UNIVERSITY OF CAPE COAST

ANALYSIS OF OUTPUT PRICE RISK OF CASSAVA IN THE VOLTA REGION OF GHANA

GODFRED ANAKPO

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BY

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Thesis submitted to the Department of Agricultural Economics and Extension of the School of Agriculture, University of Cape Coast in partial fulfilment of the requirements for award of Master of Philosophy Degree in Agricultural Economics.

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Name: Godfred Anakpo

Signature... Date:...

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Name: Dr. Henry De-Graft Acquah

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ABSTRACT

Output price risk has been a perennial challenge to cassava farmers due to their inability to foresee and quantify the level of risk associated with the price of their produce. It was against this background that the study analysed output price risk of cassava in the Volta region of Ghana. Primary data were collected from 500 sampled cassava farmers using structured interview schedule and analysed using descriptive statistics whilst secondary data were analysed using procedures such as historical value-at-risk, cointegration and standard regression analysis.

The results indicated that Cassava price increases significantly over times with high level of volatility between each period. Additionally, cassava farmers face the risk of losing Gh¢1.35 per 91kg at 95% confidence level, representing about 31% (Gh¢179millions) of their annual revenues Inflation and exchange rate significantly determine the price of cassava while cassava yield, inflation and exchange rate are significant determinants of cassava price volatility. Crop diversification, off-farm business, varying harvesting time, and reduce farm size were the major risk management strategies used by the farmers in the study area while lack of readily available market, poor processing facilities, land tenure system, insufficient fund, and imperfect information regarding price changes were the major constraints facing farmers' in adapting to output price risk. Based on the finding of the study, it is recommended that policies stabilizing inflation, exchange rate, establishment of price controls, designing output risk insurance, and training farmers in value addition will help address the challenge.

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DEDICATION

To My Family.

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CHAPTER ONE

INTRODUCTION

Background to the Study

Risk analysis in agriculture remains a major topical issue among farmers, investors, government and other key players in every sector along the agricultural chain. This is obvious considering that agricultural activity is subject to a wide range of risks due to the changing economic and biophysical environment in which farming operates. These risks include production risk, financial risk, social risk, currency risk, market risk among others, which greatly affect all the players in this endeavour. While some of these sources of risk are faced in common with other industries, many are specific to agriculture. Their presence affects production choices - with implications for the overall economic efficiency of agricultural production (Aizeman & Pinto, 2005). Furthermore, where the realisation of the risks leads to falls in farm incomes, they can adversely affect the economic welfare of those working in agriculture, with the potential to constrain future investment and growth of farm businesses (Scottish Government Rural and Environment Analytical Services [SGRE], 2010).

Ghana, being prone to a lot of environmental inconsistencies, is not left behind in taking its share of the menace of agricultural risks including the challenge of realising the Millennium Development Goals (MDGs), most especially (a) reducing the number of people living under food insecurity in

Ghana by half in 2015, (b) breaking the circle of poverty which engulfs over 28% of its population and (c) achieving increased food production to meet 2.5% population growth rate (Bentil , Bright, Franklin, & Simons, 2009).

Risk, which investment economists generally describe as the variation from expected outcomes due to imperfect knowledge of investor in decision making, is more inherent and intensive in agriculture than non-agricultural industries (Kuyrah, Obare, Herrero, & Waishaka, 2006; Odii, 1998). A perfect knowledge occurs when the cause (action) and results are known with certainty. Most economic analyses assume a perfect knowledge which is more theoretical than real. An imperfect knowledge situation, however, occurs when the decision-maker (farmer) is not very sure of the result(s) of the action to be taken. A situation of imperfect knowledge is most prominent in output prices of agricultural commodities especially the perishable produce thus exposing them to output price risk (Ndugbu, 2003).

Cassava (*Manihot esculenta Crantz*) is one of the most widely consumed and important food crops in the world in general and Ghana in particular that suffers much from output price risk (Nweke, Dunstan, & Lynam, 2001). According to International Fund for Agricultural Development [IFAD], (2004), about 600 million people in Africa, Asia and Latin America depend on the cassava crop for their food and incomes. In Ghana, over 90% of farming population produces cassava, resulting in the average annual production of cassava of 12million metric tonnes. According to Nti and Sackitey (2010) and Owusu (2011), cassava constitutes about 22% share of agriculture's contribution in Ghana's Gross Domestic Product (GDP) thus indicating the significant role of cassava in Ghana's economy.

Moreover, the output price risk of this commodity which manifest itself in output price volatility keeps the farmers in their perennial poverty and threatens food security in the country. Food security according to the Food and Agriculture Sector Development Policy [FASDEP II], (2009), is the "availability of good quality nutritious food, hygienically packaged and attractively presented, available in sufficient quantities all year round and located at the appropriate places at affordable prices". It is important to note that the availability of food depends on the production which is a function of output price of the commodities; a situation that makes output price risk analysis an important agricultural phenomenon. The extent at which markets make food available and affordable depends on output prices. If farmers, as a result of output price risk decide to reduce the size of the cassava farms or stop its production, the food security status deteriorates.

It is however, important to note that the level of output price risk has not been quantified to enable farmers, investors, and other interested players in their investment and risk management decision making against possible losses. Nto, Mbanasor, and Nwaru (2011) pointed out that assessing output price risk of agricultural commodities is a key road map to risk remediation and management culminating in food security in general. These key drivers have led to the conception of this study which seeks to analyse output price risk of cassava in terms of its measurement, determinants and risk reducing strategies in the study area.

Statement of the Problem

Agricultural activity is subject to a wide range of risks due to the variable economic and biophysical environment in which farming operates. The impact of risk has not spared cassava farmers (about 90% of farming population in Ghana grows cassava) who suffer the menace of output price risk. Volta region is one of the leading producers of cassava in Ghana (Ministry of Food and Agriculture [MoFA], 2011). It was ranked among the top 5 cassava producing regions in Ghana (Angelucci, 2013). Empirical work revealed that cassava farmers in this region are greatly affected by output price risk due to their inability to foresee the level of risk associated with the price of their commodity (Ndugbu, 2003). However, the amount of output price risk associated with this crop (cassava) has not been quantified to trigger preparedness and informed decision making in risk remediation and management against possible loss by farmers and other investors in the area.

Moreover, the fluctuating trend of agricultural performance in Ghana's GDP from about 48% to about 22.8% between 2002 and 2012 is partly attributed to the impact of output price risk of cassava (Nti & Sackitey 2010). The impact results from the imperfect knowledge on the level of risk associated with it to inform risk aversion approach.

A review of the existing literature reveals a paucity of empirical work done to quantify this risk and provide a sound knowledge in this area. These backgrounds have triggered the conception of the study to provide sound quantitative measure of output price risk of cassava and offer policy recommendation to counter the losses in the Volta region of Ghana.

Objectives of the Study

The general objective of the study is to analyse the output price risk of cassava in the Volta Region of Ghana. The following are the specific objectives:

1. Examine the output price trend and volatility of cassava in the study area.
2. Estimate the level of risk (value-at-risk) associated with cassava price.
3. Examine the determinants of output price and its volatility of cassava in the study area.
4. Examine the risk reducing strategies employed by farmers in response to output price risk of cassava in the study area.
5. Describe the constraints to the adoption of risk management strategies.

Research Questions

1. What is the trend and level of volatility of output price of cassava in the study area?
2. What is the level of risk (value-at-risk), associated with cassava prices?
3. What are the determinants of output price and volatility of cassava in the study area?
4. What are the risks reducing strategies adopted by farmers against output price risk?
5. What constraints do farmers face in their adoption of these risk management strategies?

Significant of the Study

The findings from this study, especially, on the magnitude of output price risk, and its possible determinants will provide a comprehensive road map for policy framework to MoFA especially in the areas of improving, stabilising the price system and strengthening farmers' capacity of risk management. This will help in achieving the objective of output price risk management as enshrined in the Medium Term Agricultural Sector Investment Plan (METASIP). Furthermore, the findings from this study, through dissemination, will greatly help the farmers to foreknow the possible losses and price variability resulting from output price risk so as to remediate its occurrence. Additionally, the findings from the study will be a useful ingredient to potential investors and other stakeholders in agricultural investment decision making. Moreover, it will add to the existing literature and will therefore serve as reference material for further research.

Delimitation of the Study

The study is focused on the analysis of output price risk of cassava in terms of the behaviour of price and volatility, the level of output price risk, determinants of output price and volatility, farmers' management strategies and constraints. There are several statistical apparatus used to estimate the level of output price risk. Some of these are historical simulation method, Monte Carlo simulation, extreme value theory and variance-covariance methods. This study however, employed the use of historical simulation method for estimating the level of risk using different model specifications and regression analysis and error correction model for price and volatility determinants based on preliminary analysis.

Limitations of the Study

Most empirical studies have estimated the level of output price (value-at-risk) from daily and weekly data. For instance, (Manfredo & Leuthold, 2001; Hawes, 2003) used weekly data in risk measurement. However, data on the above series could not be obtained and therefore the level of risk associated with cassava price on weekly basis could not be estimated. For this reason, monthly data was used for the estimation of output price risk in terms of value-at-risk. Also, some variables with joint effects such as weather do not have complete set of data for analysis in examining the determinant of output price and its volatility. For instance, solar radiations are not considered because of data challenges. Other determinants such as global economic activities, speculations and so forth are not considered in the analysis due to data limitations or estimation problems.

Variables of the Study

The study seeks to analyse output price risk of cassava by way of measuring the possible losses and factors that account for price and price volatility, risk strategies farmers employ to remediate and manage the risk and the constraints encountered. The variables include; monthly prices (time series from 1970 to 2012) of cassava for examining the trend and volatility and risk estimation; time series data of production volume, inflation, interest rate, exchange rate, and weather (temperature and rainfall) as these potentially determine output price and volatility (International Monetary Fund [IMF] 2008). These data were also taken from 1970 to 2012; socio-demographic characteristics such as age, sex, marital status, educational level, years of experience and farm size; risk management strategies as well constraints are also described using cross sectional data.

Organization of the Study

The study is divided into five major chapters. Chapter one envelops the background of agricultural risk with more highlights on output price risk. It introduces the problem statement, study objectives, research questions and justification of the study. Chapter two presents survey and review of theoretical and conceptual issues of agricultural risk. This chapter reviews agricultural risk, studies that estimate agricultural output price risk and highlight the methods employed and key results from these studies. Determinants of agricultural output price and price volatility, risk reducing and management strategies and constraints are also highlighted in this chapter. Major methodological approaches to output price risk analysis and determinants are also presented and reviewed. Chapter three defines the research designs, data needs and sources, population, sampling procedure and sample size, instrumentation and data collection as well as the statistical tools for approaching the problem. Presentation and discussion of results are captured in chapter four. Chapter five concludes the study and highlights some policy and methodological implications for output price risk analysis.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This chapter presents a review of relevant literature on the major conceptual and theoretical issues related to risk and uncertainty, agricultural risk, output price risk measurement, determinants of output price and volatility, management strategies of output price risk and constraints to risk management. Thus stationarity, cointegration, error correction models and autoregressive distributed lag were also reviewed.

Risk and Uncertainty

There are many different definitions of risk and uncertainty. According to Knight (1921), a situation with more than one possible outcome is risky if there is previous information available to the decision-maker about the probability of outcomes of the decision made. In contrast, a situation is uncertain if the decision maker does not have previous information that allows him or her to assign probabilities to the possible outcomes (Knight, 1921). Some researchers, for example Fleisher (1990), considered risk and uncertainty to be different concepts. She stated that risk is a situation that will affect the well-being of the decision-maker and that involves the chance of gain or loss, whereas uncertainty exists when the decision-maker does not know the outcome of every action because at least one action has more than one possible consequence.

Risk is also defined as a "piece of information" about a frequency distribution (Roumasset, 1979). This "piece of information", together with the expected value of the probability distribution, will serve to determine the risk involved in an action choice (Roumasset, 1979; Kohl & Uhl, 1998). For some authors, this "piece of information" is a measure of variability of outcomes and it can be expressed as variance, standard deviation or coefficient of variation of the probability distribution. In this study, risk will be defined as variability of possible outcomes (Nartea, 1994).

The Nature of Agricultural Risk

There are many reasons for the unpredictability of yields and prices in agriculture. For example, yields depend on factors such as biological processes and weather that are beyond the farmers' control. In addition, agricultural prices are determined in markets commonly dominated by perfect competition (Fleisher, 1990; Kohl, & Uhl, 1998). In perfectly competitive markets, there is no differentiation among products and there are many small suppliers (Kohl, & Uhl, 1998). Consequently, farmers do not have any influence on prices, which are affected by fluctuations in demand and market instability. Moreover, because the price elasticity of the demand curve for agricultural products is quite flat in comparison with other non-agricultural products, any variation in the quantity demanded significantly affects the output price (Barry, 1984). Another consequence of the fragmentation of the agricultural supply is that farmers do not have power in negotiating input prices (Fleisher, 1990). Fluctuations in input prices introduce variability in costs of production, thus representing a further source of risk.

Risk in agriculture reflects the nature of most farm production systems, which are influenced by ever-changing economic and biophysical conditions. The natural lag between when production decisions are made and when returns to farming can be realised exposes agricultural enterprises to the variability of a range of factors that determine the value of production (Fleisher, 1990; Kohl, & Uhl, 1998). These include weather, animal and plant health, changes in agricultural markets and a range of macroeconomic factors. Variability in these factors results in risk over key determinants of farm income like output price, yield, and input costs - with implications for farmers' economic welfare and effects on the economic (allocative) and technical efficiency of farm production (Aizeman & Pinto, 2005; SGRE, 2010).

Agricultural Risk and Cassava Producers

Cassava production, as with any other production activity in agriculture, is risky. Firstly, cassava production is a biological process, so its output cannot be predicted with certainty. The biological nature of cassava which allows it to go through the natural production cycle exposes the plant to series of risky variables. For instance, some crop diseases are associated with the production cycle thereby exposing it to production risk.

Secondly, cassava yield depends, in part, on the weather. In the long term, climate change is an additional source of yield risk through its effects on weather patterns (changing temperature and rainfall patterns, and potentially generating extreme weather events, etc.) – an effect which is still highly uncertain (Organisation for Economic Co-operation and Development

[OECD], 2008). It is projected, however, that changing climate may also result in the introduction and increased frequency of pests and diseases, heightening crop related risks.

Thirdly, the cassava producer neither knows the product price in advance nor is able to affect the price. The cassava market has all the characteristics of being perfectly competitive in that there are many cassava sellers with no single seller having a significant influence on the market. This therefore exposes the price to output price risk due to supply-demand behaviour. This is because the fragmentation of cassava supply weakens the cassava farmers' power for negotiating better prices for their produce, and input prices (Kay & Edwards, 1994).

Sources of Agricultural Risk

Risks can be categorised as being either business risks or financial risks (Gabriel & Baker, 1980). The sources of business risk for agriculture can be identified from an analysis of each of the major dimensions of the external environment. The four major environmental dimensions commonly identified are climatic, social, political and economic (Eidman, 1994). Each of these dimensions includes one or more important source of risk for an agricultural producer. These risks can be classified as production, institutional, human or personal, technological, and market risks, (Hardaker, Huime, & Anderson, 1997; Sonka & Patrick, 1984).

Production risk is the random variability inherent in a farm's production process.Production risks are those caused by variations in weather, climate and by diseases and pests (Lee, Boehlje, Nelson, & Murray, 1988).

Fire, flood, wind and casualties which can also be classified as casualty risks, comprise other sources of production risk (Sonka & Patrick, 1984). These variables impact on crop yields and livestock production indices. Yield variability is greatly influenced by weather and other factors such as pests and diseases. As a result, the amount and quality of the output that will result from a given bundle of production decisions are not known with certainty. The yield variability of a specific commodity can differ widely over a geographic area and over time, which expose agricultural crops to production risk.

Although some policy interventions in the agricultural sector are often intended to reduce the level of risk faced by farmers, the policy interventions themselves can be a significant source of risk. This is because it is often difficult to foresee changes in government policies, particularly where decisions are influenced by social and political considerations (Gabriel & Baker, 1980). Government policies include price and income support programmes, as well as tax, trade, credit and environment policies. Unanticipated changes in these policies are important sources of risk for agricultural producers (Sonka & Patrick, 1984).

Human or personal risks are those related to the labour and management function. These risks are related to major life crises, health problems of the farm manager and/or his family, or carelessness by the farmer or farm workers (Hardaker *et al.,* 1997). Changing objectives of individuals and family members also form a source of risk. The existences of these types of risks have contributed to the mechanisation of agriculture, since machine inputs are considered more reliable than labour inputs (Sonka & Patrick, 1984).

Technological risk is the potential that current decisions may be offset by dramatic technological improvements in the future. There is the risk that durable assets will become obsolete. Developments in the nonfarm sector can also affect farming; for example, more sensitive instruments to detect residues may change production practices (Gabriel & Baker, 1980). Technological risks comprise those associated with technical improvements and are generally greater for equipment, buildings, and other fixed structures that are less mobile than farm machinery. New technologies that may not perform as expected can both cause concern and lead to changes in production practices (Sonka & Patrick, 1984).

Input price risk represents one source of market risk that results from the volatility of input prices leading to volatility in the cost of production (Kay & Edwards, 1994). Unforeseen changes in the prices of inputs to farm business can result in costs being high or lower than expected, which is another source of price or market risk in agriculture. Generally, the significance of changes in the price of a given input is determined by the magnitude of the price change and the proportion of total costs accounted for by the input.

Output price risks arise from high volatility of output prices. The causes of fluctuations in output price are often linked to other sources of risk within agriculture, and can be split broadly into effects on market demand and supply. Thus, it is important when assessing output price risk to focus not only on output price variability, but also on the variability of the underlying drivers (Hardaker, Huime, & Anderson, 1997). For example, unforeseen changes in consumer demand due to food health scares caused by disease can have a significant effect on output prices.

Similarly, macroeconomic factors, such as movements in exchange rates and changes in economic conditions and consumer income can alter the relative competitiveness of farm businesses internationally, which can affect demand for agricultural produce and consequently output price. Also, the length of most agricultural production cycles (ranging from a few weeks to several years) results in a lag between when a farmer makes production decision and the product is sold, which means that output prices are often unknown at the start of the production cycle (Fleisher, 1990; Kohl & Uhl, 1998). This is particularly important because farm businesses are price-takers, as the output of any one farm tends to be too small relative to the total market supply and thus an individual farm cannot influence prices (Pellegrino, 1999).

These risks may have a short or long run effect on farm businesses. In aggregate, they comprise the business risk that is independent of the way the farm is financed. Business risks affect measures of farm business performance such as the net cash flow generated by the farming activities or the net farm income earned (Hardaker *et al.,* 1997), and may also cause variations in the net worth or equity and other long-run performance measures of the farm business (Sonka & Patrick, 1984).

Other type of risk faced by farmers is known as financial risk (Lee, Boehlje & Murrey, 1988). If the farmer uses borrowed funds to provide capital to fund farming activities, he/she will have to allocate a proportion of the farm profit to meet the interest charge on the debt capital before the equity owners can take their reward (Hardaker *et al.,* 1997). Increasing the proportion of debt in the capital structure increases the risk faced by the equity holders through a leverage effect. In addition to risk associated with financial leverage, unexpected rises in interest rates on borrowed funds, credit availability, changes in loan or leasing terms, and the ability of the business to generate cash flows necessary for debt payments also represent sources of financial risk (Pellegrino, 1999).

Business and financial risks are interrelated. For instance, the ability to repay debt depends on production levels and prices received for the production, while financing the production and storage of output depends on the ability to borrow the necessary capital. Business and financial risks intensify potential decreases in farmers' net income and equity capital. Furthermore, they create inefficiencies in resource use by impeding farm planning (Hardaker *et al.,* 1997).

Interactions Between Output Price Risk and Other Risk Sources

The overall impact of risks on individual farms or across the agricultural sector depends on the relationships between the different risk sources. Broadly, the correlation between risk factors can differ significantly, which affects the overall risk exposure of farm businesses. Where risks tend to occur together but in the opposite direction (i.e. one effect is positive and one is negative), that is they are negatively correlated, there is a mitigating effect on overall risk exposure and thus on farm income variability. On the other hand, risks that are positively correlated (i.e. tend to occur together and in the same direction) can exacerbate effects on farm income variability. More generally, where risks are not perfectly correlated at farm level, total risk exposure will be less than the sum of individual risks (OECD, 2008). Thus, consideration for the relationships between risk factors allows the possible effects on farm incomes to be determined more accurately and risk management strategies to be formulated more effectively, although in practice the nature of interactions between risk sources may be highly complex (Fleisher, 1990).

It is also important to consider how risk factors affect different farmers. Some risks are highly correlated between groups of farmers (systemic risk), such as those in a particular region or country, for instance, droughts and floods. Price risk is particularly systemic, with fluctuations in prices affecting all farmers in a market – often a region or country. On the other hand, some risks are only weakly correlated or unrelated (idiosyncratic risk) between farmers, such as localised weather conditions (hail, frost, etc.) and personnel risks (Pellegrino, 1999).

The distribution of risks among farmers has implications for the level of aggregation at which risk is measured (OECD, 2008). For systemic risks, such as price risk, a high level of aggregation may be suitable (e.g. region or country level), as all farmers will face similar levels of risk. Such aggregation is less suitable for risks that are relatively unsystematic across farmers; for example, country level averages of yield variation would hide significant variability between farms or regions within the country (Fleisher, 1990).

The implications of the relationships between risks can be seen in the example of price-yield correlations. Conceptually, if a yield shock were large and widespread causing a significant reduction in supply, then, assuming the level of demand is unchanged, the market price would be expected to rise. To some extent, this change in output prices should mitigate the negative impact of the yield shock, as lower output is offset by a higher return for each unit sold price (Barry, 1984). However, although this may be true at the aggregate level, it is important to consider the incidence of yield loss across farm businesses. As price shocks tend to be more systematic across farms than yield shocks, for a given yield shock some farmers will suffer more adverse impact than others. As a result, the compensating effect of a rise in output price is not felt equally across all farms. In fact, those businesses least affected by the yield shock benefit the most from the resulting higher prices (Sonka & Patrick, 1984).

In addition to the relationships between risks, it is also important to consider the probability distribution of outcomes associated with a given risk source. Downside risk – the probability that an outcome (for example yield or output price) will be lower or worse than expected – is considered particularly important for agriculture (OECD, 2008). For example, a "normal" season may be one where most or all crops achieve the expected yield. However, this outcome tends to be unlikely as there is a higher probability that yields would be lower than expected. Downside risk has important implications for the economic welfare of farm households, due to the negative impact on farm incomes price (Barry, 1984). However, upside risk (the probability that outcomes will be better than expected) and their impacts on farmer expectations can have implications for economic efficiency (Sonka & Patrick, 1984).

Determinants of Output Price and its Volatility

Over the long-run, the sources of food price volatility are related mostly to supply-demand fundamentals, which are likely to include market-specific and broader macroeconomic factors (Crain & Lee, 1996). Changes in the underlying volatility of these long-run factors may have large effects on food commodity prices given their typically low short-term supply and demand elasticities (Askari & Cummings, 1977; Bond, 1987). Demand also tends to be inelastic, given that many food products are staple items for which consumption is relatively insensitive to changes in prices or income (Seale, Regmi, & Bernstein, 2003; Thompson & Westhoff, 2009), while for higher value food items, the cost of the raw agricultural commodity may not be a significant proportion of the final value of the finished product. The choice of possible determinants of food price volatility in this study is informed by theory and the results of other empirical studies.

Firstly, as the stocks of commodities fall, it is expected that the volatility in the prices would increase. If stocks are low, then the dependence on current production in order to meet short term consumption demands would be likely to rise. Any further shocks to yields could therefore have a more dramatic effect on prices. The storage models of Deaton and Laroque (1992) have played an important role in theories of commodity price distributions.

Their theory explicitly suggests that time varying volatility will result from variations in stocks (Streeter & Tomek, 1992; Crain & Lee, 1996; Thompson & Westhoff, 2009).

Secondly, the yield for a given crop may obviously drive the price for a given commodity up or down. A particularly large yield (relative to expectations) may drive prices down, and a particularly low yield may drive prices up. However, in this report we are concerned not with the direction of change but on the impact on the absolute magnitude of these changes. If prices respond symmetrically to yield then we might expect no impact on the volatility of the series (Attie & Roache, 2009). However, if a large yield has a bigger impact on prices than a low yield, then we might expect that volatilities are positively related to yields. Conversely, if a low yield has a bigger impact on prices than a high yield then volatilities are negatively related to yields. Changing yield on the phase of other fixed variables such as income could significantly affect output prices (Williams & Wright, 1991).

Thirdly, macroeconomic factors could potentially affect food price volatility through a number of channels and cause persistent changes in the variability of supply and demand over long time horizons. However, disentangling the effects of these factors in terms of their separate effects on both supply and demand is challenging and runs into identification problems and this is not an issue that will be tackled in this study. Instead, macroeconomic factors (exchange rate, inflation and interest rate) that previous literature has suggested affect commodity price volatility, through either supply or demand effects, are included as regressors (Tomek, 1998).

Furthermore, the prices that producers receive once they are deflated into the currency of domestic producers may have a big impact on the prices at which they are prepared to sell. This also extends to holders of stocks. Volatile exchange rates increase the riskiness of returns, and thus it is expected that there may be a positive transmission of exchange rate volatility to the volatility of agricultural prices (Mussa, 1986; International Monetary Fund [IMF], 2008; Gilbert 1989). The level of real interest rates can affect commodity prices through a number of supply and demand channels (Frankel, 2006). Whether changes in real interest rate levels or variability have persistent effects on commodity price volatility is less clear and will likely depend on the extent to which market participants expect real interest rate shocks to persist.

Moreover, inflation is an obvious candidate regressor. Commodities are often regarded as stores of wealth and the incentive to hold them-as financial assets or inventory-increases with inflation. The conventional wisdom that commodities can hedge investment portfolios against inflation risk has also been largely validated by the empirical literature, (Attie & Roache, 2009). As a result, inflation levels and variability might affect commodity prices through the portfolio choices of financial investors. The causality can run in both directions, with higher commodity prices leading to higher inflation (Leibtag, 2008).

Measures of global weather patterns are considered, as some studies have shown this to have a significant influence on commodity prices (Brunner, 2002). This is by weather index measured by the composite effect of weather elements. There are various components of weather that have composite effects on volatility of agricultural food prices. For instance, changes in rainfall and temperature patterns expose farm firm to production risk and output price risk. Moreover, weather pattern favours the development of certain pests and diseases which can result in output volatility and consequently price risk (World Bank, 2011).

Moreover, the impact of speculators on price volatility has long been the subject of debate (IMF, 2008). Informed speculation can provide liquidity, facilitate price discovery, and improve resource allocation, thereby stabilizing prices. There is an inverse relationship between speculative activity and agricultural commodity price variability (Peck, 1981; Brorsen, 1989; Streeter & Tomek, 1992). Bessembinder, Henfriks, & Seguin (1993), among others, find a positive relationship between futures market volumes and agricultural commodity price volatility. In contrast, Irwin and Holt (2004) concluded that the volume traded and open interest positions of fund managers have no strong and consistent effects on futures price volatility across agricultural commodities. More recently, the IMF (2008) shows that during the 2003-08 period there was a positive but weak relationship between return volatilities and the extent of financialization. Robles, Torero, and von Braun (2009), Amanor-Boadu, and Zereyesus (2009) found evidence that speculative activities might have influenced agricultural commodity prices during the 2005-08 periods. Gilbert (2008) shows that the positions of index investors and other non-commercial investors seem to affect future returns

Global economic activity influences the behaviour of agricultural food commodities and price volatility due to the inter-economic relationship among countries (IMF, 2009). The global economic activity is measured by the proxy of global economic activity and demand for commodities, an index of real shipping costs constructed by Kilian (2009) in place of alternatives such as industrial production, as it offers a number of advantages; it does not require exchange-rate weighting and aggregates activity in all countries, incorporating changes in the composition of real output, and changes in the propensity to import industrial commodities for a given unit of real output.

International markets experience global shocks that are likely to influence global demand for agricultural prices, and these markets may also adjust to movements in policy (trade agreements that may impact a number of commodities simultaneously). Additionally, volatility in one market may directly impact on the volatility of another where stocks are being held speculatively (Robles, Torero, & von Braun, 2009). Fewer exporting countries could expose international markets to variability in their exportable supplies. This variability might stem from weather shocks and domestic events such as policy changes. Lower concentration would lead to higher potential volatility and vice versa.

Moreover, one obvious omission in the multivariate analysis that follows is the effects of agricultural policies, including price supports, direct subsidies, and trade barriers. So far, the literature has not reached a consensus on the effects of policy on volatility. Crain and Lee (1996) reported that changes in the volatility of wheat spot and futures markets are highly associated with changing government programs, with more market-oriented programs leading to lower volatility. In contrast, Weaver and Natcher (2000) argue that spot price volatility for some agricultural commodities increased as government programs became more market-oriented. Similar results were obtained by Yang, Haigh, and Leatham (2001) who focused on the 1996 U.S. FAIR Act, which aimed at increasing the flexibility of planting decisions and reducing government support for crop production. Swaray (2007) examined the demise of international commodity agreements and found few consistent results for food price volatility. Other government interventions may also play a role in volatility, including the loan rate ratio which effectively places a floor under the cash price of crops (Kenyon, Kenneth, Jim, Seal, & McCabe, 1987).

Definition and Measurements of Price Volatility

While the volatility of a time series may seem like a rather obvious concept, there are in fact several different potential measures of a series' volatility. For example, if a price series has a mean, then the volatility may be interpreted as its tendency to have values very far from this mean. Alternatively, volatility may be interpreted as a series' tendency for large changes in its values from period to period (Manfredo & Leuthold, 2001). A high rate of volatility according to the first measure needs not imply a high volatility according to the second. Another commonly held notion is that volatility is defined in terms of the degree of forecast error. A series may have large period to period changes, or large variations away from its mean, but if the conditional mean of the series is able to explain most of the variance, then a series may not be considered volatile (Mounir, 2004).

Volatility in this study is concerned with the variability of the price series around its central value, that is, the central tendency for individual price observations to vary far from its mean value. Thus volatility is often defined as high deviations from central tendency. Two kinds of volatility are found in the literature. These are historical (realised) volatility and an implicit future volatility (European Commission, 2009; Matthews, 2010). The historical volatility is based on observed past prices. It reveals how volatile a price has been in the past while implicit volatility corresponds to the markets' expectation on how volatile a price will be in the future as measured by the value of price options. This study focuses on measuring only the realized volatility based on observed cassava prices.

In the field of agricultural economics, most of the literature contains two main types of historical volatility measurements; conditional and unconditional (Gilbert & Morgan, 2010). Simple approaches like the mean deviation (MD), standard deviation (SD), coefficient of variation (CV) and the standard deviation of the log returns (SDLOG) provide a measure of total price variation while generalized autoregressive conditional heteroskedasticity (GARCH) models first remove the predictable component of prices before measuring volatility (conditionally to the mean equation). These variations impact the farmers and poor people whether they are theoretically predictable or not because their response possibilities can be rather inelastic (Askari & Cummings, 1977).

The simplest way to measure price volatility is the MD, SD or CV which is the standard deviation of prices over a particular time interval divided by the mean price over the same interval. One advantage of the measure is that it has no unit. It allows then easy comparison of, for example, domestic price volatility measured in different countries. However, the CV can create misleading impressions if there are strong trends in the data, because trend movements will be included in the calculations of volatility. Moreover, there is no universally accepted method for removing the trend component because different observers will have different ideas about the nature of the underlying trends (e.g. linear, quadratic). As mentioned earlier, an often used alternative to the CV is the SDLOG (Balcombe, 2009; Gilbert & Morgan, 2010; Huchet, 2011; Minot, 2012).

Modelling Volatility Processes

$$\text{Volatility(SDLOG)} = \text{STDEV}\left(\log\left(\frac{Price_t}{Price_{t-1}}\right)\right) * \sqrt{\text{Time}}$$

$$\text{Volatility(SDD)} = \sqrt{\text{variance}(\log(Pricet) - \log\,(\text{Price}\ t-1))}$$

$$\text{Coefficient of variation(CV)} = \frac{\text{Standard deviation}}{\text{Mean}}$$

$$\text{Mean Deviation(MD)} = \text{price values} - \text{price mean} = x - \bar{x}$$

$$\text{Standard deviation(SD)} = \sqrt{\text{variance}}$$

Other Previous Studies on Potential Determinants of Output Volatility

Roache (2010) explains volatility in international food market using a spline GARCH approach that produces estimates of volatility. Estimates are then regressed against a set of possible annual explanatory variables such as inflation, speculations, global weather pattern, inflation, interest rate. The variable with the highest impacts were inflation and interest rate.

Macroeconomic conditions have been found to also explain price fluctuations by previous research (Roache, 2010; Leibtag, 2008). As noted by Frankel (2006), interest rates can affect commodity price volatility through different demand and supply channels. Roache (2010) finds interest rates to drive food price volatility. Another study by IMF (2008) attributed substantial influence of the USD exchange rate on food price behaviour. The influence of macroeconomic variables will also be considered in the analysis to shed light price volatility.

A number of studies have discussed the factors which may explain the food price volatility (Abbott & Borot de Battisti, 2009; Gilbert, 2010; Gilbert & Morgan, 2010). The most often involved are changes in supply and demand factors. Other macroeconomic and financial factors apart from specific commodity market fundamentals are considered to influence agricultural commodity price volatility including changes in oil prices, changes in world money supply, and changes in the value of the dollar since many agricultural commodity prices are denominated in terms of the US dollar (Askari & Cummings, 1977). Other factors which are often also quoted include climate change, trade policies in exporting and importing countries (Gilbert, & Morgan 2010; De Schutter, 2010).

Output Price Risk and Farmers welfare

Farm incomes tend to vary significantly over time due mainly to price and yield fluctuations, changes in variable costs, and changes in the value of agricultural support payments. The degree to which individual risk sources manifest in variations in income depends on the relationships between sources of risk, and the effect of public and private risk management strategies in reducing and mitigating risks (Thompson & Westhoff, 2009). Farm incomes also vary, not only with time, but also across businesses, even for those of the same type and size. As a result, measuring volatility of aggregated farm income can hide significant variations at the individual farm level (Pellegrino, 1999).

While there are several risk management options available to farmers, these often provide partial protection for potential losses. Where the remaining risk exposure causes returns and farm income to vary, and this variation is uncertain, it can make it difficult for farm businesses to plan long-term investment (Crain & Lee, 1996). For example, volatility in output prices can make it more difficult for farmers to identify trends in prices, which is often a basis for making long-term investment decisions. In the presence of such volatility, the level of investment by risk-averse producers is likely to be lower than in a risk free environment, which in turn has negative impacts on long-term productive capacity in agriculture (Pellegrino, 1999).

The presence of risks in agriculture influences farm production and investment choices in a number of ways, including (a) the choices farmers make for the specific mix of commodities they produce and inputs used to produce these commodities; (b) strategies to manage and cope with risk; and (c) dynamic or investment impacts when the resolution of uncertainty results in a negative impact on farm incomes (Crain & Lee, 1996; Thompson & Westhoff, 2009). The nature of the first two of these impacts on farm businesses will depend principally on the attitude of farmers towards risk. In general, farmers may be risk-averse (i.e. they dislike riskier outcomes), risk loving (prefer riskier outcomes) or risk neutral. However, studies within the agricultural sector have found that farmers tend to be averse to risk (OECD, 2008).

Output price risk tends to have direct influence on farm production decisions. In the absence of instruments for managing risks, economic analysis of production under uncertainty often suggests that farmers will base their choices on some "expected outcome" (e.g. expected price – a weighted average of the possible outcomes taking into account the probabilities of different outcomes being realised). Risk-averse producers will tend to prefer "low-risk and low-return" outcomes at the expense of higher payoffs that are more uncertain (Bond, 1987). In practice, this means that producers may choose low-risk production technologies and low risk crops at the expense of innovation and riskier choices that potentially offer higher returns (Seale, Regmi, & Bernstein, 2003). This will generally lead to a lower average income and lower levels of economic efficiency, as resources may not be directed towards the most profitable farm enterprises.

This may be reflected in a reluctance of farmers to adopt new production techniques and technologies that may improve farm efficiency and profitability but result in some (perceived) increase in the variability of returns (Pellegrino, 1999).

Measuring Output Price Risk in Agriculture

The following sections focus on measuring output price risk on the basis that volatility in output prices is cited as the biggest source of risks faced by the farm businesses. Additionally, the impact of the range of risk sources will manifest, to some extent, through variations in prices (Matthew, 2010). Other measures of output price risk are also reviewed.

Trends in Volatility in Agricultural Commodities Prices

Several studies by Matthew (2010) indicated that output price risk can been realised or assessed by observing the pattern and behaviours of output prices over period of time to check for variability. He also pointed out that price volatility has been increasing for a number of agricultural commodities in recent years. European Union (EU) price volatility over three periods relating to different regimes using German prices as a proxy for EU prices, the study found that volatility in the prices of several agricultural commodities has increased over time.

Measurement of Output Price Risk Using Value-at-Risk Method

Value-at-risk (VaR) in this context gives a prediction, with a certain level of confidence, of potential losses that may be encountered over a specified time period due to adverse price movements in the commodity price

(Manfredo & Leuthold, 2001). VaR summarizes the worst expected loss over a target horizon within a given confidence interval (Jorion, 1996). For example, a VaR of 1 million Ghana cedis at the 95% level of confidence implies that there is 95% assurance that the overall portfolio losses will not exceed 1 million Ghana cedis. VaR measures the risk associated with the output prices and captures the extreme event that occurs in the lower tail of return distribution. It focuses on the downside risk (Manfredo & Leuthold, 2001). In light of the above definitions, it is important to understand the various functions of VaR and its implication in the financial and non-financial institutions.

Theoretical Constructs of Value-at-Risk

The concept of VaR can be traced to the late 1920s to capital requirements the New York Stock Exchange imposed on member firms (Hopper, 1996). VaR also has roots in portfolio theory, and a crude VaR measure was published in 1945. Markowitz, and Roy (1952) used VaR measures that considered covariance among risk factors to reflect hedging and diversification effects. They were working to develop a means of selecting portfolios that would, in some sense, optimize reward for a given level of risk (Hopper, 1996). Markowitz and Roy (1952) used a variance of simple return metric. They used a metric of shortfall risk that represented an upper bound on the probability of the portfolio's gross return being less than some specified "catastrophic return."

The concept of VaR was firstly proposed by Baumol (1963) when examining a model referred to as the Expected Gain-Confidence Limit

Criterion in 1963 (Alexander & Baptista, 2000). Baumol (1963) found situations where some unacceptable portfolios can actually be found among the set of portfolios that Markowitz's selection criterion lists as efficient. In this case, the confidence level selection criterion is used to incorporate both the risk and the expected return into one criterion that captures the relationship between them. Baumol (1963) used the equation $L = E - K\sigma$ to represent the lower confidence limit, where E represents the expected portfolio return, σ is the standard deviation of the portfolio returns, and K is the number of standard deviations from the expected return corresponding to the desired level of confidence.

Selection of Quantitative Factors

Time horizon and confidence interval selection are very important in the measures of VaR. The key in choosing both relates to the specific application for which the VaR statistic will be used (Jorion, 2001).

The choice of time horizon when using VaR as a risk-reporting tool is determined by the scope of management decision from firm to firm. The time horizon can range from one day, one week, one month, or one year, depending on the portfolio composition. The parameter time is determined by the entity's horizon. For this study, monthly VaR are used because price data is in monthly time series. A VaR number applies to the current portfolio, so an assumption underlying the computation is that the current portfolio will remain unchanged throughout the holding period. This may not be reasonable, particularly for long holding periods (Linsmeier & Pearson, 2000). The shortcomings of short and long horizon selection can result in users of VaR choosing a relatively short horizon and scale the statistic up to longer horizons by multiplying by the square root of time (Jorion, 2001).

However, scaling is accurate only when returns are independently and identically distributed. Also, modelling volatility only at one short horizon, followed by scaling to convert to longer horizons, is likely to be inappropriate and misleading because temporal aggregation should reduce volatility fluctuations, whereas scaling amplifies them. The use of scaling in the application of VaR can be useful; however, it can sometimes result in inaccurate results (Diebold, Hickman, Inoue, & Schuermann, 1998). Overall, the selection of time horizon differs from firm to firm. It is important to note that time horizon should reflect the portfolio composition and its specific application using VaR as a tool to measure risk. Consistency is a very important factor in the application of VaR.

The choice of confidence interval in the application of VaR is similar to the choice of time horizon as a benchmark. Consistency is very important since it is used to compare results in different scenarios and time over different periods. Confidence interval, in the measure of potential loss application of VaR, is insignificant as long as decision makers realize that VaR is a probabilistic measure and that losses exceeding the VaR figures should be expected (Hawes, 2003). However, it is important to note that the VaR results are not the absolute worst loss a firm or farm can expect because firms could sometimes experience losses greater than those predicted. In order to determine the confidence interval, there are two aspects that need to be considered. The first aspect deals with the risk aversion of the firm. The second aspect deals with costs associated with a loss exceeding the VaR. If the cost of exceeding the figure merely results in borrowing, confidence intervals can be set relatively low. However, if losses are greater than the VaR, firms need to set a high confidence interval (Jorion, 2001).

To interpret VaR numbers, it is crucial to keep in mind the confidence interval and time horizon. Without them, VaR numbers are meaningless. For example, two companies holding identical portfolios will come up with different VaR estimates if they make different choices of confidence interval and time horizon. Obviously, the loss that is suffered with a probability of only 1% is larger than the loss that is suffered with a probability of 5%. In addition, the choice of time horizon and confidence interval can have an impact on out-of-sample test (Linsmeier & Pearson, 2000).

Construction of Value-at-Risk

VaR gives a prediction with a certain level of confidence (1-c) of potential portfolio losses that may be encountered over a specified time period (t) due to adverse price movements in the portfolio's assets (Manfredo & Leuthold, 2001). In order to compute the VaR of portfolios, the initial investment and rate of return must be defined. Second, the portfolio value at the end of target horizon is defined. Third, the mean and standard deviation of the rate of return are defined, as well as the change in the time interval. Fourth, the VaR, as cedis loss relative to what was expected is expressed. The initial investment and rate of return on the portfolio of assets are defined as W_0 and R, respectively. The end of target horizon is defined as the $W = W_0\ (1+R)$

The annual mean and standard deviation of R are μ and σ, respectively. The change in time interval is represented by $\Delta\ t$. If the returns of the portfolio are uncorrelated, then the expected return and risk are defined over the holding time as $\mu\Delta t$ and $\alpha \Delta t$, respectively (Jorion, 1996).

The VaR as a cedi loss relative to what was expected is defined by Jorion (1996) as $VaR = E(W) - W^*$

$= W_0 (\mu - R^*)$.

W* represents the lowest portfolio value (price) at a particular level of confidence. Also, R* is the cut-off return of a portfolio of assets which is also equivalent to finding the VaR of a portfolio of assets. The above description of variables and equations related to VaR computation are important to understand in order for managers and policy makers to implement or take steps and decisions that would reduce their exposure to price risk.

VaR Methodologies

This section introduces the three major methodologies used to compute or measure/estimate output price risk using VaR. The three methodologies, namely; parametric method also known as variance/covariance method, full-valuation and Monte Carlo simulation, are introduced.

The parametric model of VaR was motivated by the efforts of JP Morgan and the dissemination of its Risk Metrics methodology for developing estimates of standard deviation and correlation among a portfolio of assets using an exponentially weighted average approach (Manfredo & Leuthold, 2001). The parametric method is based on the assumption that the underlying market factors have a normal distribution. Using this assumption, one can determine the distribution of market-to-market portfolio profits and losses, which is also assumed to be normal (Linsmeier & Pearson, 2000).

The general distribution, f (w), is converted into standard normal distribution
Φ (ε), where ε is a random variable with a mean of 0 and a standard deviation of 1. R*associated with the standard normal distribution is expressed as (Jorion,1996)

$$-\alpha = \frac{\mu\Delta t - R*}{\sigma\sqrt{\Delta t}}$$

where R* is considered the cut-off return of the portfolio of assets. VaR of a portfolio can be found in terms of W*, R*, or α which are portfolio value, cut-off return and normal deviation, respectively (Jorion, 1996). The following equations illustrate the above concept:

$$1 - c = \int_{-\infty}^{W*} f(w)dw$$

$$= \int_{-\alpha}^{R*} f(r)dr$$

$$c = \int_{-\infty}^{\alpha} \emptyset(\varepsilon)d\varepsilon$$

The VaR can be expressed as

$VaR = W_0 * \alpha * \sigma$

where W_0 is the initial portfolio value, α is the normal deviate associated with 1-c and σ is the portfolio standard deviation. The critical element of parametric VaR is the estimate of portfolio standard deviation (σ), also referred to as portfolio volatility (Manfredo & Leuthold, 2001). Alternatively, a short-term VaR is extrapolated to the desired holding period (time scaling).

$VaR(h) = VaR(1)*\sqrt{h}$

Where $\sqrt{h}$ is a scaling factor that adapts the time horizon of the volatility to the length of the holding period h.

Parametric methods of VaR provide a superior forecast of downside risk for portfolios with little options content (Jorion, 1997). There are two main requirements to compute parametric methods. The first requirement is that, for each risk factor, forecasts of volatility and correlations are needed to help managers protect their firms or farms against large losses. Second, positions on risk factors are needed to provide management with information necessary to implement other risk management tools to protect against future risk. However, parametric methods used to compute VaR have been criticized for two main reasons (Mounir, 2004). The main criticism of the parametric method is its assumption about normal distribution of return series. VaR literature has focused on the problem of non-normality often found in the data and the potential bias that it causes when using parametric VaR model with horizon (Christofersen, Diebold & Schuermann, 1998).

Full-valuation methods attempt to model the entire return distribution instead of providing a point estimate of volatility (Manfredo and Leuthold, 2001). Full-valuation requires relatively few assumptions about the statistical distributions of the underlying market factors. Historical simulation is the simplest full-valuation procedure. It exposes the portfolio to past observation of the risky positions over a given historical period (Linsmeier & Pearson, 2000).

The historical simulation method has been praised for its flexibility and ease of implementation. It does not rely on distributional assumptions, so deviations from normality are not a problem (Linsmeier & Pearson 2000;

Mahoney, 1995). When option positions are in the portfolio, the historical simulation method captures the nonlinearity of the position. The historical simulation method is easy to understand, one of the prime considerations in using VaR estimates in business (Linsmeier & Pearson, 2000; Jorion, 1996).

Despite the positive review about the historical simulation method, there are setbacks in its estimates. Long series of data are required and need continuous updating because more accurate distributions can be approximated only with large periods of data (Hendricks, 1996; Mahoney, 1995). Longer historical data sets present the possibility of including more extreme market moves associated with the tails of a probability distribution, potentially causing upward bias in the VaR estimate (Bulter, & Schachter, 1998). VaR can be derived from the probability distribution for the future portfolio value where

$$c = \int_{W*}^{\infty} f(w)dw$$

or the probability of a lower value than W* can be expressed as 1-c,

$$1 - c = \int_{\infty}^{W*} f(w)dw$$

Future commodity value is defined as $f(w)$ and c is defined as the confidence level at a given time.The area from ∞ to W* should sum up to 1-c. The expression 1-c is the probability that the firm would lose a particular amount in a given holding period.

Monte Carlo simulation is similar to full valuation method except that it generates pseudo-random values of the risk factors of the portfolio based on a predetermined data generating process (Manfredo & Leuthold, 2001). Monte Carlo methods are the most flexible of VaR estimation techniques. The flexibility of Monte Carlo has its downside (Jorion, 1997); Linsmeier and Pearson, 2000). Monte Carlo methodology is criticized for estimating VaR because its process to specification process must be determined (Jorion, 1997). In addition, time variation can be added through Generalized Autoregressive Conditional Heteroscedasticity (GARCH) variance terms; however, this can be distorted with Monte Carlo methods, suggesting a trade-off between time variation and model flexibility (Jorion, 1997). Furthermore, Monte Carlo and full-valuation techniques do not have the ability to capture variance/covariance matrices to analyze the marginal contribution of an asset to overall portfolio risk (Ho, Chen, & Eng, 1996).

Advantages of VaR

Firstly, VaR gives farm managers the ability to think of risk in monetary terms instead of risk being classified with respect to standard deviation from the expected returns used in mean-variance and decision analyses. Although the real option methodology quantifies risk in monetary terms, it does not address the downside risk. VaR is easier to interpret and implement. The managers, who may or may not have a statistical background view, can use VaR as an easier tool to estimate or predict losses in cedis terms (Manfredo & Leuthold, 2001). Second, for a range of holding periods and probability levels, VaR estimates give a full description of the distribution of returns of a portfolio (Mahoney, 1995). Thus, VaR is a powerful lens through which to view the risk of a portfolio.

Thirdly, VaR focuses on downside risk and it tells the amount that firms or investors will lose in a particular given period. This is different from the traditional measures, which focus on the deviations from the expected returns as risk. Therefore, VaR is the most appropriate methodology for this study, to address risk in both monetary terms and downside risk. VaR estimates simplify the measurement of risk by combining the volatility estimate and the distributional assumption in a single step to arrive at a potential downside risk (Mahoney, 1995). Finally, an advantage offered by VaR is the ability to capture the nonlinear payoffs of portfolios that contain options, or option-like instrument (Manfredo & Leuthold, 1999). One of the fundamental assumptions of most traditional risk measures, including analytical VaR, is that returns of a given amount above or below those expected occur with equal likelihood.

Applications of VaR in Measuring Output Price Risk

The use of VaR as a risk reporting and measurement tool has several potential applications in agriculture. The use of VaR in agriculture can help firm managers to employ a specific management strategy or strategies to reduce their exposure to risk. Although the study and application of VaR has received considerable attention in the financial literature, its implementation in the agricultural economics literature is limited (Hawes, 2003). Manfredo and Leuthold (2001) presented the best-known work done with VaR in agricultural economics. In their study, a portfolio of risk assets, which included fed cattle prices, feeder cattle prices, and corn prices in weekly series, was built. The main objective of their study was to examine VaR measures in the context of cattle feeding margin. Full-valuation and parametric methods were used to predict large losses in the cattle-feeding margin with a particular level of confidence and time horizon. This study indicated high possible losses in the returns of the cattle prices.

Moreover, Mournir (2004) also used VaR to predict losses for a characteristic and small turkey processing plant. The data used for this study included monthly wholesale price of turkey ($/lb), wholesale cost of turkey ($/lb), monthly food recalls and number of turkeys processed. Secondary data was obtained to compute the VaR prior to and after Pathogen Reduction and Hazard Analysis and Critical Control Point (PR/HACCP). The years prior to and after PR/HACCP implementation are 1995-2000 and 2001-2003, respectively. In addition, primary data was used to compute VaR for a small turkey processing plant using microbial count to determine the actual risk reduction benefits of PR/HACCP system. The focus of his study was to examine whether PR/HACCP implementation significantly reduced food safety risks and improved the profit situation of the turkey processing plant (Mounir, 2004).The result indicated significant reduction in risk exposure.

Furthermore, Martin, and Hinrichs (2002) used VaR in assessing market risk associated with Germans' hog production. They stated that "in the last quarter in 2000, German hog and cattle producers have been exposed to tremendous price fluctuations due to the BSE crisis and the foot and mouth disease". Weekly data was used in the estimation. Their results indicated that hog producers were exposed to high output price risk and therefore suggested risk aversion approach to remediate its occurrence.

Management of Output Price Risk

Risk management is an approach that anticipates accidental losses, and designs and implements methods for minimising the occurrence of loss or the financial impact of the losses that do occur (Vaughan, 1997). It can also be defined as a systematic application of management policies, strategies, procedures, and practices to the tasks of identifying, analysing, assessing, treating, and monitoring risk (Hardaker *et aI.,* 1997). Risk management is a continuous and adaptive process that needs to be integrated into all the relevant aspects of the farm decision-making process to control risk successfully (Hardaker *et aI.,* 1997). Its objective is to reduce the possibilities of losses while gaining the highest possible returns to the owners of equity consistent with their risk preferences (Martin, 1996).

The steps in risk management can be arranged in a cycle: 1) establish the context, i.e., set the scenario and identify the parameters which risks are going to be considered; 2) identify the risks to be managed using a systematic approach; 3) analyse the risks, i.e., evaluate the chances of occurrence and consequences of the risks; 4) assess the risks, i.e., identify the risks for which current risk-management practices are not appropriate; 5) manage the risks; and (6) implement the monitoring and reviewing necessary to establish that the risk management plan is working and to identify aspects that need to be adjusted (Hardaker *etal.,* 1997; Martin, 1996*).* Risk management (step 5) can itself be divided into phases: the first phase is to design strategies to cope with risks; the second phase is to evaluate the most suitable strategies; and the third phase is to implement those risk responses to control risks (Hardaker *et al.,* 1997).

Decision-Making on Output Price in a Risky Environment

Farmers are continually confronted by the need to make decisions. However, a decision problem only exists when the decision-maker feels that the possible consequences are important and yet does not know what best thing to do. If the decision-maker is uncertain about the consequences of the decision, it can be said that the decision-maker faces a risky choice (Anderson, Dillon, and Hardaker, 1977*)*. There are three approaches or models that purport to explain decision-making under uncertainty. These include models grounded in the behavioural approach, models based on the lexicographic safety-first approach (a combination of the behavioural and expected utility models) and models grounded in the expected utility model, also called decision analysis (Nartea, 1994).

The behavioral approach assumes that the decision-maker is led by a decision rule to select the best decision. The choice of the decision rule is arbitrary and can be developed almost at will. Safety-first and cautious optimizing are two of these decision rules, both of which are based on the principle of bounded rationality (Roumasset, 1979). The safety-first rule assumes that a decision-maker endeavours to maximise expected profits subject to the constraint that the risk of earnings falling below some critical minimum must not exceed a given level (Kumeuther, 1974).

The lexicographic safety-first model integrates the behavioural and expected utility model approaches into a single model. While this model is more appropriately applied to decisions where the consequences have multiple attributes, it can also be applied to decisions with single attribute outcomes with multiple characteristics (Anderson *et al.,* 1977). This model ranks the attributes or features of the decision outcomes according to priorities or hierarchies of wants (Maslow, 1943). No trade-offs between attributes or characteristics are allowed (Anderson *et al.,* 1977).

The expected utility model involves characterising a rational choice under risk. It seeks to determine an optimal choice consistent with the decision maker's beliefs about the chances of occurrence of alternative uncertain consequences and the relative preferences for those consequences (Hardaker *et al.,* 1997). The decision maker's beliefs about the chances of occurrence of the risky event are presented in the probabilities assigned to uncertain states of nature. Meanwhile, the decision-makers' preferences for the outcomes are reflected in an expected utility function. The expected utility model suggests that a decision-maker who follows certain axioms acts as if expected utility is being maximised. These axioms (Von Neumanil & Morgenstern, 1947) describe how people behave, and constitute a general assumption that people are rational and consistent in choosing among risky alternatives (Robison, Barry, Kliebenstein, & Patrick, 1984). Anderson *et al.,* (1977) set out the axioms as:

1. ordering and transitivity of choices. A person either prefers one of two risky prospects 'a' and 'b' or is indifferent between them. The logical extension of ordering is the transitivity of orderings of more than two prospects, e.g., 'a' 'b' and 'c'. This implies that a person preferring 'a' to 'b' (or being indifferent between them) and preferring 'b' to 'c' (or being indifferent between them), will prefer 'a' to 'c' (or will be indifferent between them);

2. continuity. If a person prefers ‘a’ to ‘b’ to ‘c’, a subjective probability exists such that the person is indifferent between ‘b’ and ‘c’. This implies that faced with a risky prospect involving a good and bad outcome, a person will accept the risk if the probability of getting the bad outcome is low enough.

Output Price Risk Management Strategies or Responses

Risk management strategies or responses can produce two effects. Some strategies may control or reduce risk exposure; others may control the impact of risk on the farm business (Jolly, 1983). Business risk exposure is controlled by reducing the variability or increasing the mean of the probability distribution of the income. 'This can be achieved by reducing the variability of prices and yields, increasing their expected values, changing their shape, or cutting off or truncating one end of their distributions (Fleisher, 1990). Strategies that control risk exposure include enterprise selection and diversification, which affect prices and yields, and marketing responses, which affect only prices, (Jolly, 1983). Insurance, government programmes, or volume of business or scale of operation is also strategies that can modify the underlying distributions of prices and yields (Jolly, 1983).

In general, risk management strategies or responses are categorised according to the risk that they are designed and implemented to cope with. Thus, there are production, marketing, and financial strategies. Flexibility is another type of response that can be implemented to simultaneously manage several risks (Martin, 1996). In this study, flexibility will be categorised as general response.

Managing Strategies Against Output Price Risk

Output responses are implemented to offset output variability. The most important according to Barry, and Baker, (1984); Sonka, and Patrick, (1984); Martin and Anderson, (1992); Kay and Edwards, (1994) are:

1. selecting enterprises with low expected price variability, thus reducing farm income variability;
2. sequential marketing of storable crops or livestock, resulting in price averaging over the marketing periods, and thus providing greater certainty in price expectations;
3. forward contracting so farmers can price their products prior to delivery and thus assure their income;
4. contracting for purchasing inputs, so input prices are stabilised;
5. hedging on the futures and options markets, so the products are priced before delivery and risk is reduced;
6. improving quality of information on price forecasts and ends and market requirements and
7. participating in government commodity programs if they are available.

General responses involve maintaining the flexibility of the farm business so that the farmer can adjust to changed circumstances. The risk-management strategies that can be implemented by farmers to enhance flexibility according Hardaker *et al.,* (1997) include:

1. asset flexibility that involves investing in assets that have more than one use;

2. product flexibility that exists when an enterprise produces a product that has more than one end use, or when the enterprise yields more than one end product;
3. market flexibility that exists when a product can be sold in different markets which may not be subject to the same risks;
4. cost flexibility that involves organising production by keeping fixed costs low or incurring higher variable costs as necessary; and
5. time flexibility that relates to the speed with which adjustments to farming operations can be made. The general responses outlined above can be divided into short-run flexibility or long-run
6. flexibility categories. All of the risk ameliorating responses listed above represents the potential decisions that farmers should make to control risks.

Price Risk Management Related Policies in Agriculture

There is a range of policy instruments that have traditionally been used at country or regional levels to reduce the exposure of the agricultural industry to market or price risks. Broadly, these policies are targeted at addressing problems associated with output price volatility.

Price stabilisation policies help in curbing market or price risk. This includes export subsidies which helps stabilises domestic prices by facilitating exports of excess domestic supply, hence preventing domestic price from falling. Import tariffs also protect producers from variability in world prices by limiting imports. Moreover, intervention purchasing and public storage reduces price fluctuations in the domestic markets by building up public stock when the supply is relatively high (Roache, 2010).

In a range of countries, policies also exist to assist the agricultural industries to manage at farm-level a range of risk factors affecting farming. These measures are different from the price stabilisation policies in that while they may be available to all farmers in a country or region as a matter of policy, it is often up to agricultural businesses to choose when they want to use them to manage risks (Askari & Cummings, 1977). Consequently, the outcomes of these measures reflect, to some extent, the risk perception of farmers.

Constraints or Barriers to Output Price Risk Management Strategies

Productivity Commission, (2011) defines a barrier as something that could reduce the willingness or capacity of individuals, businesses or other organisations to adapt to the impacts of change. This means that the existence of barriers is likely to make farmers in particular and communities in general not to effectively adapt to or manage risk.

Three broad categories of barriers to adaptation. Firstly, ecological and physical limits which comprise the natural limitations to adaptation, associated largely with the natural environment, ranging from ecosystem thresholds to geographical and geological limitations. Secondly, human and informational resource-based limits relating to knowledge, technological and economical restrictions. These include the various spatial and temporal uncertainties associated with forecast modelling, and low levels of awareness and information amongst policy-makers on the impacts of price change, as well as a lack of financial resources and assistance to facilitate adaptation interventions. Thirdly, social barriers which are made up of various processes relating to cognitive and normative restrictions that prevent individuals or groups from seeking the most appropriate forms of adaptation.

Onyeneke and Madukwe (2010) found that there are five major constraints to adaptation in the southeast rainforest zone of Nigeria. According to the authors, these are lack of information on appropriate adaptation option confirmed by 50% of the farmers, lack of finance cited by 35% of the farmers, shortage of land confirmed by 5% of the farmers, and poor access to market agreed by 5% of the farmers.

Time Series Analysis

According to Gujarati (2004), a time series is a set of observations on the values that a variable takes at different times. Most empirical work based on time series data assumes that the underlying time series is stationary. On the other hand, casual inspection of most economic time series data reveals that these series are non stationary or have a unit root. He thus stated the following as key features of the various series.

1. Most of the series contain a clear trend (Gujarati, 2004). In general, it is hard to distinguish between trend stationary and discrete stationary processes.
2. Some series seem to meander. For example, the cedi exchange rate shows no particular tendency to increase or decrease. The cedi seems to go through sustained periods of appreciation and then depreciation with no tendency to revert to a long-run mean. This type of random walk behavior is typical of unit root series.

3. Any shock to a series displays a high degree of persistence. Overall, the general consensus is at least empirically that most macroeconomic time series follow a unit root process.
4. Some series share co-movements with other series. For example, short- and long-term interest rate, though meandering individually, track each other quite closely maybe due to the underlying common economic forces. This phenomenon is called cointegration.

These imply that the non stationary series variables invalidate classical methods like the Ordinary Least Square (OLS). The OLS estimation procedure cannot handle time series containing unit roots since they do not fulfil the classical properties of the residuals which are:

1. $E(U_t) = 0$
2. $E(U_t)^2 = \sigma^2$
3. $E(U_t\ U_s = 0$

These three properties are a sufficient and necessary condition for white noise residual. However, non stationary time series breaks with the first two properties i.e. zero mean and constant variation. Thus, the conventional test of hypothesis will be seriously biased towards rejecting the null hypothesis of no relationship between the dependent and the independent variables. Cointegration techniques are applied in this study due to the breakdown of the ordinary least square when applied to time series data.

Stationary and Non Stationary Time Series

Babiker and Abdalla (2009) defined a stationary time series as one whose statistical properties such as mean, variance and autocorrelation are all constant over time and non stationary time series as having time dependent statistical properties. They further added that the variables of the non stationary series may contain stochastic or deterministic and exhibit systematic but unpredictable variation as compared to series that contain deterministic trends and display completely predictable variation. However, stationary series have a finite variance, transitory innovations from the mean and a tendency for the series to return to its mean value (Tveteras, 2000). It is worth noting that the value of the mean is time dependent.

Testing for Unit Root

A unit root or non stationary process as defined by Babiker and Abdalla (2009) is a series with time dependent statistical properties which may contain stochastic or deterministic trends called integrated. A unit root test is thus conducted to determine whether a series is non stationary. Tveteras (2000) asserted that a unit root test is a univariate test used to determine if a time series is stationary or not. According to him, the order of stationarity of the variables is very vital for the testing of co-integration. The order of integration which specifies whether the variables are stationary or non stationary is usually checked by several methods such as Philip Perron (Philip & Perron, 1988), Augmented Dicky Fuller test ADF (Dickey & Fuller, 1979), Elliott-Rothenberg-Stock (ERS) test (Elliott, Rothenberg & Stock, 1996) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests (Kwiatkowski, Phillips, Schmidt, & Shin, 1992). This work employs the use of Elliot Rothenberg and Stock and Augmented Dicky fuller test (ADF). Usually the hypothesis is set in favour of the unit root process against an alternative of no unit root process. In instances where the null hypothesis cannot be rejected, it is concluded that the series are non stationary. But if the different series have different order of integration, then they are not integrated collectively (Babiker & Abdalla, 2009). On the other hand, if the series contain stochastic trends and are integrated of the same order, the series are said to be co-integrated (Maddala & Kim, 1998).

Engle-Granger Test for Cointegration

To test for cointegration between two or more non-stationary time series, it simply requires running an OLS regression, saving the residuals and then running a unit root test on the residual to determine if it is stationary. The time series are said to be cointegrated if the residual is itself stationary. In effect the non-stationary I(1) series have cancelled each other out to produce a stationary I(0) residual.

$$y_t = \beta_0 + \beta_1 x_t + u_t$$

Where y_t and x_t are non-stationary series.

Johansen's Multiple Cointegration Model

According to Babiker and Abdalla (2009), simple cointegration tests developed by Granger (1986); Engle and Granger (1987) failed to address linkages between more than two series because they were developed in a bivariate framework. They however, added that a better and more powerful test of cointegration was developed by Johansen (1988); Johansen and Juselius

(1990) and thus enabling analysis to be conducted in a multivariate framework. Under the Johansen's procedure, cointegration among the price series is tested using Johansen's maximum likelihood test based on the error correction representation or a reduced rank model also known as the vector error correction model (VECM). The multivariate system is specified as

$$\Delta p_t = \varphi_1 \Delta p_{t-1} + \cdots + \varphi_{k-1} \Delta p_{t-(k-1)} + \pi p_{t-k} + \pi p_{t-k} + \mu + \varepsilon_t$$

This can be rewritten as

$$\Delta p_t = \sum_{i=1}^{i=k-1} \varphi_i \, \Delta p_{t-1} + \pi p_{t-k} + \mu + \varepsilon_t$$

where pt is (n x 1) vector of I(1) variable, Δ pt = pt – pt-1, φi and π are (n x n) coefficient matrices, (t) is time, t = 1, 2,…, T, k = 1,2,…, t -1, μ is constant, and εt is an error term. The latter two are both (nx 1) vectors. When there are r linearly independent co integrating vectors, π could be rewritten as αβ,where both αand β are (n x r) matrices with rank r.β contains the cointegrating vectors and is n x (n -1) matrix.

According to Jha, Bhanu, and Sharma (2005); Hong and Felmingham, (2006); Siliverstovs L'Hégaret, Von Hirschhausen, and Neumann, (2005), if we have (n) endogenous variables, each with one unit root, there can be from zero to n -1 linearly independent cointegration relations i.e. r = n – 1, if the locations share the same long-run information. α is n x (n -1) matrix of coefficients or adjustment parameters, and is known as the speed of adjustment coefficient of the error correction term. This measures the average speed of convergence of the series in question towards the long-run equilibrium. If α equals zero, then this series does not participate in the adjustment back towards equilibrium and is described as being weakly exogenous Johansen's procedure allows us to test the coefficients αandβ, using several likelihood ratio tests. In other words, the rank of π in equation equals the number of cointegrating vectors, which is tested by maximum eigenvalue and likelihood ratio test statistics (Johansen, 1988; Johansen & Juselius, 1990). If there are co-movements between prices, then there is a possibility that they will trend together in finding a long-run stable equilibrium relationship. For any commodity complexes to be integrated in the true sense, they must share a common trend and therefore should have one common integrating factor.

According to Gonzalez-Rivera and Helfand (2001), for there to be a common integrating factor among the integrated prices, all the price series must be cointegrated and the rank (r) of π must be (n -1), which should equal the number of cointegrating vectors. In a situation where there are fewer than (n-1) cointegrating vectors, there would be more than one common trend. Supposing there are four cointegrating vectors among six non-stationary variables, this would mean that there are at least two common trends. In such a situation, some prices could be generated by the first common trend, some by the second and some by a combination of the first and second trends. Such prices cannot be considered integrated, since the long-run movements in prices would be governed by different components (Kumar & Sharma, 2003).

Johansen's approach estimates the VEC model under various assumptions about the trend or intercept parameters and the number of (r) the cointegrating vectors, and then conducts likelihood ratio tests. Assuming that the VEC model errors (et) are independent and normally distributed Nn $[0,\sigma^2]$, and given the cointegrating restrictions on the trend or intercept parameters, the maximum likelihood Lmax(r) is a function of the cointegration rank (r). Johansen (1988) proposes two tests for (r), as follows:

i) The lambda-max test

This is described by the following equation:

$\lambda max(r) = -TLn(1\text{-}ln)^1$

This test is based on the log-likelihood ratio Ln[Lmax(r)/Lmax(r+1)], and is conducted sequentially for r = 0, 1,.., k -1. It tests the null hypothesis that the cointegration rank is equal to (r) against the alternative that it is equal to (r+1).

ii) The trace test

$\lambda\ trace(r) = -T \sum_1 (i = r + 1)\, n \equiv [Ln(1)]$

Similarly, the trace test is based on the log-likelihood ratio Ln[Lmax(r)/Lmax(k)], and is conducted sequentially for r = k -1,..., 1,0. The name comes from the fact that the test statistic involved is the trace of a diagonal matrix of generalized eigenvalues. The trace test tests the null hypothesis that the cointegration rank is equal to (r) against the alternative that it is equal to (k). The latter implies that the trend is stationary. In addition, if the cointegration rank is zero the series are not cointegrated and if the rank is (k – 1) the series are cointegrated. Johansen's maximum-likelihood technique is a multivariate technique; it makes it possible to test more than two series at a time (Johansen, 1988; Johansen & Juselius, 1990).

Error Correction Model

The cointegration only considers the long-run property of the model, and does not deal with the short-run dynamics explicitly. However, a good time series modelling should describe both short-run dynamics and the long-run equilibrium simultaneously. For this purpose an error correction model (ECM) is specified. According to Engle and Granger (1986), the principle behind the error correction model is that there often exists a long run equilibrium relationship between two economic variables and in the short run, however, there may be disequilibrium. With the error correction mechanism, a proportion of the disequilibrium is corrected in the next period. The error correction process is thus a means to reconcile short-run and long run behaviour.

A basic error correction model would appear as follows:

$$\Delta y_t = \chi_0 + \chi_1 \Delta x_t - \tau(u_{t-1}) + \varepsilon_t$$

Where τ is the error correction term coefficient, which theory suggests should be negative and whose value measures the speed of adjustment back to equilibrium following an exogenous shock. The error correction term u_{t-1}, which can be written as: $(y_{t-1} - x_{t-1})$, is the residual from the cointegrating relationship.The error correction term is obtained from the OLS regression (Rapsomanikis, Hallam, & Conforti, 2004).

Diagnostic Tests

In econometric analyses, care must be taken to determine the appropriate estimator. The choice of estimator depends on the model to be estimated and the properties of the data. In this analysis, diagnostic tests are used to test for no serial correlation and heteroskedasticity.

No Serial Correlation

Standard errors are underestimated when the assumption that the residuals are independent is violated. The null hypothesis of the test is that there is no first-order autocorrelation. If e_t is the residual associated with the observation at time t, then the test statistic is

$$d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2},$$

where$T$ is the number of observations. Since d is approximately equal to $2(1-r)$, where r is the sample autocorrelation of the residuals, $d = 2.0$ indicates no autocorrelation (Cameron & Trivedi, 1990).

The value of d always lies between 0 and 4. If the Durbin–Watson statistic is substantially less than 2.0, there is evidence of positive serial correlation. As a rough rule of thumb, if Durbin–Watson is less than 1.0, there may be cause for alarm. Small values of d indicate successive error terms are, on average, close in value to one another, or positively correlated. If $d > 2.0$ successive error terms are, on average, much different in value to one another, that is, negatively correlated.

Homoskedasticity

The linear regression model is based on the assumption of homoskedasticity. Homoskedasticity is observed when the variance of the error term is constant. When this assumption is not satisfied (i.e. there is heteroskedasticity), OLS estimates remain consistent but the standard errors are no longer valid as they are underestimated. To test for homoskedasticity, the '*Imtest'* function was used in statistical R programming language (Cameron & Trivedi, 1990). The '*Imtest'* in the R programming language could also be used as it has the convenient null hypothesis of constant variance. The '*Imtest'* performs three versions of the Breusch-Pagan (1979) and Cook-Weisberg (1983) test forheteroskedasticity.

Model Selection

This study uses a general to specific modelling approach. Wasserman (as cited by Acquah, 2010), stated that model selection refers to the problem of using the data to select one model from the list of competing models. Essentially, it involves the use of a model selection criterion to find the best fitting model to the data. There are a number of model selection criteria, but in this study the Akaike information criteria (AIC) and Schwarz Bayesian information criteria (SBIC) are employed based on numerous advantages and because they are the most widely used ones in literature.

Akaike Information Criteria

The Akaike information criterion is a measure of the relative goodness of fit of a statistical model. It was developed by Hirotsugu Akaike, under the name of "an information criterion" (AIC), and was first published by Akaike in 1974. The AIC is one of the most frequently used information criteria due its ability to minimize the amount of information required to express the data and select models that are efficient representation of the data (Acquah, 2010). It functions on the principle of selecting the model that minimises the negative likelihood penalised by the number of parameters and thus the minimum AIC value is used for the selection of the best fitted model.

$$AIC = -2\log(L) + 2k$$

Where L refers to the maximum value of the likelihood function under the fitted model and k is the number of parameters in the model. Specifically, AIC is aimed at finding the best approximating model to the unknown true data generating process and its applications draws from (Akaike, 1973; Bozdogan, 1987).

Schwarz Bayesian Information Criteria

This is a criterion for model selection among a finite set of models. It is based, in part, on the likelihood function, and it is closely related to Akaike Information Criterion (AIC). When fitting models, it is possible to increase the likelihood by adding parameters, but doing so may result in over fitting. The BIC resolves this problem by introducing a penalty term for the number of parameters in the model. The BIC generally penalizes free parameters more strongly than does the Akaike information criterion, though it depends on the size of n (the number of data points in xor sample size) and relative magnitude of *n* and k *(*the number of free parameters to be estimated*)*. Schwarz Bayesian Information Criteria (SBIC) is closely related to the Akaike information criterion (AIC).

$$BIC = -2 \log (L) + k \log (N)$$

Where *L* refers to the maximum value of the likelihood function under the fitted model, kis the number of parameters in the model and N is the number of observations or sample.

Conceptual Framework

There exist complex dynamics between economic and non economic variables and cassava price causing output price volatility which is an epitome of output price risk. Output price risk is the result of many variable economic factors; inflation, interest rate, exchange, and policy and non economic factors; crop yield, weather, and so forth. This risk negatively affects the welfare of farmers in particular and economic wellbeing of the nation in general. Consequently, farmers adopt risk management strategies to improve their welfare.

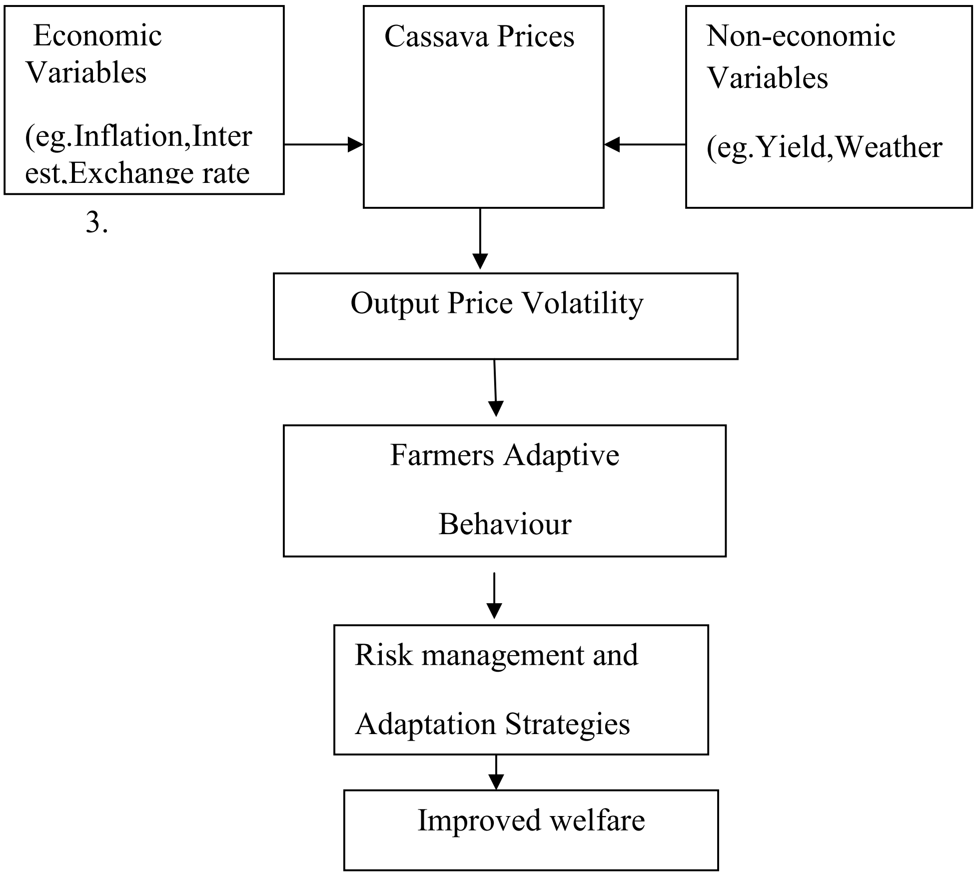

Figure 1: Conceptual Framework of the Study.

Source: Author's construct

CHAPTER THREE

METHODOLOGY

Introduction

This chapter presents the research design, data needs and sources, population, sample and sampling procedures, instrumentation, data collection and data analysis.

Research Design

The study employed descriptive-correlational survey design for the topic under investigation. The descriptive-correlational survey design was deemed appropriate as it involves the description of the selected cassava farmers in terms of their socio-demographic characteristics, risk management strategies and their constraints. In addition, as discussed by Saunders, Lewis and Thornhill (2007), the survey strategy is perceived as authoritative by people in general and is both comparatively easy to explain and to understand. Surveys are simple and flexible and suitable for evaluating a programme or project that has been implemented.

The researcher employed the correlational study design because the study sought to identify relationships between sets of variables (dependent and independent).Another aspect of the study is the longitudinal nature which entails describing processes occurring over time and thus conducting their observations under extended period of time; such is appropriate for repeated observations of the same items over a long period (Rubin & Babbie, 2001). The flexibility of the design coupled with the combination of qualitative and quantitative approaches facilitated the gathering of the required data on time. Both quantitative and qualitative types of research have their strengths and weaknesses. According to Jick (1979), qualitative and quantitative methods can be considered as complement to each other. The qualitative approach, though expensive and time consuming can control for both the end points and the pace of the research process whilst preventing problems related to rigour and objectivity (Yates, 2004). Furthermore, qualitative approach is helpful in giving rich explanations of complex phenomena and creating evolving theories or conceptual bases, and in proposing hypotheses to clarify the phenomena. The major disadvantage of this approach is that a small group of interviewed individuals cannot be taken as representative.

The quantitative approach is advantageous because of the ease and speed with which research is conducted and also its wide coverage of a range of situation (Amarantunga, Baldry, Sarshar, & Newton, 2002). Using the quantitative method in analysing data with statistical methods facilitates generalization and the final results are based on actual quantities rather than interpretations, which may simplify potential future development and comparisons with the work. This approach does not tend to be inflexible, artificial and ineffective in gauging the significance people attach to actions, it is helpful in generating theories (Crotty, 1998).

Data Types, Needs and Sources

Primary and secondary data were used for the current study. The use of secondary data was essential to adequately capture past output prices pattern, estimates risk level and determinants of price and volatility of cassava. Primary data was collected on farmers' socio-economic characteristics, risk management measures in response to output price risks and their constraints from the farmers. Information on government policy on agricultural price stabilization was elicited from the district MoFA directors.

Secondary data was used to analyse output price trend and volatility, estimate the level of risk and determinants of cassava price and volatility. The data on cassava prices and annual production were obtained from the Statistical Research and Information Directorate (SRID) of MoFA (from 1970-2012, a period of 43 years) while interest rate and exchange rate data were obtained from Bank of Ghana. Data on inflation and weather were obtained from Ghana Statistical Service and Ghana Meteorological Service respectively as these, according to literature, influence price variability.

Study Population and Area

The target population for the study was cassava farmers and District Directors of Agriculture in the Volta Region of Ghana. The region is one of the ten (10) Regions of the Republic of Ghana with 19 administrative districts. Geographically, Volta Region lies at the eastern side of Ghana. Volta Region share common boundaries with four (4) major regions of Ghana namely, Greater Accra, Eastern, Brong Ahafo and Northern regions. According to the 2010 Population and Housing Census, Volta region recorded a population of

2,118,252. The sex structure of the population shows that 48.12% of the population was male and 51.88% female with the annual growth rate of 1.9%

The Volta Region is located at 3^{o} 45' latitude N and 8^{o} 45' longitude N. It covers a total land area of 20572 km^{2} and stretches from the coast of Gulf Guinea running through all the vegetational zones found in the country. The region has a length of about 500 km stretching from the south to the north and its vegetation can be categorized as (a) The coastal strand Mangrove Swamps, (b)The woodland Savannah, (c) Savannah grassland, (d) The Mangrove Swamps, and (e) The Deciduous Forest. The topography of the region has a low-lying altitude from less than 15 meters above sea level at the coast and 855 meters including mountain Afadzato being the highest point. The region have the world's largest man-made lake, river Dayi, Oti, Daka several seasonal streams like Aka, Agali, Kplikpa etc. The soil type ranges between heavy clay to sandy loams, that is, heavy clay loams, sandy loams and alluvial soils.

The region has tropical climate, characterized by moderate temperature, 12 ^{o}C to 32 ^{o}C for most of the years. The rainfall pattern is bi-modal, that is, it has two rainfall regimes in the year, the first from March to July and the second from the mid-August to October. Rainfall figures, which vary greatly throughout the region, are highest in the central highland areas and in the forest zone; they are lowest in the Sahel-savannah zone in the north of the region. The annual rainfall ranges from 513.9 mm and 1099.88 mm.

Agriculture plays a vital role in the socio-economic development of the Region since Gold Coast and then to the present Ghana. The Region's economy is mainly rural and dominated by agriculture and employs about 74% of the economically active population. The main sub-sectors include Crops, Livestock, Fisheries, Agroforestry and the Non-Traditional Commodities. The average holding is about 0.46 Ha. The Region cultivates industrial and food crops such as Cereals, Legumes, Vegetables, Oil trees, Root and Tubers, Pulses and plantation crops. Nonetheless, the Region is endowed with rich vegetation that supports rearing of livestock of many species. The farming practices that dominates are mono-cropping, mixed cropping and mixed farming.

Sample and Sampling Procedures

Selection of Districts

The study employed the multi-stage sampling procedure. Firstly, purposive sampling technique was used in the selection of the districts. Purposive (judgemental) sampling according to Frankfort-Nachmias, and Nachmias (1996) is the process of selecting sampling units subjectively to obtain a sample that appears to be a representative of the population, and the underlying assumption as the representativeness of the selected sample to their respective populations. The selection criteria were based on the volume of cassava produced, geographical distribution and consistency with the secondary data that were collected. The high production records coupled with diverse agro-ecological zones influence the choice of Volta region for the study. The selected districts in the region are Jasikan, Kadjebi, Hohoe, Keta, Ketu-North, Ketu-South, Kpando, Adaklu, Krachi-East, Krachi west, Nkwanta North, Nkwanta South, North Tongu and South Dayi districts.

Selection of Communities

In selecting the study areas in the districts chosen, a sampling frame of the number of cassava growing communities in each district was obtained from MoFA. Then the lottery method of simple random sampling was used to select four communities from each district. Data were then collected from these selected communities.

Table 1: Sample Size Distribution from the Selected Districts

Districts	Population	Sample Size
1. Jasikan	59,181	32
2. Kadjebi	59,303	32
3. Hohoe	262,046	42
4. Keta	147,618	38
5. Ketu-North	99,913	32
6. Ketu –south	160,756	38
7. Kpando	124,543	38
8. Adaklu	64,404	32
9. Krachi-East	116,804	38
10. Krachi-West	122,105	38
11. Nkwanta-North	64,553	32
12. Nkwanta-South	117,878	38
13. North-Tongu	149,188	38
14. South-Dayi	46,661	32
Total		**500**

Source: Field data, 2014

Sample Size

The size of the sample influences both the representativeness of the sample and the statistical analysis of the data.The larger the population size, the smaller the percentage of the population required to get a representative sample (Jacob, 2010). According to him, beyond a certain point (N = 5000), the population size is almost irrelevant and a sample size of 400 may be adequate. Due to the infinite nature of the population as well as the homogeneity in their activities, a total sample size of 514 (500 farmers and 14 District Directors of Agriculture) was used for the study. The simple random and proportional sampling techniques were then used to obtain the required sample size. This selection of farmers was done in a proportional manner in relation to the population in these districts. All the 14 MoFA directors in the selected districts were selected using census. For the secondary data, the sample size of 43 was chosen using desk research, carefully collecting the already available data.

Instrumentation

The primary data were collected through the use of self-administered questionnaires and interview schedule. Interview schedule was used for the farmers while questionnaire was used for the district MoFA directors. The questionnaire and interview schedule were specifically designed to measure variables proposed by all the various theories reviewed in the related literature. The variables were broadly categorised into socio-demographic characteristics, output price change information, production and marketing information, risk management strategies for output price risk and their constraints.

Two categories of research instruments were designed; one each for farmers and the MoFA district directors of Agriculture. The interview schedule for the farmers was grouped into 32 items with four sections, A-D. Section A was made up of 9 items that elicited information on the socio-demographic characteristics of the farmers. Section B was on output price information; Section C was on production and marketing information, and lastly section D, which was on the farmers' risk management strategies and their constraints. The questionnaire which comprised 6 items was used for the district directors of agriculture. Desk research was used to obtain the secondary data such as cassava price, cassava yield, inflation rate, exchange rate, rainfall, temperature and interest rate.

Key (1997) stated that content validity is not an easy task and therefore suggested panel of experts in the field of study are used to assess it. In this regard, the research instruments were given to supervisors and other experts in other institutions to assess its content. Based on their comments, some modifications were made.

Pilot-Testing

The research instruments for the primary data collection were pre-tested in the North Dayi district on the 4th January, 2014. The purpose of the pilot-test was to identify errors associated with the instrument and omit double barreled questions and ambiguous statements. Furthermore, pilot testing was conducted to detect issues that were not anticipated and to assess 1) Clarity of questions, 2) whether the questions are understandable and 3) whether the order and wording of the questions elicited the desired responses. The total number of questionnaires administered was 30. Based on the responses provided, modifications were made in the research instruments before administration.

Data Collection Procedure

The primary data collection began on the 7th of January, 2014 and ended on 2nd February, 2014. Ten field assistants were selected by the researcher to aid in the data collection. They were trained to understand the concept of the study including the objectives, purpose and methods of data collection. They were also trained to have a common understanding of the questions of the research instruments and to ask the questions to the understanding of the respondents. The selection criteria were as follows: (1) relevant educational background, (2) Previous research experience and (3) Knowledge of the local language (Twi and Ewe). The instruments were explained to the respondents in the local dialect and then recorded by the field assistants in English.

On the other hand, the secondary data were collected from the Statistical Research and Information Directorate (SRID) of the Ministry of Food and Agriculture, Bank of Ghana, Ghana Statistical Services and Ghana Meteorological Service. The data were collected from the selected districts.

Data Analysis

In estimating the output price risk in terms of Value-at-Risk(VAR), The first step determines the structure and therefore the treatment of the dataset followed by the Verification for conditional and unconditional model, then distributional assessment (tail determination), Estimation of output price risk, Model evaluation and Back testing.

VaR is defined as follows:

$$VaR = E(V) - V*$$

E(V) means the expectation of V and the critical revenue *V** is defined by:

$$VaR = E(V) - V*$$

$$\int_{-\infty}^{V*} f(v)dv = prob(v \leq V*) = p$$

Using the identity:

$$V = W_{t0} \times X$$

$$X = \log (W_{t1} / W_{t0})$$

VaR can also be expressed in terms of the critical return *X**:

$$VaR = W_{t0}(E(X)X*)$$

E(X) and *X** are defined analogous to *E(V)* and *V**. From this it is obvious, that the calculation of VaR boils down to finding the *p*-quantile of the random variable *V*, i.e. the profit-and-loss-distribution.

The Analytical Framework for Value-at-Risk Estimation

The estimation of value-at-risk begins with the assessment of the type of distribution underpinning the data. This can be done with Jarqe bera and Lagrange multiplier test. When the data is normally distributed, then parametric method of value-at-risk estimation such as variance-covariance method is used. However, if the data is not normally distributed, then non-parametric method such as historical method is used for the estimation of value-at-risk.

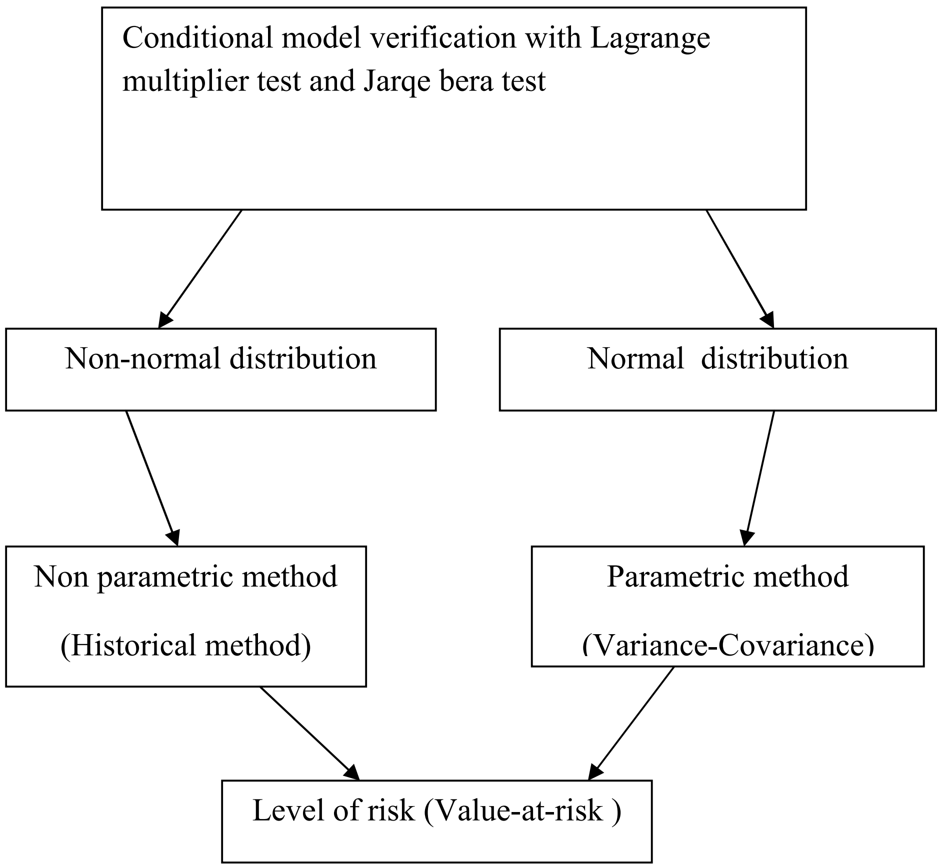

Figure2: Analytical Framework for Value-at-Risk Estimation

Source: Author's construct

Secondly, in examining the determinants of output price changes or volatility, the first step determines the structure and therefore the treatment of the dataset. The next step is to test for the presence of a unit root using appropriate tests according to data structure. Depending on the results of this test, the series is either kept in level form or tested for the presence of cointegration. If cointegration is found, an error correction model (ECM) is considered, otherwise the variables are analysed in first differences. Series of diagnostic tests is performed to detect the presence of serial correlation and heteroskedasticity. All regressions and tests are implemented using R programme and Stata 11.0 .

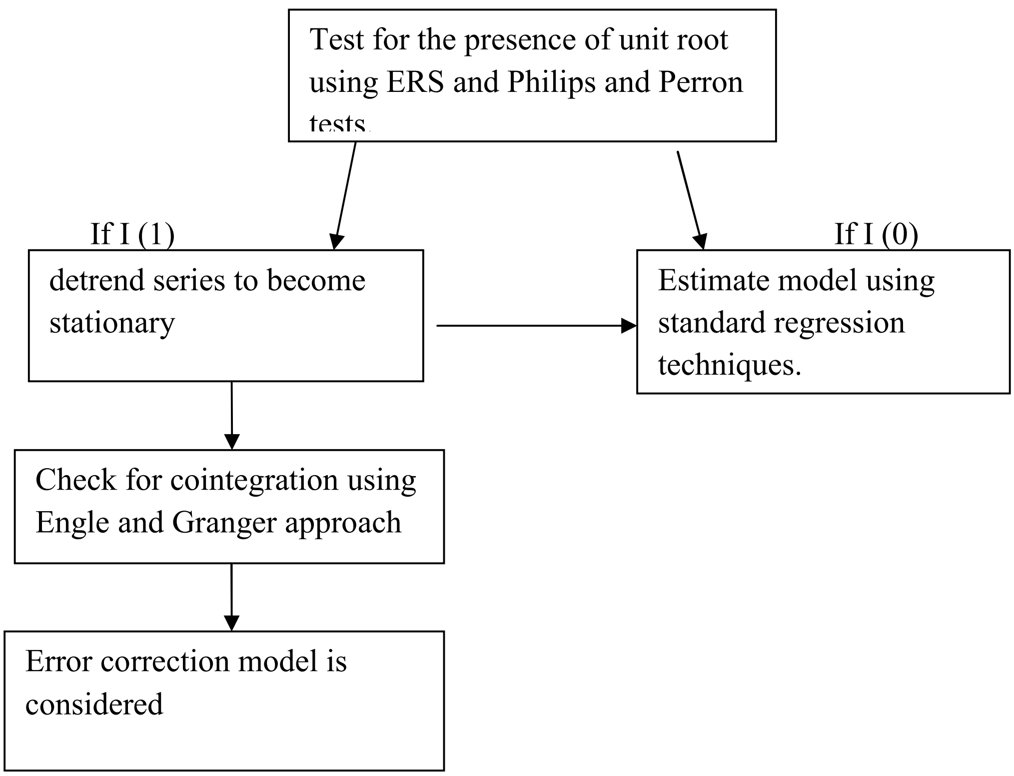

Figure 3: Analytical Framework for Time Series Analysis.

Source: Author's Construct.

Before fitting the regression model, it is necessary to determine whether or not the data are stationary. This would enable us to determine whether "standard" regression techniques can be used or if a cointegration approach is required.

There are several tests that exist to test for the presence of non-stationarity of time series. In this study, Augmented Dickey-Fuller test and Elliott-Rothenberg- Stock (ERS) tests were used due to their popularity and high estimation power. The determination of the lag length is essential as the ERS is based on an autoregressive regression and lags of the dependent variable are used to avoid serial correlation. Because of the small sample size, selection of the optimal lag length is based on the Schwart Bayesian Information Criteria (SBIC) and in order to keep the sample as large as possible, the test was re-implemented with the maximum lag value reduced to the optimal lag length. As the data generating process is not known a priori, a constant and a time trend are included. The ERS procedure tests the hypotheses:

$H_0: \alpha_0 = 0$ and $H_1: \alpha_0 < 0$

Where H_0 is the null hypothesis of the presence of a unit root and H_1 is the alternative hypothesis of stationarity. Cointegration and diagnostic tests (for no serial correlation and heteroskedasticity) were then performed.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This chapter presents results and discussions of the study. The first section describes the socio-demographic characteristics of the respondents. The second section examines the output price trend and volatility of cassava and farmers' perceptions of output price change. The third section highlights the level of risk (value-at-risk) associated with cassava output price. Section four presents results on the variables that determine the output price and volatility. Section fives talks about the various risk management strategies adopted by the farmers. Section six presents the constraints faced by farmers in risk management and some government policies in cassava industry in the study area.

Socio-Demographic Characteristics of Respondents.

Sex Distribution

There were a total of 500 respondents interviewed, with the exception of 14 district MoFA directors, in the study; 305(61.0%) were males and 195 (39.0%) were females as shown in Table 2. This result shows that cassava farming in the study area is highly dominated by males. This result is consistent with report by United State Department of Agriculture [USDA],

(2007) which stated that agriculture has experienced a paradoxical shift from women domination to men domination in sub Saharan Africa. The result, however, contradicts an empirical finding by Baden (1998) who reported that, it is erroneous and misplaced to ascribe farming in sub Saharan Africa as male dominated. This discrepancy may be due to time variation that has caused females to focus on post-harvest activities such as marketing thus leaving more of their male counterpart to on-the-farm work (USDA, 2007).

Table 2: Sex Distribution of the Farmers

Sex	No.	%
Male	305	61.0
Female	195	39.0
Total	500	100.0

Source: Field data, 2014

Marital Status of Farmers

Within the 500 farmers that were interviewed and reported in Table 3, 14.0% were never married, 80.0% were married while 3.2% were divorced and the remaining 2.8 were widowed. This explained clearly that since married people predominate in the data, cassava farming is an activity of married people although a few percentage of divorced, never married and widowed took part in farming as well. The finding that married people dominated in the agricultural sector in the studied area concurs with earlier report by Danso-Abbeam (2010); Falola, Ayinde and Agboola (2013), that farming is dominated by married people in Ghana and Nigeria respectively.

Table 3: Marital Status of Farmers

Marital Status	No.	%
Never married	70	14.0
Married	400	80.0
Divorced	16	3.2
Widowed	14	2.8
Total	**500**	**100.0**

Source: Field data, (2014)

Age Distribution

The result in Table 4 indicates that the dominant age group of farmers was 51-60 years representing 32.0% while the least age group representing 8.8% of farmers were within 71-80 years. The result further reveals that 70.0% of farmers were above 40 years. This result confirms the report USDA (2007) that the fastest growing group of farm operators is the older group". This finding also tends to confirm those of Andoh (2007), who found out that farming in rural communities has been left for the older generations and assigning reasons such as the lack of lucrativeness of the farming enterprise for the younger generation.

Table 4: Frequency Distribution of Age of Farmers

Age of respondents	No.	%
21-30	65	13.0
31-40	85	17.0
41-50	86	17.2
51-60	160	32.0
61-70	60	12.0
71 -80	44	8.8
Total	**500**	**100.0**

Source: Field data, 2014

Educational Level

Educational levels of respondents for this study ranged from no formal to the tertiary levels. The results in Table 5 show that only 1.6% of farmers had tertiary education while 40.0% and 45.2% had no education andJHS/MLSC education respectively.This finding concurs with report by USDA (2007) which states that farming in developing countries is dominated by people with low level of education. The finding is also parallel to the assertion of Asenso-Okyere cited in Owusu (2011) and Andoh, (2007) who indicated that increase in education reduces the proportion of poor people in society. This high level of illiteracy among farmers may negatively affect their adoption behaviour towards technology. In addition, in view of Ebewore and

Emuh (2013), literacy level among the farmers is a crucial factor in the adoption of innovation and technology.

Table 5: Frequency Distribution of the Educational Level of Farmers

Educational Level	No.	%
No formal education	200	40.0
Primary school	51	10.2
Middle / Junior High School	226	45.2
O Level / Senior High School	15	3.0
Tertiary level	8	1.6
Total	**500**	**100.0**

Source: Field data, 2014

Farming Experience

In terms of farming experience, Table 6 reveals that 48.0% of the farmers have been farming for over twenty (20) years. This is followed by those who have farmed for between 16-20 years representing 40 percent. The least number of years of farming was 0-4 years (2.0 %). This suggests that the farmers began farming in their early years (USDA, 2007).

Table 6: Years of Farming Experience of Farmers

Years	No.	%
0-4	10	2.0
5-10	20	4.0
11-15	30	6.0
16-20	200	40.0
Above 20	240	48.0
Total	500	100

Source: Field data, 2014

Farm Size

Table 7 reveals that 66.0% of the farmers had 0-4 acres while 8.0 % had 10-14 acres with a mean farm size of 3 acres. This result clearly reveals that the farm sizes under cultivation are small. The finding is consistent with the IFAD (2005) statement that cassava is produced on a small scale. Furthermore, Andoh (2007); Aryeety and Nyanteng (2006) asserted that food crop production is predominantly small scale in terms of the area cultivated. The small land areas under cultivation may be attributed to the land tenure system in the production areas. Another critical factor that could have accounted for this is the unavailability of market facilities for the produce and the fact that the crop is highly perishable.

Table 7: Size of Farm in Acres

Farm Size	No.	%
0-4	330	66.0
5-9	166	33.2
10-14	4	0.8
Total	500	100.0

Source: Field data, 2014

Cassava Price Trend and Volatility in the Study Area

A graphical illustration of cassava output price has been depicted in Figure 4 to examine the price movement and fluctuations over the period. Thelast decade (1992-2012) recorded the highest level of price variability as compared to the previous decades which recorded higher to relatively low level of fluctuation. This current fluctuation may be attributed to unstable economic variables such as inflation, exchange rate and so forth as they show significant relationship with the output price of cassava. This result is consistent with Huchet (2011) who reported that the degree of price fluctuation of most agricultural commodities is higher over the last decade than the previous. Other studies which confirm the result include Gilbertand Morgan (2010) who agreed to high fluctuation of agricultural prices. In addition, International Institute of Tropical Agriculture [IITA] (2004) also disclosed that agricultural output prices increase over time but at decreasing rate.

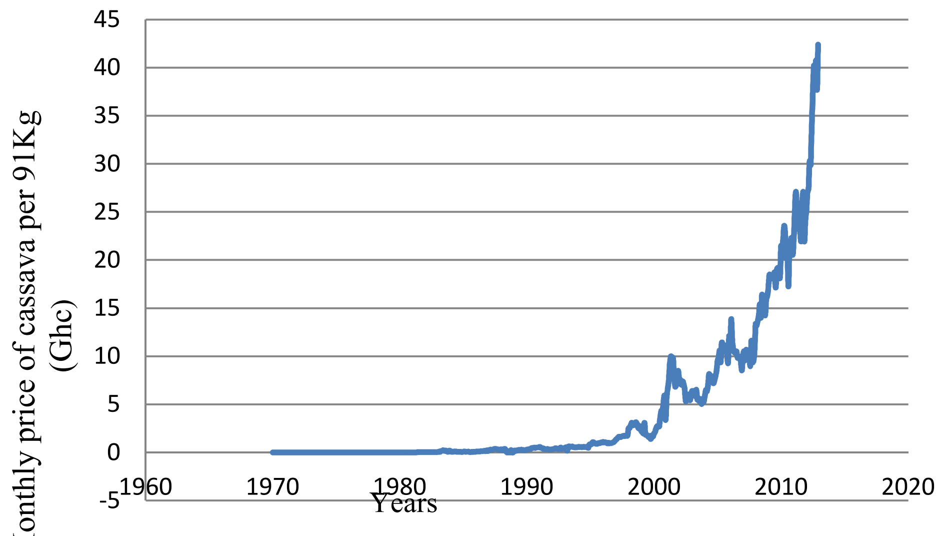

Figure 4: Monthly Prices of Cassava Per 91Kg

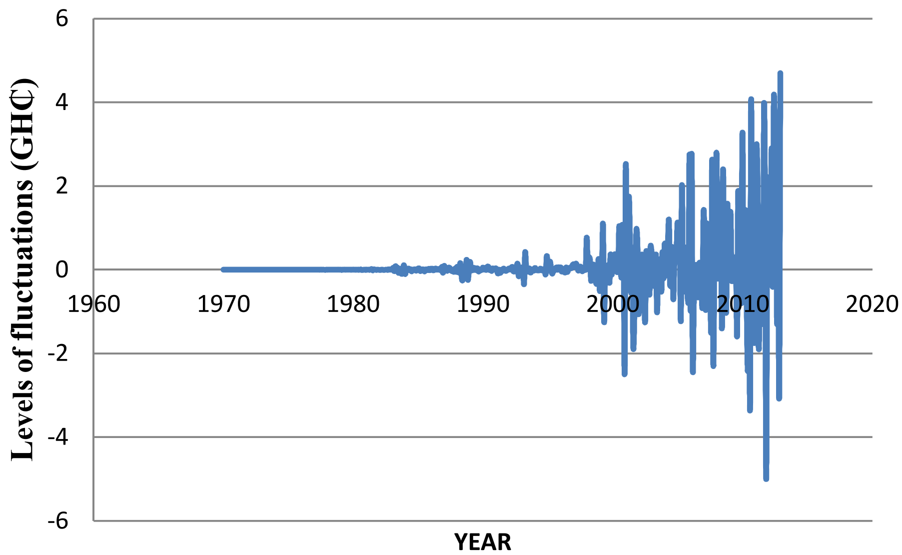

Figure 5: Levels of Fluctuations of Cassava Price

Cassava price trend was analysed (by regressing the series on time) and results displayed in Table 8. The result shows that cassava price increasing significantly by 46.1% every year. Also, 56.3% of the variation in the price of cassava occurs over time while F statistics shows the significant of model in fitting the data.

Table 8: Regressing the Series on Time

Response variable: cassava price in Gh¢ (log)	
Variable	Coefficients
Intercept	-913.990(126.425)***
Time(year)	0.461(0.063)***
R^2	0.563
F statistics	52.77***
Adjusted R^2	0.552

Notes: standard errors in parentheses; *** denotes significance at 0.1% level.

Source: Field data, 2014

In splitting the entire period into sub-periods of ten years as proposed by Huchet (2011), Table 9 provides a relatively crude visual indication of whether volatility has been changing over time.The result shows that volatility in cassava price estimated with coefficient of variation, a standard statistical measure recommended by FAO, (2011), is increasing and is relatively highest during the last decade (2002-2012) to about 102.0 % than during the previous three decades while the least volatility was recorded within 1970-1980 representing 0.1% . Furthermore, the volatility recorded for the entire period was 177.8% while 30.8% is recorded annually. The trend and the degree of volatility in Table 9 confirm a report by FAO and IMF (2011). Another study with similar findings includes (Pierre, Morales-Opazo & Demeke, 2014). In addition, volatility equality tests was conducted with analysis of variance

(ANOVA) to make comparisons over time and to see if a clear picture of the price volatility emerges within and between the groups. The result shows that volatility varies significantly at 0.1% significant level within and between the groups (Huchet, 2011).

Table 9: Price Volatility Estimates Using Coefficient of Variation and Analysis of Variance

Periods	Volatility (%)	P-value within groups	P-value between groups
1970-1980	0.1	2.21e-09 ***	2.21e-09 ***
1981-1990	2.3		
1991-2001	18.6		
2002-2012	102.0		
1970-2012	177.8		
Yearly	30.8		

Note: *** denotes significance at 0.1% level.

Source: Field data, 2014

According to FAO and IMF (2011), most agricultural commodity markets are characterized by a high degree of volatility. They indicated that three major market fundamentals explain why that is the case. First, agricultural output varies from period to period because of natural shocks such as weather and pests. Secondly, demand elasticities are relatively small with respect to price and supply elasticities are also low, at least in the short run. In order to get supply and demand back into balance after a supply shock, prices therefore have to vary rather strongly, especially if stocks are low. Third, because production takes considerable time in agriculture, supply cannot respond much to price changes in the short term, though it can do so much more once the production cycle is completed. Huchet (2011) also indicated that unstable economic variables such as inflation, exchange rate among others could be the potential cause of high volatility over the last decade.

Farmers' Perception of Change in Cassava Prices

With respect to price volatility, Figure 6 shows that 5.2% of farmers perceived an increase in cassava price, 4.8% perceived a decrease in cassava price while 90% perceived an irregular pattern (volatile) of cassava prices. This confirms the empirical price analysis reported in Table 9 which indicated high volatility in cassava price. The finding is also consistent with IMF (2009) which found that agricultural produce including cassava is highly volatile and fluctuates more especially in the period of unstable economic environment. The finding also concurs with an empirical work done by Matthew (2010) who registered high volatility and irregular pattern of agricultural produceincluding cassava prices, maize priced among others.

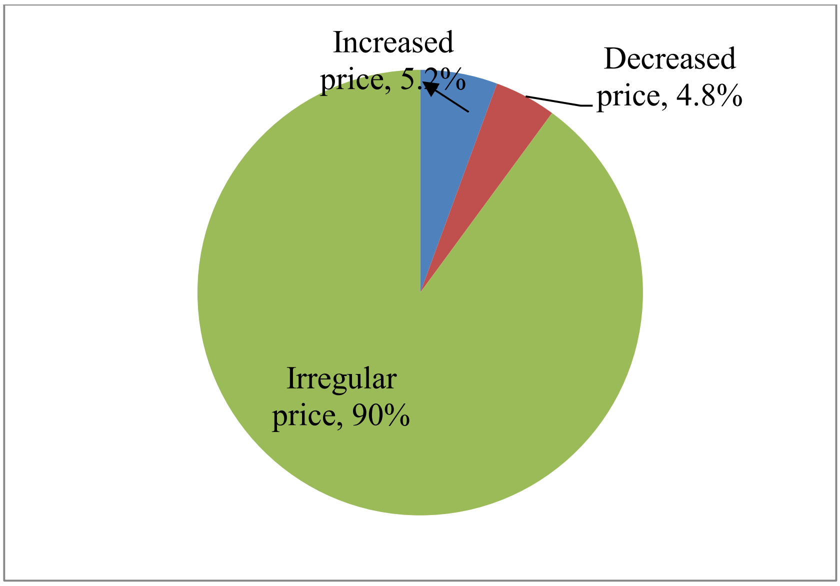

Figure 6: Farmers' Perception of Change in Cassava Prices

Source: Field data, 2014

Risk Level Associated with Cassava Price Using Different Model Specifications

The first step in estimating the level of risk value is to clarify, what kind of distribution underlies the market factor, that is, cassava output prices? This task breaks down into two questions: firstly, should a conditional or an unconditional model be used, and secondly, are the respective distributions fat tailed or thin tailed or otherwise? To answer the first question, a Lagrange Multiplier was used to test the presence of conditional heteroskedasticity (Greene, 2000). This test rejects the null hypothesis of the homoskedasticity for the monthly cassava output price changes as shown in Table 10. This again confirms the finding reported by Matthew (2010) that agricultural produce varies significantly over time thus making it very risky.

Table 10: Tests the Null of Conditional Homoskedasticity Using Lagrange Multiplier Test Statistic

Chi-squared	Df	p-value
11.58	3	0.0089

Source: Field data, 2014

Now turning to the question of whether the considered time series are fat tailed or not. At a first instance, this issue can be inspected by Q-Q plots, which compare the quantiles of an empirical distribution and a theoretical reference distribution. If the data points are approximately located on a straight line, it can be assumed that the observed data follow the reference distribution. In Figure 7, the normal distribution is chosen as a reference distribution. The Figure indicates a positive excess for the monthly changes of output price. Finally, the Jarque-bera-test, which summarizes deviations from the normal distribution with respect to skewness and kurtosis, provides further evidence about the non-normality of the distribution as shown in Table 11. Thus the test results provide evidence of non-normal distribution.

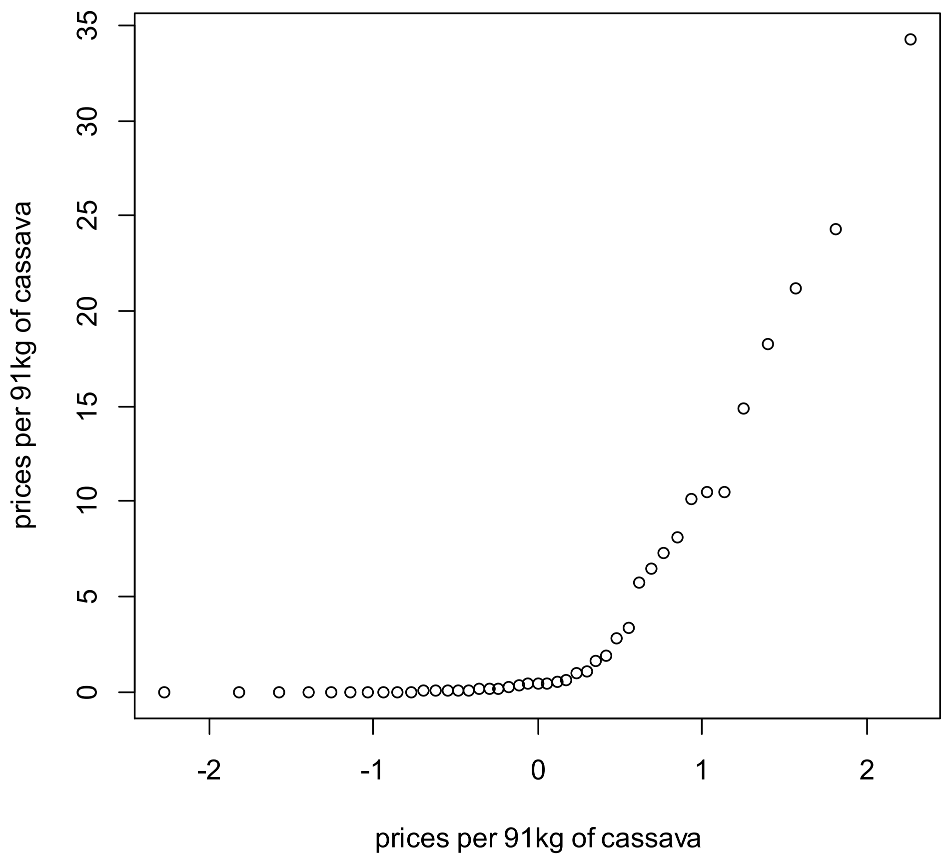

Figure 7: Q-Q Plot of Cassava Price Data

Table 11: Tests the Null of Normality for Cassava Price Using the Jarque Bera Test Statistic

X-squared	Df	p-value
72.3782	2	2.22e-16

Source: Field data, 2014

Based on the preceding test for model selection, historical approach for risk estimation was employed due to flexible assumption (that is no distributional assumption once access to complete date set is available), its high estimation power, easy computational procedure and interpretation (Manfredo & Leuthold, 1999).The result in Table12 shows that farmers face the risk of losing Gh¢1.358 for every 91kg of cassava at 95% confidence level. Thus farmers face the risk of losing Gh¢179million representing about 31% of their annual revenues. The finding is consisted with the finding of Manfredo and Leuthold (2001); Martin and Hinrich (2002) who, with a similar approach of estimating VaR, also indicated that farmers lose high amount of money due to output price risk. Another work done using VaR by Mounir (2004) identified high risk associated with agricultural output.

Table 12: Level of Risk (Value-At-Risk) of Cassava Per 91kg

Value-at risk (Gh¢)	Proportion of revenues loss (%)	Annual loss (Gh¢)
1.358*	31.0	179million

* shows 95% confident level

Source: Field data, 2014

In order to test the reliability of VaR estimate, Sean (2005) recommended back testing. This test is done by imposing the whole VaR estimation procedure to half the data set (backtest1,then further to half the data set back test 2) to ascertain whether or not the estimated value-at-risk with this data set will be equal to the actual loss. High deviation of the estimated VaR from the actual means the approach is not reliable and could lead to either overestimation or under estimation of the actual value lost. The result of back testing is displayed in Table 13.The Table shows that the VaR estimate for the first half of the data set was Gh¢ 0.0473 per 91kg at 95% confidence level as against the actual loss of Gh¢ 0.0315per 91kg,and Gh¢0.0025 per 91kgagainst the actual loss of Gh¢0.0012 per 91kgfor the second data set also at 95% level. As shown in the Table13, the estimated values and the actual are very close thus indicating that the approach is reliable. The test shows no significant difference between the estimated values and the actual values showing that the historical approach of risk estimation fits the data.

Table 13: Summary of Back test Results

	Backtest 1	Backtest 2	z-test,	p-value
VaR calculated in monthly(Gh¢)	0.0473**	0.0025**	3.01	0.50
Actual value lost	0.0315	0.0012		

** shows 95% confident level

Source: Field data (2014)

Determinants of Output Price and Price Volatility

This begins by examining the time series properties of the data for the study. Elliott-Rothenberg- Stock (ERS) unit root test of Elliott et al. (1996) and Dickey Fuller unit root test were performed on each variable in the series before models were estimated. The null hypothesis of a unit root was accepted for price, yield, inflation, interest rate, exchange rate and temperature. Rainfall was found to be stationary in levels. Consequently, the same tests were performed on the first difference of each variable and the presence of a long-run relationship is tested using Engle and Granger (1986) cointegration test.

Additionally, diagnostic tests of first order serial correlation and homoskedasticity were performed for each specification. Following these tests, tables reporting regression results were presented.

Model 1: Determinants of Cassava Prices

log (price) = β_0 + β_1(log yield) + β_2(log inflation) + β_3(log interest) + β_4(log exchange rate)+ β_5(log temperature) + $\beta_6$rainfall + ε

Table 14 summarizes the regression results of model 1 explaining cassava price as a function of cassava yield, inflation, interest, exchange rate, temperature and rainfall. This model allows us to investigate the influence of cassava yield, inflation, interest, exchange rate, temperature and rainfall on the first moment of cassava price.

Table 14: Parameter Estimates for Determinants of Cassava Prices

Response variable: log (price) in Gh¢	
Control Variable	Coefficient
Intercept	-11.276 (14.684)
Log (yield)	0.115 (0.196)
Log (inflation)	0.791 (0.164)***
Log (interest)	-0.528(0.278)
Log (exchange rate)	1.016(0.073)***
Log(Temperature)	3.66(4.285)
Rainfall	-0.007(0.006)
R^2	0.969
F statistic	191.1 ***
Adjusted R^2	0.965

Notes: standard errors in parentheses; *** denotes significance at 0.1% level.

Source: Field data, 2014

The results suggest that 96.9% of the variation in the cassava price (in Ghana cedis) is caused by the independent variables in the model as shown by R^2. The F-statistics test the overall significance of the regression model. The significant level of F-value implies that the independent variables in the model are good predictors of the dependent variable. The number of parameters and the degree of freedom accounted for by the Adjusted R^2 shows the fitness and goodness of each additional variable in the model since its value is close to the R^2.

The findings of the model show that inflation and exchange rate have positive and significant effects on the price of cassava. This means that a percentage change in inflation is expected to increase the price of cassava by 0.79 % and 1% increase in the exchange rate is expected to increase cassava price by 1.02%.This calls for effective management of these macroeconomic variables to provide continuous stable environment against price fluctuation. Moreover, variables such as yield and temperature have positive relationship with the price of cassava while interest rate and rainfall have negative relationship with cassava price though they are not significant.

The result is consistent with an empirical work by Gilbert (1989) which indicated that inflation level and its variability are major factors that influence food price volatility and can greatly affect the investors including farmers. This assertion is supported by IMF (2008) which also showed that fluctuations in inflation and exchange rate are condiments for output price volatility. The positive relationship between the price of cassava and the quantity supplied (cassava yield) is consistent with the economic theory which states a positive relationship between the price of a commodity and its supply. In addition, according to FAO (2011), trade in many agricultural commodities is denominated in USD. It further stated that a depreciating USD, as occurred in the years before and up to the peak of the price rises, causes dollar denominated international commodity prices to rise, although not to the full extent of the depreciation. These currency movements added to the amplitude of the price changes observed. They also help to explain why demand remained strong in countries where the currency was appreciating against the dollar and why falling prices were not fully felt in the same countries once the dollar began to appreciate again.

Model 2: Cointegration and Error Correction Modelling

Δ $Price_t = \beta_0 + \beta_1(\Delta$ yield$) + \beta_2(\Delta$ inflation$) + \beta_3(\Delta$ interest$) + \beta_4(\Delta$ exchange rate$) + \beta_5(\Delta$ temperature$) + \beta_6 (ECT_{t-1}) + \varepsilon$

This test is carried out to determine the long-run relationship between the non-stationary series in the study. According to Engle and Granger (1986), variables are cointegrated if they individually follow a unit root process, but jointly move together in the long run. That is if the prediction errors of the dependent variable regressed on the independent variable(s) are stationary, there is evidence of cointegration. According to the authors, the relationship between the variables can be expressed as an error correction model (ECM), in which the error term from the OLS regression, lagged once, acts as the error correction term. In this case the cointegration provides evidence of a long- run relationship between the variables, whilst the ECM provides evidence of the short-run relationship.

Table 15: Parameter Estimates for Error Correction Model

Response variable: Δ price in in Gh¢

Control Variable	Coefficient
Intercept	0.293 (0.072)
Δ yield	-0.004 (0.078)
Δ inflation	0.365 (0.085)
Δ Interest	-0.034 (0.201)
Δ Exchange rate	-0.115 (0.209)
Δ Temperature	1.761(1.563)
ECT_{t-1}	-0.229(6.956e-02)**
R^2	0.416
F statistic	191.5 **
Adjusted R^2	0.316

Notes: standard errors in parentheses; *** denotes significance at 0.1% level.

Source: Field data, 2014

From the Table 15, the speed of adjustment(error correction term) to restore equilibrium indicates that in the short run, 22.9% of any deviation from the long run path between the cassava price and the independent variables is corrected over the next period, that is every year. The error correction term in the model is statistically significant, confirming the existence of long run steady-state equilibrium between cassava price and the independent variables in the error correction model. The short term disequilibrium that is adjusted by the error correction term could result from structural or institutional break, macroeconomic policy failures or climatic change among others. The number of parameters and degree of freedom as accounted for by the adjusted R^2 shows the fitness and goodness of each additional variable since its value is close to the R^2. F statistics also shows the goodness of fit of the model implying that the independent variables are good predictors of the dependent variable (cassava price).

Determinants of Cassava Price Volatility

Before examining the determinants of cassava price volatility, a standard statistical measure called mean deviation was used to estimate the levels of volatility of cassava price over the period under consideration (FAO, 2011)

Model 3: Determinants of Cassava Price Volatility

Volatility (price) in level = β_0 + β_1(log yield) + β_2(log inflation) + β_3(log interest) + β_4(log exchange rate)+ β_5(log temperature) + $\beta_6$rainfall + ε

Table 16 summarizes the regression results of cassava price volatility as a function of cassava yield, inflation, interest, exchange rate, temperature and rainfall.

Table 16: Parameter Estimates for Cassava Price Volatility

Response variable: volatility of cassava in Gh¢	
Control Variable	Coefficient
Intercept	-14.222 (96)
Log (yield)	3.706 (1.285)**
Log (inflation)	0.609 (1.076)**
Log (interest)	-6.361(1.833)
Log (exchange rate)	1.400(0.481)**
Log(Temperature)	-7.646(28.081)
Rainfall	0.023(0.042)
R^2	0.733
F statistic	16.51. **
Adjusted R^2	0.69

Notes: standard errors in parentheses; *** denotes significance at 0.1% level.

Source: Field data, 2014

Table 16 shows that 73.3% of the variation in the volatility of cassava price is caused by the explanatory variables in the model, that is, yield, inflation, interest rate, exchange rate, temperature and rainfall as shown by R^2. Furthermore, the result indicates the goodness of fit of the model as shown by F statistics with the significant level of 0.1%. Thus the explanatory variables in the model are good predictors of cassava price volatility. The number of parameters and the degree of freedom as accounted for by the adjusted R^2 shows the fitness and goodness of each additional variable since its value is close to the R^2. The result shows that a percentage change in cassava yield significantly raises the volatility of its price per 91kg by Gh¢0.037. This suggests more intervention through the provision of storage facilities, market facilities among others to absorb the surplus. In addition, a percentage change in inflation and exchange rate significantly raises the volatility of cassava price per 91kg by Gh¢0.006 and Gh¢0.014 respectively. Interest rate, temperature and rainfall however show negative relationship with the volatility of cassava price but are statistically insignificant.

The finding is consistent with FAO and IMF (2011) which reported that increase in agricultural output increase the volatility of its price. The finding also confirms a report by Hutchet (2011) that economic variables such as inflation and exchange rate significantly influence the volatility of agricultural produce. Other works with similar finding are reported by FAO (2011) and IMF (2009) which indicated significant positive relationship of inflation and exchange rate with food prices.

Farmers' Perceived Factors Influencing Price Volatility

Table 17 shows factors farmers perceived as contributing to the cassava price fluctuation. The Table shows that 355 farmers interviewed representing 70.2% perceived unavailability of readily market as a major factor contributing to price volatility. This, according to them, causes excess supply over demand thus triggering price volatility which is in line with a finding by Kohl and Uhl (1998) who indicated that unavailability of ready market for agricultural produce is a major precursor for price volatility.

Table 17: Farmers' Perceived Factors Contributing to Cassava Price Volatility

Farmers' Perceived Factors	No.	%
Inadequate readily market for the produce	355	70.2
Inadequate government intervention through policy	308	61.6
Poor processing facilities	310	62.0
Weather	340	68.0
Insufficient financial support	315	63.0
High cost of risk management strategies	210	42.0

Source: Field data, 2014

The Table also shows that 308 farmers (representing 68.6%) interviewed said that inadequate government intervention through policy is a cause of price volatility in cassava price. This according to them can be done by establishing price policy for the produce to help stabilise the price against price volatility. This expression is consistent with Kohl and Uhl (1998) who asserted that price control system protects producers against output price risk. In addition, 340 farmers (representing 68%) perceived weather as a key contributing factor to cassava price volatility which also confirms similar assertion by Pierre, Morales-Opazo and Demeke (2014) that variability in climatic factors causes variability in some agricultural produce. Other perceived factors contributing to price volatility include inadequate financial support (63.0%), poor processing facilities (62%) and high cost of risk management strategies representing 42%. Another study with similar finding was reported by (World Bank, 2011).

Farmers' Risk Management Strategies Against Output Price Risk.

Farmers were asked if they employ some risk management methods due to the perceived change in output price of cassava. The result indicated in Figure 8 indicates that 90% of farmers surveyed indicated that they use some form of strategies while 10% do not use risk control measures. Crop diversification, processing, off farm business, varying harvesting time and reduce farm size were the major strategies farmers use to minimise output price risk. Forward contract and whole selling, were found to be the least adaptation options. The study also found that farmers used at least two of these risk management methods. Of the farmers interviewed, 89.5% used crop diversification, while 78% of them engaged in some form of processing of cassava into cassava dough and gari. Furthermore, 75% of the farmers find off farm jobs, 70.2% reduce their farm size while 25% and 2.6% used whole selling and forward contract respectively to manage output price risk.

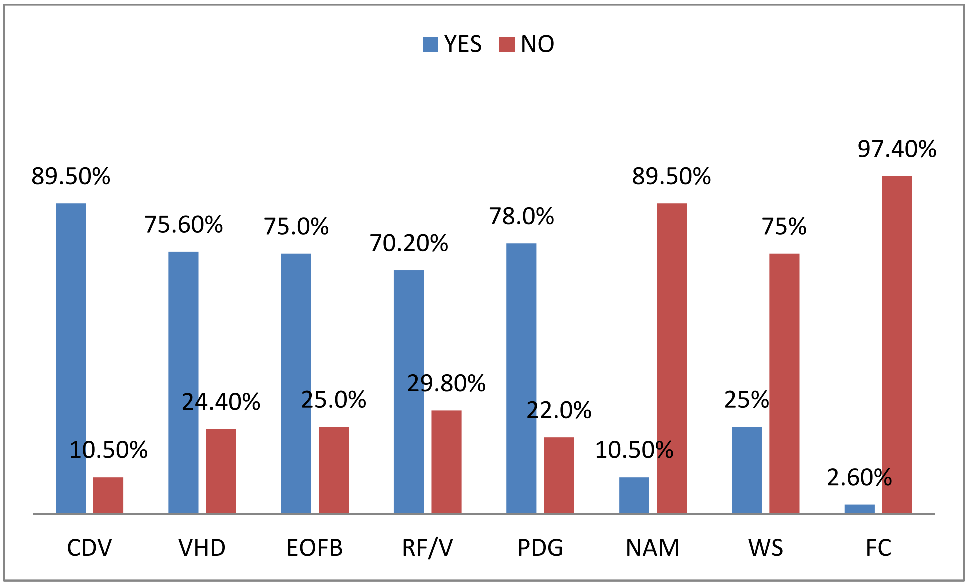

Figure 8: Risk Management Strategies Adopted by the Farmers in the Study Area.

CDV=Crop diversification, VHD=Varying harvesting time, EOFB=Engage in on-farm business, RFS/V=Reduce farm size and volume, PDG=Processing into dough/ gari.NAM= No application of risk strategy, WS= Whole selling of produce, FC=Forward contract.

These findings are consistent with that of Hardaker, Huirne and Anderson (2004). The authors investigatedcoping with risk in agriculture by farmers and found out that majority of famers in developing countries resort to crop diversification(that is growing different crops),some are in off farm activities and varying harvesting time as means of minimizing the impact of risks. In a similar study, Pellergrino (1999) also disclosed that farmers in developing countries grow different crops as risk mitigation strategies. The choice and the limited number of risk management option adopted by farmers could also be caused by their back ground level such as small farm sizes and low education level.

Farmers' Constraints to Risk Management Strategies

The study investigated constrains preventing farmers from adopting risk management strategies. The result in Figure 9 indicates that, constraints such as; no readily market, poor processing facility, imperfect information on price change, land tenure system and insufficient fund (with the proportion of 88.1%, 79.4%, 76%, 74.3% and 65.8% respectively), are the major constraints to farmers in their adoption of risk management strategies while imperfect knowledge about risk management options representing 20.9% is the least constraints faced by the farmers. The finding concurs with a report by SGRE (2010); Kohl, and Uhl (1998) which found out that market facilities and information flow are major constraints faced by the famers in developing countries. The report also revealed that inadequate market infrastructure is a major challenge facing farmers in developing countries.

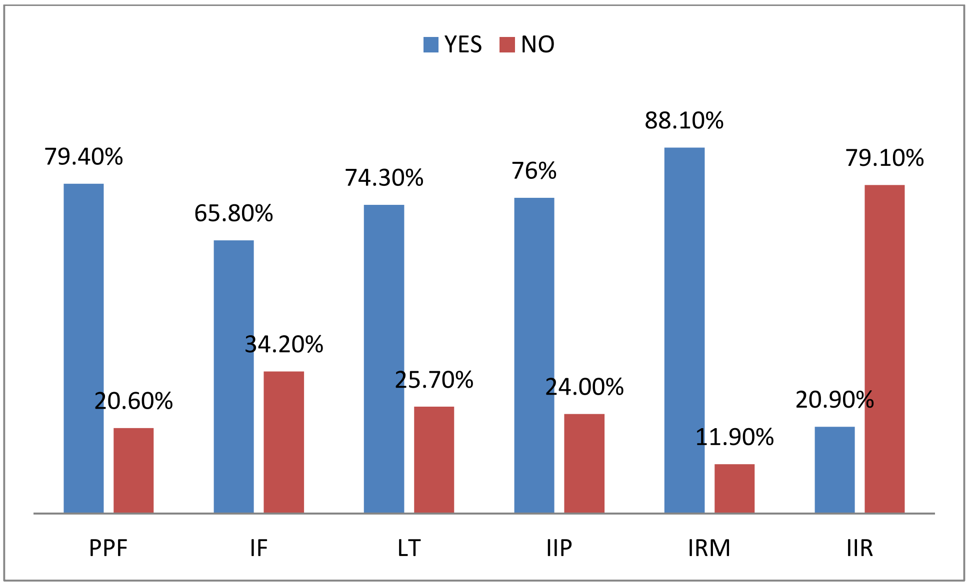

Figure 9: Constraints to Risk Management Strategies by the Farmers in the Study Area.

PPF=Poor processing facilities, IF= Insufficient fund, LT=Land tenure system, IIP= Insufficient information on price changes, IRM= Inadequate /No readily market, IIR= Imperfect information/knowledge on risk management options

Policies that exist in Ghana for Promoting Cassava Industry (From

Interviews with the 14 Ministry of Food and Agriculture (MoFA) district directors in the study area was conducted on issues such as price stabilization policy, financial support, infrastructure, research, farmer based organization, marketing and programmes to boost and develop the cassava industry. They .revealed that currently the main policy for the cassava industry is the Root and Tuber Improvement and Marketing Programme (RTIMP) (a follow up on the Root and Tuber Improvement Programme [RTIP]), implemented 1999-2005 under the sponsorship of the International Fund for Agricultural Development (IFAD). The RTIMP became necessary due to the short falls of the RTIP programme which looked at developing crop production through research and extension to increase cassava productivity. Marketing, however, was very poor which necessitated the RTIMP to be implemented over 8 years beginning in 2006. The goal of RTIMP is to enhance income and food security to improve livelihoods of the rural-poor and to build a market-based system to ensure profitability at all levels of the value chain. Through this programme, financial support is supplied to farmers to produce planting materials for distribution to other farmers. All the costs associated with the production are borne by the RTIMP programme. However, the program has not fully picked up in the area.

In addition to the RTIMP there is also the Farmer Field Flora (FFF) that collaborates with research institutions such as the Centre for Scientific and Industrial Research (CSIR) and Universities to embark on meaningful research and further ensures the formation of farmer based organisation. Adjunct programmes designed to boost production and development of the cassava industry includes CAVA (Cassava Value Addition) and Unleashing the Potential of Cassava in Africa (UPOCA).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter summarises the study, draws conclusions and presents recommendations for policy formulation.

Summary

Agricultural activity is subject to a wide range of risks due to the variable economic and biophysical environment in which farming operates. This impact of risk has not spared cassava farmers who suffer the menace of output price risk. Empirical work revealed that cassava farmers in the Volta region are greatly affected by output price risk due to their inability to foresee the level of risk associated with the price of this commodity. This study has therefore sought to analyse the output price risk of cassava in the area. Descriptive statistics and econometric models for primary and secondary data respectively were used to investigate the problem under study.

Desk research was used to obtain the secondary data. The secondary data was used to examine the output price trend of cassava, estimate the output price risk and determinants of output price volatility of cassava. The cassava output price and yield data were obtained from the Statistical Research and Information Directorate (SRID) of the Ministry of Food and Agriculture

(MoFA). Data on economic variables such as interest rate exchange rate were obtained from Bank of Ghana. Inflation data was obtained from Ghana Statistical Service while, data on weather (temperature and rainfall) was obtained from the Meteorological Services of Ghana. The data was available over time for 43 years (1970-2012). The data series were subjected to various econometric modelling such as Lagrange multiplier test, normality test, ERS unit root test, regression and cointegration (Engle and Granger two Step procedure) test.

Primary data was used to better accentuate the understanding of the socio-demographic characteristics of farmers' risk management strategies and their constraints. A sample size of 514 was used (500 farmers and 14 MoFA staff directors). Multi-stage sampling procedure was used. First, the purposive and simple random sampling techniques were used for the selection of districts and communities respectively. Then proportional sampling technique was used for the selection of the required sample size. The research instruments were pilot tested at North Dayi district and with the help of ten field assistants, the data were collected using interview schedule and questionnaires. All analysis was implemented in R programming language with the help of Microsoft excel.

Findings

Cassava Price Trend and Volatility

The results of trend analysis show that cassava price increases, on average, by 46% annually. The study also shows that the price of cassava experienced increasing volatility of 30.8% yearly. Furthermore, the highest level of price volatility representing 102% occurred during the last decade while 177.8% volatility level was record for the period under study (1970-2012) using coefficient of variation methods.

Estimating the Level of Risk (Value-at-Risk) Associated with the Cassava Price

The cassava price data was passed through series of statistical tests to estimate risk associated with the output price. Firstly, Lagrange multiplier test was conducted to check the presence of conditional heteroskedasticity which consequently reject the null hypothesis of homoskedasticity for the monthly price changes. Secondly, distributional assessment was conducted using Q-Q plot and Jarque bera test which reveal non-normal distribution of the data set. These preliminary tests form the basis for using historical method for calculating the risk associated with cassava output price. The result shows that cassava farmers face the risk of losing Gh¢1.358 monthly for every 91kg of cassava at 95% confidence level. This represents about 31% (Gh¢179 million) of their annual revenues.

Determinants of Cassava Price and Volatility

The results show that the independent variables tend to have some influence on cassava price. The linear specification show that inflation and exchange rate have a positive and significant influence on the price of cassava, thus a percentage increase in inflation and exchange rate raises cassava price by 0.79% and 1.02% respectively. Yield and temperature have positive and insignificant effect, while interest and rainfall have negative and insignificant effect on cassava price. In terms of volatility of cassava price, the results show that yield, inflation and exchange rate have significant positive relationship with the volatility of cassava price. Thus a percentage change in yield raises the volatility level of cassava price per 91kg by Gh¢0.037 while a percentage change in inflation and exchange rate significantly increase the volatility of cassava price per 91kg by Gh¢0.006 and Gh¢0.014 respectively. Furthermore, result from the error correction model between output price and independent variables were also conducted. The speed of adjustment(error correction term) to restore equilibrium indicates that in the short run, 22.3% of any deviation from the long run path between the cassava price and the independent variables is corrected over the next period, that is every year. The error correction term in the model is statistically significant, confirming the existence of long run steady-state equilibrium between cassava price and the independent variables. The study also reveals that farmers perceived insufficient readily market, inadequate government support, weather and lack of processing facilities and funds as major factors affecting the price volatility.

Risk Management Strategies Adopted by Farmers

The results show that 89.5% of the farmers had practised some forms of risk management control. Crop diversification, off-farm business, varying harvesting time, and reduce farm size were the major risk management strategies used by the farmers while forward contract and whole selling of farm produce, were found to be the least risk management strategies. The study also found that farmers used at least two of these methods.

Constraints to Farmers' Risk Measures

Results indicate that no readily market, poor processing facility, land tenure system, insufficient fund, and imperfect information regarding price changes are the major constraints facing farmers in managing output price risk.

Conclusions

From the findings of the study, the following conclusions were drawn:

1. Cassava price increases significantly over times with high level of volatility between each period.
2. Cassava farmers face the risk of Gh¢1.35 per 91kg at 95% confidence level, that is about 31% of farmers' annual revenues (Gh¢179 millions) is at risk.
3. Inflation and exchange rate significantly determine the price of cassava while cassava yield, inflation and exchange rate significantly affect the volatility of cassava price.
4. Crop diversification, off-farm business, varying harvesting time, and reduce farm size were the major risk management strategies used by the farmers in the study area.
5. Lack of readily available market, poor processing facilities, land tenure system, insufficient fund, and imperfect information regarding price changes are the major constraints facing farmers' in adapting to output price risk.

Recommendations

Based on the study findings, the following recommendations are made.

1 Agricultural output price insurance package should be designed for the farmers by the government in partnership with other insurance companies. This will minimise the output price risk and its possible impacts.

2 The Ministry of Food and Agriculture and other supporting agencies should train and educate farmer on the various options available for output price risk management. This will help manage the output price risk and generally improve farmers' welfare.

3 The government through the Ministry of finance and economic planning and Bank of Ghana should put in place good economic policy to stabilise inflation and exchange rate to the barest minimum since these variables significantly affect cassava price and volatility

4 The government through the Ministry of Food and Agriculture and other supporting agencies should train farmers on the processing of raw cassava into other products, provide market facilities against possible loss and educate them on output price risk management. This will also help the cassava farmers to manage the output price risk and consequently improve their welfare.

5 Government should pay much attention to the building of price information systems and transparency of the cassava markets.

6 The Information and marketing services of MoFA should intensify their education of cassava farmers and marketers on the need for efficient communication.

Suggestions for Further Research

The following suggestions are made for further research to improve the knowledge base provided by this study.

1. Similar analyses to the one conducted for this study should be done for the remaining regions of Ghana where cassava is produced. This will give comprehensive picture on the output price risk of cassava in Ghana.
2. Similar studies should also be conducted on other sources of risk including production risk since they correlate with output price and are also farmers' concern.
3. Studies should be conducted on the other agricultural produce as this will provide a holistic view of agricultural risk.

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APPENDICES

Appendix A: Questionnaires

UNIVERSITY OF CAPE COAST

SCHOOL OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

INTRODUCTION: This questionnaire is purely for academic purposes and all information given will be treated as such. Information provided will be handled with the highest degree of confidentiality. Thank you in advance for your time.

TOPIC: **ANALYSIS OF OUTPUT PRICE RISK OF CASSAVA IN THE VOLTA REGION OF GHANA**

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

1. Location of respondent..?

2. Sex of respondent (a) Male (b) Female

3. Age of respondent in years...?

4. What is your marital status? (a) Single (b) Married (c) Divorced

5. What is the size of your household..?

6. How many years of education have you had...?

7. Educational level of respondent (a) No formal education (b) Primary school(c) Middle school leaver/junior high school (d) O'level/senior high school (e) Tertiary level

8. How many years have you been in farming...?

9. Do you have other income generating activities...?

SECTION B: OUTPUT PRICE CHANGE INFORMATION

10. Do you perceive changes in prices of your output? (a) Yes (b) No

11. If yes, (in Q10) is output change a serious phenomenon? (a) Yes (b) No

12. What are your perceptions of the changes in output price of cassava?

- ❖ Increase in output prices [ ]
- ❖ Decrease in output prices [ ]
- ❖ Irregular output prices [ ]
- ❖ No change in output prices [ ]

13. What do you think is contributing to this change?..................................

SECTION B: PRODUCTION AND MARKETING INFORMATION

14. What is the size of your farm in acres?

....
.

15. How many bags do you usually harvest?.........................

16. Do you cultivate both in the major and minor seasons?

(a) Yes (b) No, if no why?..

17.Do you have market for your produce? (a) Yes (b) No

18. How do you market your produce after harvesting

a) Wholesaling [ ] b) retailing [ ] c) both [ ]

19. Do you have storage facilities for your produce Yes [ ] No [ ]

20. If yes, how do you store the cassava?...

21. Do you sell immediately after harvesting (a) Yes (b) No

22. If Yes, how much do you sell a bag of cassava…………………

23. How long does the cassava stay in storage before deteriorating? ....

24. What influence your prices? Tick as many that apply. (a) Fuel price [ ] (b) Transportation cost [ ] (c) price of your competitors in the market[ ](d)weather [](e) season[ ] (f)buyers[ ] (g) prices from other market [ ]

Others please specify………………………………………………

25 How do you obtain the information?……………………………………..

SECTION D: REDUCING STRATEGIES AVAILABLE TO FARMERS AGAINST OUTPUT PRICE CHANGE

26. Do you adapt to output price change? (a) Yes (b) No

27. If yes, what major adaptation strategy do you usually use?

- Storage of output after harvest (a) Yes (b) No
- Varying harvesting time (a) Yes (b) No
- Reducing the volume of harvest (a) Yes (b) No
- Reduce farm size (a) Yes (b) No
- Whole selling of output (a) Yes (b) No
- No adaptation (a) Yes (b) No
- Change in crops (a) Yes (b) No
- Find off farm jobs (a) Yes (b) No
- Leave the production (a) Yes (b) No
- Diversification (a) Yes (b) No
- Engage in other business (a) Yes (b) No
- Increase price in next season (a) Yes (b) No
- Other (specify)...

28. Why do you prefer your choice of adaptation strategies (in Q25) to other strategies?

29. Do you have any constraints to your adaptation methods above?

30. How many times do extension service personnel's visit farmers?................

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TOPIC: **ANALYSIS OF OUTPUT PRICE RISK OF CASSAVA IN THE VOLTA REGION OF GHANA**

MoFA: DISTRICT DIRECTORS

SECTION A: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

1. Sex of Respondent (a) male (b) female
2. Age of respondent ..……………………….
3. Educational level of respondent ....
4. What policies exist to help farmers mitigate the effects of output price change?

....

....

....

Specific areas of support

(a) Financial support……………………………………

(b) Infrastructure…………………………………………..

(b) Programmes to stabilise cassava price in the country

(c) Others specify...

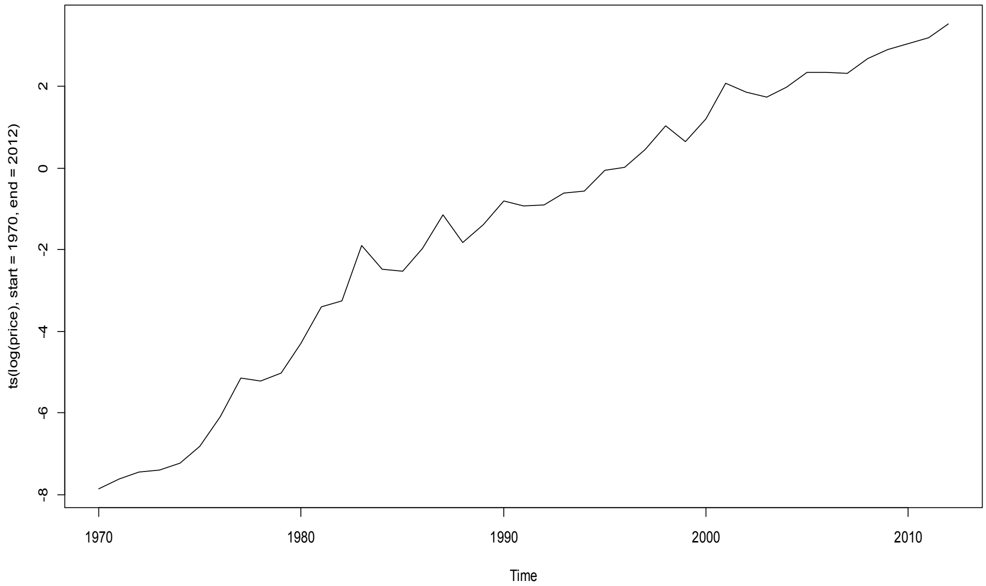
5. Do you provide farmers with information on adaptation to output price change?

(a) Yes (b) No

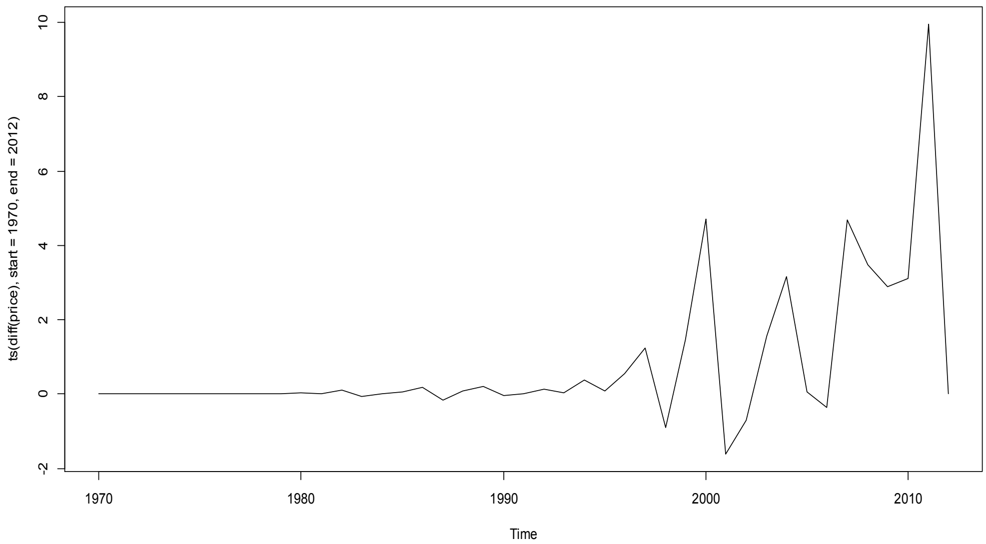
6. Do government provide storage facilities to farmers? (a) Yes (b) No

Appendix B: Graphical presentation of the Unit Root Tests Both at Levels and First Difference.

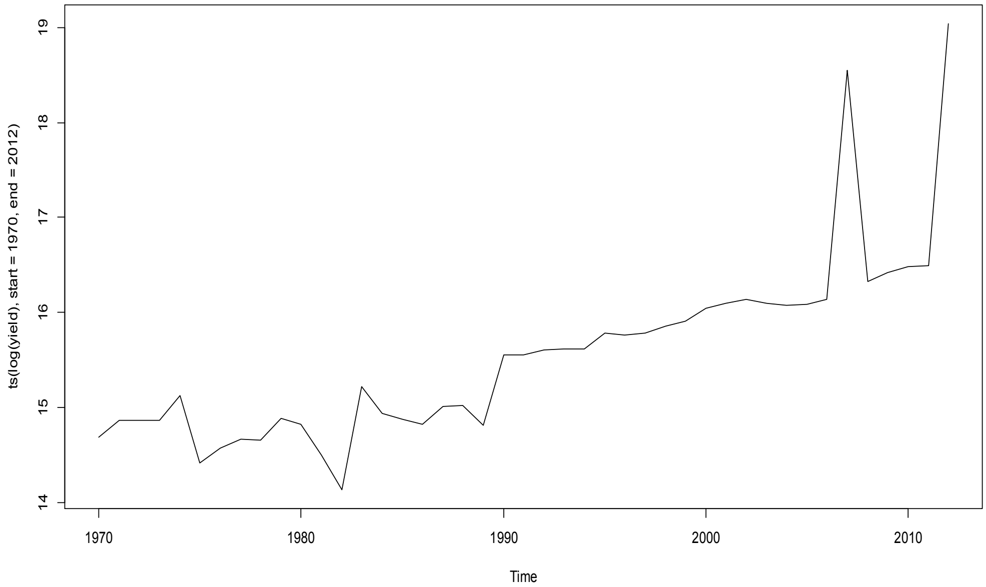
Cassava price in level



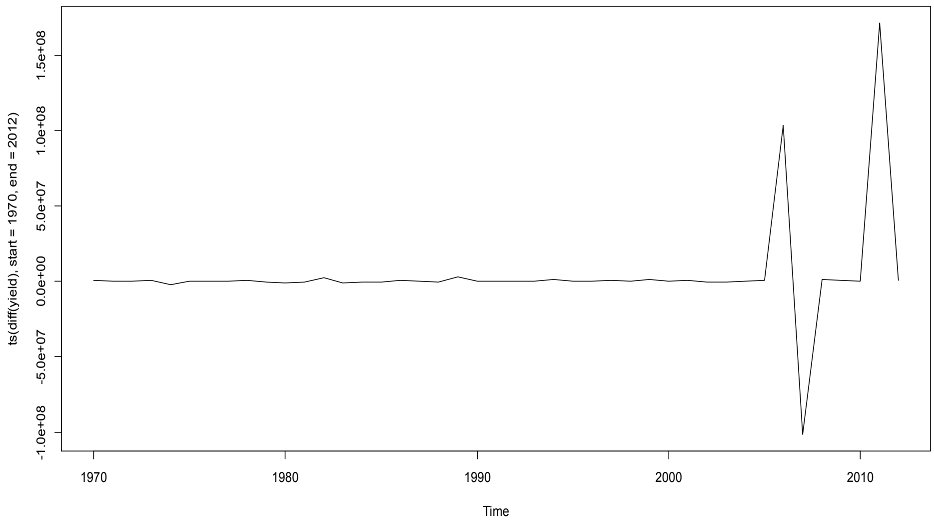
Cassava price (in first difference)



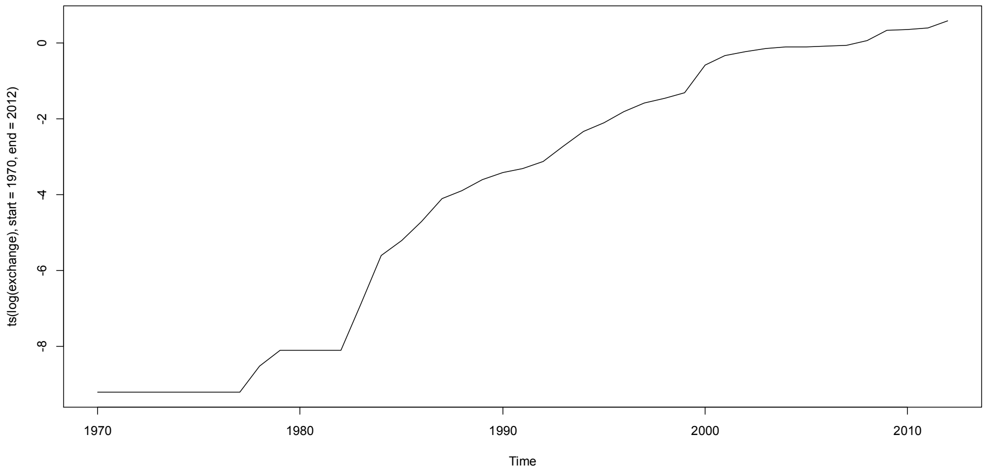
Cassava yield in level



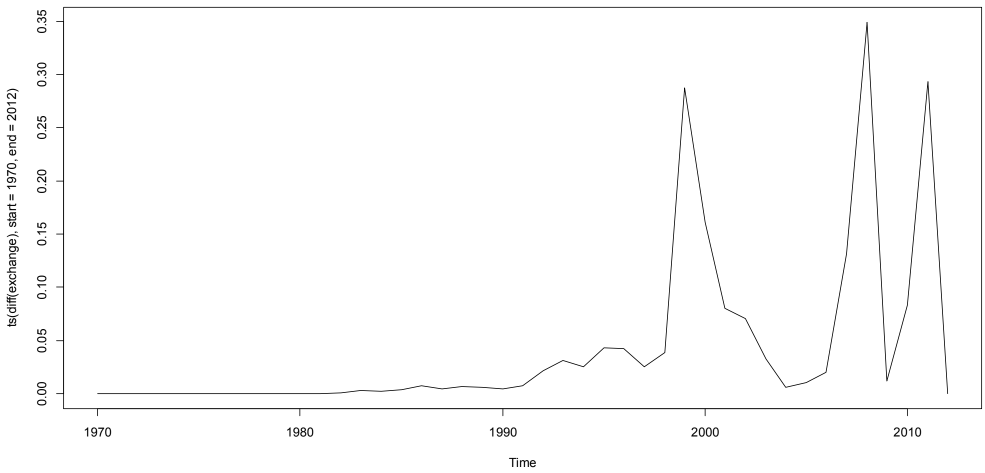
Cassava yield (differenced)



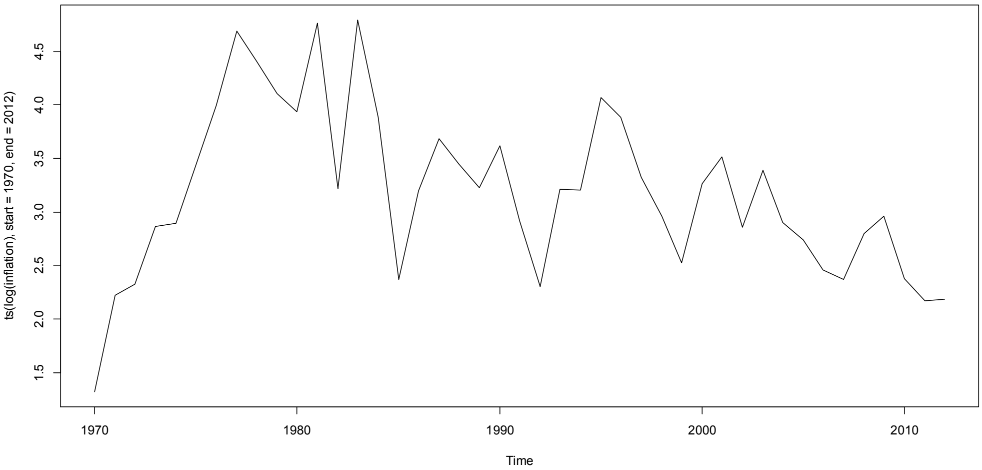
Exchange rate



Exchange(differenced)



Inflation



Inflation (first differenced)