved from http://www.journal.au.edu/au_techno/2007/jan07/vol10no3_article6.pdf

Iwugo, K. O., Brian, D., & Andoh, R. (2003). Aspects of Land-Based Pollutioin of An African Coastal Megacity of Lagos. *Diffuse Pollution Conference, Dublin*. Retrieved from http://www.ucd.ie/dipcon/docs/theme14/theme14_32.PDF

Izukanne, A., & Chinweota, M. (2018). Challenges of post-harvest losses among Tomato (Solanium lycopersium) farmers in Zing Local Government Area of Taraba State, Nigeria. *New York Science Journal*, *11*(3), 26–32. https://doi.org/10.7537/marsnys110318.04

Jaspreet, A., & Anita, R. (2013). Post-Harvest Food Losses Estimation -Development of Consistent Methodology. *Selected Poster Prepared for Presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting*. Retrieved from http://www.fao.org/fileadmin/templates/ess/documents/meetings_and_workshops/GS_SAC

_2013/Improving_methods_for_estimating_post_harvest_losses/Final_PHLs_Estimation_6-13-13.pdf

Kaguongo, W., Ortmann, G., Wale, E., Darroch, M., & Low, J. (2012). Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties: Evidence from an extension intervention in Nyanza and Western provinces, Kenya. *African Journal of Agricultural Reseearch*, *7*(3), 493–503. https://doi.org/10.5897/ajar11.062

Kamga, R., Kouamé, C., & Akyeampong, E. (2013). Vegetable Consumption Patterns in Yaounde, Cameroon. *African Journal of Food, Agriculture, Nutrition and Development*, *13*(2), 1–16. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=cookie,ip,shib&db=awn&AN=ajfand-87465&site=ehost-live%5Cnhttp://www.ajol.info/index.php/ajfand/article/view/87465

Kikulwe, E. M., Okurut, S., Ajambo, S., Nowakunda, K., Stoian, D., & Naziri, D. (2018). Postharvest losses and their determinants: A challenge to creating a sustainable cooking banana value chain in Uganda. *Sustainability (Switzerland)*, *10*(7), 1–19. https://doi.org/10.3390/su10072381

Kimura, S., & Sinha, N. (2008). Tomato (Solanum lycopersicum): A Model Fruit-Bearing Crop. *CSH Protocols*, *2008*(11), pdb.emo105. https://doi.org/10.1101/PDB.EMO105

Kitinoja, L. (2013). Returnable Plastic Crate (RPC) systems can reduce postharvest losses and improve earnings for fresh produce operations. *The Postharvest Education Foundation (PEF) White Paper*, *13*(01), 30. Retrieved from www.postharvest.org

Lancsar, E., & Savage, E. (2004). Deriving welfare measures from discrete choice experiments:

inconsistency between current methods and random utility and welfare theory. *Health Economics, 13*(9), 901–907. https://doi.org/10.1002/hec.870

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R., & Searchinger, T. (2013). *Reducing Food Loss and Waste*. Retrieved from http://www.worldresourcesreport.org.

Mango, N., Mapemba, L., Tchale, H., Makate, C., Dunjana, N., & Lundy, M. (2015). Comparative analysis of tomato value chain competitiveness in selected areas of Malawi and Mozambique. *Cogent Economics and Finance*, *3*(1), 1–15. https://doi.org/10.1080/23322039.2015.1088429

Masuki, K. F. G., Mutabazi, K. D., Tumbo, S. D., Rwehumbiza, F. B., Mattee, A. Z., & Hatibu, N. (2006). Determinants of Farm-level Adoption of Water Systems Innovations in Dryland Areas: The Case of Makanya Watershed in Pangani River Basin, Tanzania. *Proceedings of the East Africa Integrated River Basin Management Conference, 2006*, 330–337. Retrieved from http://www.suaire.suanet.ac.tz:8080/xmlui/handle/123456789/1656

Masuku, M. B., & Xaba, B. (2013). Factors Affecting the Productivity and Profitability of Vegetables Production in Swaziland. *Journal of Agricultural Studies, 1*(2), 37. https://doi.org/10.5296/jas.v1i2.3748

Meliko, M. O. (2012). The efficiency of small-scale agriculture in Limpopo province of South Africa. *African Journal of Agricultural Research*, *7*(12). https://doi.org/10.5897/ajar10.345

Mutayoba, V., & Ngaruko, D. (2018). Assessing Tomato Farming and Marketing Among Smallholders in High Potential Agricultural Areas of Tanzania. *International Journal of Economics, Commerce and Management*, *VI*(8), 577–590.

Naika, S., Van Lidt De Jeude, J., De Goffau, M., Hilmi, M., & Dam, B. V. (2005). *Cultivation of Tomato Production, Processing and Marketing* (Fourth Edi; B. Van Dam, Ed.). Retrieved from https://cgspace.cgiar.org/bitstream/handle/10568/52975/17-e-2005-screen.pdf?sequence=1

Natsa, R. T. (2015). *Tackling Post-harvest Losses Towards Food Security*. Retrieved from http://www.milanfoodlaw.org/wp-content/uploads/2015/11/15-11-08-Tackling-Post.pdf

NBS. (2011). *National Bureau of Statistics (NBS).* Retrieved from http://istmat.info/files/uploads/53129/annual_abstract_of_statistics_2011.pdf

NBS. (2017). *Internally Generated Revenue At State Level 2017*.

Nchinda, V. P., Ambe, T. E., Holvoet, N., Leke, W., Che, M. A., Nkwate, S. P., … Njualem, D. K. (2010). Journal of applied biosciences. In *Journal of Applied Biosciences* (Vol. 36). Retrieved from https://www.cabdirect.org/cabdirect/abstract/20113087922

NEPAD. (2016). Guidelines CAADP Country Implementation under the Malabo Declaration. *New Partnership for Africa's Development*.

Nkonya, E., Schroeder, T., & Norman, D. (1997). Factors affecting adoption of improved maize seed and fertiliser in Northern Tanzania. *Journal of Agricultural Economics*, *48*(1), 1–12. https://doi.org/10.1111/j.1477-9552.1997.tb01126.x

Nunoo, F. K. E., Asamoah, E. K., & Osei-Asare, Y. B. (2014). Economics of aquaculture production: a case study of pond and pen culture in southern Ghana. *Aquaculture Research*, *45*(4), 675–688. https://doi.org/10.1111/are.12003

Nwabeze, G. O., Erie, A. P., Ifejika, P. I., Ayanda, J. O., & Erie, G. (2013). Effectiveness of

Information Sources on Livelihood of Artisanal Fisherfolk in Inland Fishing Communities in Delta State, Nigeria. *Journal of Agricultural Extension*, *16*(1), 79–87. https://doi.org/10.4314/jae.v16i1.9

Obayelu, A. E., Arowolo, A. O., Ibrahim, S. B., & Croffie, A. Q. (2014). Economics of Fresh Tomato Marketing in Kosofe Local Government Area of Lagos State, Nigeria. *Nigerian Journal of Agricultural Economics (NJAE)*, *4*(1), 58–67. Retrieved from https://ageconsearch.umn.edu/record/267884/files/Economics of Fresh Tomato Marketing .pdf

Obayelu, A. E., Okuneyep, P. A., Shittu, A. M., Afolami, C. A., & Dipeolu, A. O. (2016). Determinants and the perceived effects of adoption of selected improved food crop technologies by smallholder farmers along the value chain in Nigeria. *Journal of Agriculture and Environment for International Development*, *110*(1), 155–172. https://doi.org/10.12895/jaeid.20161.436

Obidike, N. A. (2011). Rural farmers ' problems accessing agricultural information : a case study of Nsukka Local Government area of Enugu State , Nigeria. *Library Philosophy and Practice (e-Journal)*, *11*(1), 660. Retrieved from http://digitalcommons.unl.edu/libphilprac/660http://unllib.unl.edu/LPP/

Obuobisa-darko, E. (2015). Socio-Economic Determinants of Intensity of Adoption of Cocoa Research Innovations in Ghana. *International Journal of Africa and Asian Studies*, *12*, 29–41.

Odemero, A. F., & Okoh, R. N. (2014). *Post-Harvest Properties of Tomato and Effect on Its Marketing Efficiency*. *1*(1), 52–58.

Olaoye, O. J., Ezeri, G. N. O., Akegbejo-Samsons, Y., Awotunde, J. M., & Ojebiyi, W. G. (2017). Dynamics of the adoption of improved aquaculture technologies among fish farmers in Lagos State, Nigeria. *Croatian Journal of Fisheries*, *74*(2), 56–70. https://doi.org/10.1515/cjf-2016-0012

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I., & Daura, A. M. (2010). Assessment of Post-Harvest Challenges of Small-Scale Farm Holders of Tomatoes, Bell and Hot Pepper in some Local Government Area of Kano State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, *3*(2), 39–42. Retrieved from http://www.measurepostharvestlosses.com/sites/default/files/survtomatoeph.pdf

Olumuyiwa, B., Folorunso, B., & Richard, O. (2017). Willingness to Adopt Plastic Crate by Actors in the Tomato Value Chain in Nigeria. *The 1st All Africa Post Harvest Congress & Exhibition, Reducing Food Losses and Waste: Sustainable Solutions for Africa*, 146–147. Retrieved from https://www.cabdirect.org/cabdirect/abstract/20183237987

Omosomi, O. (2016). The Recent Tomato Crisis, Household Consumption and Disposable Incomes. *Business Day Intelligence*. Retrieved from http://www.businessdayonline.com/wp-content/uploads/2016/10/Tomato-consumer-survey.pdf

Orebiyi, J. S., Ben-Chendo, G. N., & Effiong, P. (2016). *Economics of Tomato Post-harvest Losses at Market Level in Akwa-Ibom State, Nigeria*. Retrieved from http://www.aes.ac.uk/upload_area/member_documents/Nkiru_BEN-CHENDO_ECONOMICS OF TOMATOES LOSES- BEN-CHENDO.pdf

Osuji, M. N., Ukoha, I. I., Chikezie, C., Chikaire, J. U., & Ajibola, B. O. (2016). Determinants of

Factors Affecting Net Return of Tomato Marketing in Owerri Metropolis Imo State Nigeria. *Elixir International Journal*, *91*, 38232–38235. Retrieved from www.elixirpublishers.com

Paxton, K. W., Mishra, A. K., Chintawar, S., Roberts, R. K., Larson, J. A., English, B. C., … Martin, S. W. (2011). Intensity of Precision Agriculture Technology Adoption by Cotton Producers. *Agricultural and Resource Economics Review*, *40*(1), 133–144. https://doi.org/10.1017/s1068280500004561

Rapusas, R. S., & Rolle, R. s. (2009). Management of reusable plastic crates in fresh produce supply chains- A technical guide. In *RAP Publication 2009/08*. https://doi.org/10.1145/1544012.1544048

Robinson, E. J. Z., & Kolavalli, S. L. (2010). The Case of Tomato in Ghana: Marketing. Ghana Strategy Support Program (GSSP). *International Food Policy Research Institute (IFPRI), GSSP Worki*. Retrieved from http://www.ifpri.org/themes/gssp/gssp.htm

Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). New York: The Free Press.

Rutten, M. M. (2013). What Economic Theory Tells Us about the Impacts of Reducing Food Losses and/or Waste: Implications for Research, Policy and Practice. *Agriculture and Food Security*, *2*(13). https://doi.org/10.1186/2048-7010-2-13

Segrè, A., Falasconi, L., Politano, A., & Vittuari, M. (2014). Background Paper on the Economics of Food Loss and Waste. In *Food and Agriculture Organization of the United Nations*. Retrieved from www.fao.org/publications

Sheane, R., McCosker, C., & Royston, S. (2008). *Food System Framework: A Focus on Food Sustainability*. Retrieved from https://www.ifst.org/sites/default/files/IFST Sustainable Food

System Framework.pdf

Sibomana, M. S., Workneh, T. S., & Audain, K. A. (2016). A Review of Postharvest Handling and Losses in the Fresh Tomato Supply Chain: A Focus on Sub-Saharan Africa. *Food Security*, *8*, 389–404. https://doi.org/10.1007/s12571-016-0562-1

Singh, A. S., & Masuku, M. B. (2014). Sampling Techniques and Determination of Sample Size in Applied Statistics Research: An Overview. *International Journal of Economics, Commerce and Management*, *II*(11).

Teklewold, H., Dadi, L., Yami, A., & Dana, N. (2006). Determinants of Adoption of Poultry Technology: A Double-hurdle Approach. *Livestock Research for Rural Development*, *18*(3), 1–15. Retrieved from http://www.lrrd.cipav.org.co/lrrd18/3/tekl18040.htm

Teklewold, H., Kassie, M., & Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics*, *64*(3), 597–623. https://doi.org/10.1111/1477-9552.12011

Tiamiyu, S., Usman, A., & Ugalahi, U. (2014). Adoption of On-farm and Post-harvest Rice Quality Enhancing Technologies in Nigeria. *Tropicultura*, *32*(2), 67–72.

Ugonna, C. U., Jolaoso, M. A., & Onwualu, A. P. (2015). Tomato Value Chain in Nigeria: Issues, Challenges and Strategies. *Journal of Scientific Research and Reports*, *7*(7), 501–515. https://doi.org/10.9734/JSRR/2015/16921

Underhill, S. J. R., & Kumar, S. (2014). Quantifying horticulture postharvest wastage in three municipal fruit and vegetable markets in Fiji. *International Journal of Postharvest Technology and Innovation*, *4*(2/3/4), 251. https://doi.org/10.1504/IJPTI.2014.068740

United Nations. (2016). *Transforming our World: the 2030 Agenda for Sustainable Development*.

Vella, F. (2011). Estimating and Interpreting Models with Endogenous Treatment Effects. *Journal of Business*, *17*(4), 473–478.

Wanjiku, J., Ackello-Ogutu, C., Kimenye, L. N., & Place, F. (2003). Socio-economic Factors influencing the Intensity of Use of Bio Mass Transfer in Food Crop Production in Western Kenya. *African Crop Science Conference Proceedings*, *6*, 661–667. Retrieved from http://erepository.uonbi.ac.ke/bitstream/handle/11295/49582/89.pdf?sequence=1&isAllowed=y

Weinberger, K., Genova II, C., & Acedo, A. (2008). Quantifying postharvest loss in vegetables along the supply chain in Vietnam, Cambodia and Laos. *International Journal of Postharvest Technology and Innovation*, *1*(3), 288. https://doi.org/10.1504/IJPTI.2008.021463

Wongnaa, C. A., Mensah, S. O., Ayogyam, A., Asare-Kyire, L., & Athony, Z.-K. S. (2014). Economics of Tomato Marketing in Ashanti Region, Ghana. *Russian Journal of Agricultural and Socio-Economic Sciences*, *26*(2), 3–13. https://doi.org/10.18551/rjoas.2014-02.01

Wooldridge, J. M. (2015). *Introductory Econometric: A Modern Approach* (Fifth Edit). Nelson Education.

APPENDICES

Appendix 1: Variance Inflation Factors (VIF) Results for the Multicollinearity test

Results of the Variance Inflation Factors of the Explanatory Variables in the Double-Hurdle Model

Variable	VIF	1/VIF
Profit of the trader	1.9	0.525025
Use of radio in accessing tomato trade related information	1.71	0.585467
Years of schooling	1.58	0.630977
Being a household head	1.47	0.681544
Number of market associations belonged to	1.46	0.685898
Age of the trader	1.43	0.697547
Use of television in accessing information	1.41	0.708029
Perception towards RPC in reducing losses	1.36	0.736322
Household size	1.28	0.781872
Perception of traders towards RPCs	1.23	0.812785
Access to credit services	1.19	0.843728
Number of decision makers in the tomato trade	1.13	0.883678
Exposure to training programs related to the tomato trade	1.08	0.926992
Number of income sources	1.05	0.948378
Mean VIF	**1.38**	

Field Survey, 2019

Results of the Variance Inflation Factors of the Explanatory Variables in the Endogenous Treatment Regression Model

Variable	VIF	1/VIF
Log of monthly expense of the traders	1.37	0.731261
Years of schooling	1.35	0.742542
Years of learning the tomato trade	1.20	0.833926
Number of decision makers	1.20	0.835752
Intensity of media usage in accessing information	1.18	0.849669
Sex of the trader	1.12	0.890145
Number of income sources	1.04	0.962755
Mean VIF	**1.21**	

Field Survey, 2019

NB: There was no multi-collinearity as VIF for all explanatory variables are below five (5)

Appendix 2: Correlation Matrix for the Multicollinearity test

Correlation Matrix for the Explanatory Variables used in the Endogenous Treatment Model

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Sex of the trader (a)	1.0000						
Years schooling (b)	0.1503	1.0000					
Number of income sources (c)	0.0224	0.0090	1.0000				
Years of learning tomato trade (d)	0.1294	-0.1779	0.0905	1.0000			
Log of monthly expense (e)	0.2450	0.4151	0.0685	0.1748	1.0000		
Intensity of media use (f)	-0.0097	0.0141	0.1336	0.1942	-0.0336	1.0000	
Number of decision makers (g)	0.2190	0.1508	-0.0457	0.1236	0.1337	0.2949	1.0000

Field Survey, 2019

Variable	**Code**
Age of the trader	(1)
Household size	(2)
Number of income sources	(3)
Number of market associations belonged to	(4)
Years of schooling	(5)
Use of radio in accessing tomato trade-related information	(6)
Perceptions of traders towards RPCs	(7)
Use of television in accessing information related to the tomato trade	(8)
Profit of the trader	(9)
Exposure to training programs related to the tomato trade	(10)
Perceptions towards RPC in reducing losses	(11)
Number of decision-makers in the tomato trade	(12)
Being a household head	(13)
Access to credit services	(14)

Correlation Matrix for the Explanatory Variables used in the Double-Hurdle Model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	1.0000							
(2)	0.4012	1.0000						
(3)	0.0843	-0.0257	1.0000					
(4)	-0.0128	0.0090	0.0048	1.0000				
(5)	-0.2372	-0.1610	0.0183	-0.2127	1.0000			
(6)	-0.0431	0.0146	0.0803	0.3609	-0.4299	1.0000		
(7)	0.0758	-0.0735	-0.0007	-0.2529	0.2434	-0.2706	1.0000	
(8)	0.0946	-0.0307	0.1272	0.2169	0.2430	-0.1031	0.0644	1.0000
(9)	-0.1618	-0.0409	-0.0236	0.4039	-0.3106	0.5190	-0.3583	-0.0876
(10)	-0.1419	-0.0306	-0.0244	-0.0019	0.0870	-0.0161	-0.0608	0.0258
(11)	0.1310	-0.0646	0.0638	-0.1283	0.0796	0.0263	0.0985	-0.0084
(12)	0.0305	0.0183	-0.0457	0.1158	0.1581	-0.0778	0.0436	0.2689
(13)	0.0034	0.1164	-0.0781	0.0130	-0.2738	0.2544	-0.2252	-0.3450
(14)	-0.0278	0.1178	-0.0022	0.1979	0.0720	0.0041	-0.0367	0.2029

	(9)	(10)	(11)	(12)	(13)	(14)
(9)	1.0000					
(10)	0.0244	1.0000				
(11)	-0.2605	-0.1659	1.0000			
(12)	-0.0068	-0.0277	-0.0037	1.0000		
(13)	0.2958	0.0687	0.1601	-0.1269	1.0000	
(14)	0.0239	0.0826	-0.1978	0.1731	0.0157	1.0000

Field Survey, 2019

Appendix 3: Diagram of the Returnable Plastic Crates in the Fresh Tomato Market

Appendix 4: Questionnaire

University of Nairobi
Department of Agricultural and Applied Economics

Topic: Factors influencing Adoption and Profitability of Returnable Plastic Crates as a Food Loss Reducing Technology among Fresh Tomato Traders in Lagos State, Nigeria

Survey Questionnaire, February 2019

Thank you for giving us an opportunity to speak to you. We are researchers from the University of Nairobi, Kenya. The reason for conducting this field survey is to get some insights on Returnable Plastic Crates (RPCs) and how it affects profits in the sale of fresh tomatoes in Lagos state. You have been randomly selected to participate in this study, and your voluntary participation in answering these questions is highly appreciated. Your responses will be analyzed and the findings will be used to inform policy on better strategies for improving the use of RPCs in tomato distribution and marketing. All the information obtained will be treated with utmost confidentiality and will only be used for the purpose of this survey, which is strictly academic. This interview will take approximately **ONE HOUR** to complete. Please note that your participation in this study is purely voluntary. You can decide to withdraw anytime or not answer any question you do not want to. In case you decline/withdraw, your lack of participation will not have any negative consequence on you. **We would, however, be very grateful if you can answer every question and complete the interview**. Your name or contact will not be revealed or reported. **Only traders involved in the distribution and sale of fresh tomatoes in Lagos State was interviewed.** I request your permission to start now. For any further clarification, please contact Crystal on +2348132866106 or crystalaghadi@gmail.com.

SECTION A: GENERAL INFORMATION

1.	Enumerator's Code:	2.	Date (DD-MM-YYYY): / /
3.	Questionnaire number:	4.	Respondent's contact:
5.	Respondent's Name:	6.	Name of LGA:
7.	State of Residence:	8.	Name of city/village/area:
9.	GPS Location:		

SECTION B: SOCIO-ECONOMIC CHARACTERISTICS

10. What is your position in the supply chain: Off-loaders =1 Wholesaler=2 Retailer=3 Others=4, if others please specify_____
11. Is dealing in tomatoes your principal (number one) occupation? No = 1, Yes =2
12. What is your gender? Male = 1 Female = 2
13. What year were you born? _____(years)
14. How many years of formal education have your received? _____ (years)
15. How many sources of income do you have?
16. What is/are your source(s) of monthly income? Paid salary = 1, Petty trade = 2, Remittances = 3, Gifts = 4, Others = 5, please specify _____
17. About how much do you spend monthly?
18. What is your total average monthly income? _____(Naira)
19. How many years have you been in the tomato business? _____(years)
20. How long (in years) have you stayed in your current location?
21. For how many years have you been learning about the tomato business?
22. What is your marital status? Single = 1, Married = 2, Widowed = 3, Divorced/Separated = 4, Others = 5, please specify ___
23. Who is the head of the household? Myself = 1, Nuclear family member = 2, Extended family member = 3
    a. Please specify the exact relationship. Husband = 1, Wife = 2, Father = 3, Mother = 4, Son = 5, Daughter = 6, Sister = 7, Brother = 8, others, please specify _____
24. How much does your income contribute to the total household expenses? All of the expenses = 1, Very high amount = 2, High amount = 3, Half of the expenses = 4, Low amount = 5, Very Low amount = 6, None =7
25. To what extent do you influence the decisions taken in the household? Sole influence = 1, Very high influence = 2, High influence = 3, Average = 4, Low influence = 5, Very low influence = 6, No influence = 7
26. How many people live in the house? _____
27. How many people do you have to feed from your income?
28. How many people in the house has received formal education up to the University level?

29. What is the highest level of education of the household members?
30. Does the sale/distribution of tomatoes yield the highest amount of your income? No = 1 Yes = 2
31. On a scale of 1-10, how much does tomatoes business contribute to your total income? _____
32. Apart from tomato, do you distribute or sell other fresh produce that spoils easily within a week if not handled properly like tomatoes? No = 1 Yes = 2. If your answer was yes, please list the other fresh produce you sell/distribute _____
33. Do you distribute or sell any other produce that can last more than a week without spoiling? No = 1, Yes = 2
    a. If your answer was yes, please list the other types of produce you sell/distribute _____
34. On a scale of 1-10, please state how much priority you give to tomatoes as a produce you sell or distribute. 1 being the lowest priority and 10 being the highest priority? _____
35. Do you engage in any other income earning activities asides the sale of tomatoes (and/or any other produce)? No = 1 Yes = 2
    a. If your answer was yes, please list them and how much you earn from them_____
36. How many people contribute to making decisions in your tomato business?
37. Please list other people that influence your decisions and their years of formal education _____
38. How many formal or informal training or sensitization of any sort have you received on tomato packaging and/or marketing? If none, please write zero (0). Please give details of the training you received on the paper provided
39. How many market association do you belong to? If none, please write zero (0) otherwise write the details on the paper provided.
40. Do you belong to any other external group or association that affects your decisions on the sale of tomatoes? No = 1, Yes = 2
    a. If your answer is yes, please give details in the sheet provided
41. What motivated you to enter into the tomato business? Profitability = 1, Peer influence = 2, Family business = 3, Others = 4, please specify _____
42. What was your major source of initial capital? Bank loan = 1, Personal savings = 2, Family and Friends = 3, Informal loan = 4, others = 5, please specify _____
43. What is your major source of finance in sustaining the business? Personal savings = 1, Salary = 2, Formal loan = 3, Informal loan = 4, Ploughed back profit, Gift = 5, Others = 6, please specify _____
44. Do you have access to credit when you need them? No = 1, Yes = 2, if yes, please your possible sources _____

45. Have you ever accessed any loan or credit for your business? No = 1, Yes = 2, if yes, please specify _____
46. Do you have access to media (TV, radio and newspaper), internet and other online platforms? No = 1, Yes = 2. If Yes, please give more details in the sheet provided.

SECTION C: TOMATO SALE AND PROFITABILITY

In this section, I will be asking about your sales and costs for the past year divided into the peak and lean seasons in the year

47. What is the source of your tomato supply? Self-producing = 1, Purchase = 2, Others = 3, please specify _____
48. How many times on average do you make purchases or harvest in a month during the peak season?
49. How many times on average do you make purchases or harvest in a month during the lean season?
50. What is the average number of baskets or crates you buy/bring per purchase or harvest made in the peak season?
51. What is the average number of baskets or crates you buy/bring per purchase or harvest made in the lean season?
52. How many baskets or crate are spoilt and unmarketable in each purchase or harvest made?
53. How many days does it take to sell each purchase or harvest of tomatoes made or produced?
54. Who are your major suppliers? Farmers = 1, Wholesalers = 2, Importers = 3, Retailers = 4, Self = 5, Others = 6, please specify___
55. What is the mode of payment during purchase? Cash = 1, Bank transfer = 2, Cheque payment = 3, Others = 3, please specify __
56. What is the method of payment during purchase/supply? Payment on delivery = 1, Advance payment = 2, Installment payment plan= 3, Payment through an association = 4, No payment = 5, Others = 5, please specify _____
57. What unit of measurement is used during purchase or harvest? Please give details in the sheet provided
58. If your source of tomatoes is self-produced, at what stage do you harvest your tomatoes? Fully ripened = 1, Partially ripened = 2, Others = 3, please specify _____
59. What is the nature of your market? Roofed shop = 1, Open space = 2, Under tree shade = 3, Thatched shop = 4, Others = 5, please specify _____
60. Who are your major buyers? Wholesalers = 1, Retailers = 2, Consumers = 3, Processor = 4, Others = 5, please specify _____
61. How many containers or unit of measurements do you make use of during sale? Please give more details in the sheet provided.
62. What is the mode of payment during sale? Cash = 1, Bank payment = 2, Others = 3, please specify ____

63. What is the method of payment during sale? Payment on delivery = 1, Advance payment = 2, Payment through association = 3, Payment on installments = 4, Others = 6, please specify_
64. What type of tomatoes do you sell? Fresh = 1, Dried = 2, Both = 3, Others = 4, please specify _____
65. Are there any barriers to entry into the tomato market? No = 1, Yes = 2. If yes, please specify _____
66. Are there any barriers towards leaving the tomato market? No = 1, Yes = 2. If yes, please specify _____
67. How many days in a week do you sell? _____ (days)
68. For how many hours on average do you sell daily? _____ (hours)
69. At what time of the day do you buy or harvest your tomatoes?
70. What mechanism is used for price determination in the market? Fixed price = 1, Bargaining = 2, Set price by market associations = 3, Others = 4, please specify _____
71. What is your mode of transportation for transporting the tomatoes? Truck = 1, Car = 2, Motorcycle = 3, Keke napep = 4, Bicycle = 5, Wheel barrow = 6, Others = 7, please specify _____
72. How long in hours does the tomato have to travel with your current mode of transportation? _____ (hours)
73. How many baskets/crates/kg does the mode of transport carry? _____
74. Where do you purchase your tomatoes from?
75. Where do you sell it?
76. What variety of tomatoes do you buy/cultivate? _____
77. How many years ago did you start doing the tomato business?
78. What was the initial start-up capital used in the business? _____

SECTION D: USE OF RPCs AND OTHER CONTAINERS

79. Are you responsible for purchasing the packaging material used for the tomatoes? No =, Yes = 2
    a. If yes to question (55), where do you buy the packaging materials from? Please specify _____
80. What do you use in packaging your fresh tomatoes? Baskets = 1, Crates = 2, Nylon = 3, Buckets = 4, No packaging = 5, Others = 6, please specify _____

81. What is the average weight of the packaging container when it is fully packed with tomatoes? _____ (kg)
82. How many of the packaging containers are transported at once according to your mode of transport? _____
83. Can your current packaging container be re-used? No = 1, Yes = 2
    b. If Yes to question (60), how many times can it be re-used on average? _____
    c. If Yes to question (60), how often do you clean it? Daily = 1, Three times a week = 2, Twice a week = 3, Weekly = 4, Occasionally = 5, Others = 6, please specify _____
    d. If Yes to question (60), how often do you spend money on maintenance of the packaging container? Daily = 1, Three times a week = 2, Twice a week = 3, Weekly = 4, Occasionally = 5, Others = 6, please specify _____
84. Are there any other cost associated with the use of your packaging container apart from the cost of purchase, sanitization and maintenance? No = 1, Yes = 2. If Yes, please state the costs involved _____
85. What is the reason for your current choice of packaging container? Used widely = 1, Ease of use = 2, Efficient in reducing losses = 3, Ease of carriage = 4, Reduced cost = 5, Easily accessible = 6, Others = 7. Please specify _____
86. What was the source of information on the use of your current packaging material? Co-trader = 1, Radio = 2, Social media = 3, Family and friends = 4, Training programme = 5, Others = 6, please specify _____
87. How efficient would you say your current packaging containers are in reducing losses? Very efficient = 1, Efficient = 2, Neutral = 3, Inefficient = 4, Very inefficient = 5
88. How many tomatoes can be contained inside your current packaging containers? _____
89. Are you aware of the existence and use of Returnable Plastic Crates (RPCs) for tomato packaging? No = 1, Yes = 2
90. Have you at any time made use of the RPC for packaging tomatoes? No = 1, Yes =2
91. Did you receive any training or awareness on the use of RPC by anyone? No =1, Yes = 2
92. Do you know of any distributor or seller of RPC? No = 1, Yes = 2
93. Do you currently make use of Returnable Plastic Crates for packaging your tomatoes? No = 1, Yes = 2
    e. If No to question (69), why? High cost of PRC = 1, Difference in unit of measurement = 2, Unavailability = 3, Reduced carriage quantity = 4, Others = 5, please specify _____
94. If Yes to question (69), please answer the following questions [(a) – (e)]

f. Do you use RPCs to package **ALL** your tomato produce? No = 1, Yes = 2

g. How many plastic crates do you make use of? _____

h. When did you start making use of the RPCs? _____ (years)

i. What motivated you to start using RPCs? Co-traders = 1, Family/Friends = 2, Others = 3, please specify _____

j. What is the unit cost of the plastic crate you purchase _____

95. Do you make use of the RPC for packaging of any other produce on sale? No =1, Yes = 2

k. If yes to question (71), please specify _____

96. Are there any traders around you making use of RPC? No = 1, Yes = 2

97. What do you do to the damaged tomatoes? Sell at reduced cost = 1, Sell at the same price = 2, Dispose = 3, Others = 4, please specify _____

Please tick the extent to which you agree with the following statements on the Returnable Plastic Crates

No.	**Characteristics of the RPC**	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
1.	The use of RPC as a tomato packaging containers is widely known					
2.	Do you agree that the RPCs are widely available					
3.	The plastic crates are affordable to tomatoes traders					
4.	The use of RPC reduces postharvest losses in tomatoes compared to the use of woven baskets					
5.	It is more profitable to make use of the RPC					
6.	Buyers purchase more from those sell with RPCs					
7.	The use of RPCs are more hygienic					
8.	It is easier to carry the tomatoes with the use of RPCs					
9.	RPC makes transportation of tomatoes easier					
10.	RPCs can re-used (used more than once)					

SECTION E

Name _____ Questionnaire number _____ Enumerator code _____ Market _____

Training or Sensitization received on tomato marketing or packaging

Name of the training/sensitization	Organizers/Sponsors	Purpose of the training	Duration	Benefit

Groups/Association that influence the tomato marketing

Name of group/association	Monthly payments to the group	Date of entrance into the group?	Benefits of being a member of the group	Requirements in being a group member
Tomato Sellers Association				

Media Access

Type of Media/Online Platform	Do you have access to it? No = 1 Yes = 2	Frequency of use (Number of times monthly)	Has it been of any help to you in your tomato business? No = 1, Yes = 2	How many times per week do you receive information of any sort related to your tomato business? If none, please write zero	What is it mostly used for?	How much do you pay for maintenance or use monthly? (₦)
TV						
Radio						
Newspaper						
Whatsapp						
Facebook						
Blogs						
Youtube						
Others _____						

Unit of measurement used during sale/purchase of tomatoes

Tomato packaging/sale container or Unit of measurement	**Do you make use of this container during sale? No=1 Yes = 2**	**How many tomatoes on average can this container carry?**	**How many of this container do you have?**	**How much is this container sold for when packed with tomatoes? (₦)**	**How long does this container last in days, months or years, please specify the unit**	**How many times can it be re-used?**	**What is this container mostly used for? (A)**	**When using this container, how much of the tomatoes are lost or condemned?**	**On a scale of 1-10, please state your level of preference for this container in comparison to others. 1 being the least preferred and 10 as the most preferred**
1.Basket				Peak: Lean:					
2. Plastic Crates									

3.Bucket									
4.Plate									

Uses of the container: Packaging = 1, Sale = 2, Purchase = 3, Storage = 4, Display = 5, Others = 6. Please specify above in the 8th column labeled (A)

Tomato Business Loan in the past one year

Type of loan collected	Total amount of loan (₦)	Duration of payment (years)	Interest rate (%)	Frequency of payment	Installment amount paid (₦)	Purpose of loan

Costs associated with tomato farmers

	Associated Costs for Farmers of Fresh Tomato				
No	**Description**	**Period (B)**	**Unit Cost (₦)**	**Number of times per planting season**	**Total Cost (₦)**
98.	Cost of land purchase or land-lease				
99.	Cost of labor involved in nursery preparation and maintenance				
100.	Cost of seedlings				
101.	Cost of labor in land preparation				
102.	Cost of labour in transplanting				
103.	Cost of manure and fertilizer				
104.	Cost of harvesting and other related costs				

105.	Cost of transportation to the farm				
106.	Others, please specify _____				

	Associated Costs for Traders of Fresh Tomato				
No	**Description**	**Unit/ Period**	**Unit Cost per period (₦)**	**Number of times paid per year**	**Total Cost (₦)**
1.	Interest rate on borrowed money				
2.	Cost of Packaging material				
3.	Transportation of Tomatoes				
4.	Labour charges for the loading/offloading from the truck				
5.	Labor cost for sanitization				
6.	Commission agent fee				
7.	Tax and other charges				
8.	Maintenance cost of the packaging material				
9.	Others, please specify				
10.	Others, please specify				
11.	Others, please specify				

Tomato supply or purchase	**Type of container used**	**Price per container (₦)**	**Number of containers purchased per month**	**Number of containers purchased per season**	**Average Total cost per season**

During peak season					
During lean season					
Total					

Tomato sales	**Type of container used**	**Average Price sold per container (~~₦~~)**	**Number of containers sold each month**	**Number of containers sold each season**	**Total tomato sold per year**
During peak season					
During lean season					
Total					

Tomato losses	**Type of container used**	**Amount of losses per container**	**Value of tomato losses per container**	**Amount of losses in each batch bought**	**Number of batches bought per season**	**Total tomato sold per year**

During peak season						
During lean season						

Mode of transportation for the fresh tomatoes

Mode of transport	**How many containers filled with tomatoes can it carry? Please specify the container**	**Is it owned by you? No = 1, Yes = 2**	**How long in hours does the tomato travel with this mode of transport?**	**How much is wasted and unmarketable with this mode of transport?**	**How much do you pay for fueling, renting, transport or maintenance with this mode of transportation weekly?**
Truck					
Car					
Keke napep					
Motorcycle					
Bicycle					
Wheel barrow					