

**MARKET INTEGRATION AND PRICE TRANSMISSION ANALYSIS OF PROCESSED
FISH MARKETS IN GHANA**

BY

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON, IN
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INTEGRI PROCEDAMUS

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DECLARATION

I, Victor Ntow Djarbeng, author of this thesis titled “**Market Integration and Price Transmission Analysis of Fish Markets in Ghana**” do here by declare that with the exception of the references duly acknowledged; this work was undertaken by me from August 2017 to July 2018 in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon. I do hereby declare that, this work has not been submitted in part or whole for a degree in this University or anywhere.

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DEDICATION

I dedicate this thesis to my entire family for the care, love and support they have shown me throughout my education. May the Grace and Favour of our Lord Jesus Christ always be with you.

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ABSTRACT

This study presents an analysis of market integration and price transmission of 10 processed fish markets in Ghana over the period 2012-2017. Monthly processed fish prices for Koobi, Kpala and Smoked herrings from the 10 markets namely Makola, Ada, Agbozume, Cape Coast, Half Assini, Kpandu, Mankessim, Techiman, Tema and Wa markets were used for the analysis. Data was analysed using the Johansen Co-integration procedure, Granger Causality test, Asymmetric Vector Error-Correction model and Autoregressive Distributive models. The results revealed a lack of cointegration among most of the markets for Kpala, smoked herrings and koobi indicating that their markets were not linked together. The granger causality test showed unidirectional, bidirectional and independent causality in the Koobi and Kpala markets. The smoked herring markets exhibited only bidirectional and unidirectional causality. The speed of adjustment from the asymmetric vector error correction model for cointegrated markets were higher for smoked herring than for Koobi. The study further revealed that positive shocks were corrected faster than negative shocks. There was asymmetry present only in the Makola-Mankessim markets for smoked herring. The results of the autoregression distributive lag model show that most of the current and previous prices of the markets did not influence the current prices in the Makola market. Thus, in most cases the price of processed fish was dependent on the prevailing market conditions. In conclusion, the results show the presence of poor price transmission and poor integration between processed fish markets. It is recommended that infrastructure could be improved to enhance market integration and efficiency. Also information on the prices of processed fish should be made available to processors to help them know which markets offer lucrative prices for their product. This could improve spatial arbitrage and hence market integration.

TABLE OF CONTENTS

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENT	iii
ABSTRACT.....	iv
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF ACRONYMS	xi
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background to the Study.....	1
1.2 Problem Statement	6
1.3 Research Questions.....	8
1.4 Research Objectives of the Study	9
1.5 Justification of the Study	9
1.6 Organization of the Study	10
CHAPTER TWO	11
LITERATURE REVIEW	11
2.0 Introduction.....	11
2.1 Economic Importance of Fish in Ghana	11
2.1.1 Contribution of Fish to Food Security	11

2.1.2 Contribution of Fish to Poverty Reduction	12
2.1.3 Contribution of Fish to Employment	12
2.3 Processing of Fish	15
2.4 The Concept of Markets.....	16
2.5 The Concept of Market Integration, Price Transmission and Spatial Arbitrage.....	18
2.5.1 Price Transmission.....	20
2.5.2 The Concept of Spatial Arbitrage	21
2.5.3 The law of One Price	22
2.6 Conditions for Efficient Market Arbitrage	24
2.7 Techniques for Measuring Spatial Market Integration	24
2.8 Asymmetry in price transmission	30
2.8.1 Causes of Asymmetry in Price Transmission	31
2.9 Empirical Studies linked to Market Integration and Price Transmission in Ghana and Elsewhere	33
2.8 Summary	40
CHAPTER THREE	41
METHODOLOGY	41
3.0 Introduction.....	41
3.1 Theoretical Framework.....	41
3.2 Conceptual Framework.....	42

3.3 Empirical Framework	43
3.4 Method of Analysis.....	46
3.4.1 Analyzing the extent of market integration	46
3.4.1.1 Johansen Cointegration.....	47
3.4.1.2 Test for Granger Causality.....	49
3.5 Extent of Price Transmission.....	51
3.5.1 Extent of Price Transmission in Processed fish Market (ARDL).....	51
3.5.2 Extent of Price Transmission in Processed fish Market (VECM).....	52
3.6 Estimation of Extent of Asymmetry in processed fish Market.....	53
3.7 Study Area and Data Source.....	55
CHAPTER FOUR.....	57
RESULTS AND DISCUSSIONS.....	57
4.0 Introduction.....	57
4.1 Descriptive Analysis of Processed Fish Markets.....	57
4.2 Unit Root Test Results	63
4.2.1 Unit Roots Test Results for Processed Fish.....	63
4.3 Cointegration Test Results.....	67
4.3.1 Extent of Market Integration between Processed Fish Market.....	67
4.4 Direction of causality in Processed Fish Market	70
4.4.1 Result of Granger-causality Test for Processed Fish Markets.....	70

4.5 Price Transmission between Processed Fish Markets in Ghana	72
4.5.1 Results of the Asymmetric Vector Error Correction Model	72
4.5.2 Evidence of Price Transmission (ARDL Model).....	75
CHAPTER FIVE:	78
SUMMARY, CONCLUSSIONS AND RECOMMENDATIONS	78
5.0 Introduction.....	78
5.1 Summary and Major Findings	78
5.2 Conclusions.....	80
5.3 Policy Recommendations.....	81
APPENDICES	99

LIST OF TABLES

TABLE	PAGES
Table 4.1 Descriptive statistics of monthly processed fish prices (2012-2017)	60
Table 4.2: Results of ADF tests on the monthly processed fish price series	66
Table 4.3 Johansen cointegration test Statistics for processed fish markets.....	69
Table 4.4: Result of granger-causality test for processed fish markets	71
Table 4.5 Results of the AECM Model	75
Table 4.6 Results of the ARDL model.....	77

LIST OF FIGURES

FIGURE	PAGES
Figure 3.1 Empirical framework for assessing price transmission.....	44
Figure 3.2: Map of Ghana showing the locations of the market under study.....	56
Figure 4.1: Trend plot of monthly prices of Koobi.....	62
Figure 4.2: Trend plot of monthly prices of Kpala.....	62
Figure 4.3: Trend plot of monthly prices of smoked herrings.....	63

LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
APT	Asymmetric Price Transmission
ARDL	Auto Regressive Distributed Lag
AVECM	Asymmetry Vector Error Correction Model
CPI	Consumer Price Index
ECM	Error Correction Model
ECT	Error Correction Term
ESTJ	Enke-Samuelsson-Takayama-Judge
FAO	Food and Agriculture Organization
FASDEP	Food and Agricultural Sector Development Plan
FIFO	First-In-First-Out
GSS	Ghana Statistical Service
KPSS	Kwiatkowski, Phillips Schmidt and Shin
LOP	Law of One Price
METASIP	Medium Term Agriculture Sector Investment Plan
PBM	Parity Bound Model
TAR	Threshold Autoregressive Model
VAR	Vector Autoregressive Model
VECM	Vector Error Correction Model

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Markets have an important role in facilitating the interactions between the forces of demand and supply such as through the adjustment of commodity prices across time and space and also in dealing with the risks arising as a result of shocks to the demand and supply factors existing in a market. Markets that are well-integrated tend to facilitate adjustments in net export flows across space, thereby reducing variability in prices encountered by both consumers and producers (Barrett, 2005).

In developing countries, the degree to which markets are integrated and the price transmission of shocks to food markets is a key determinant of stability in prices and overall food security. In markets that are not well integrated signals from price shocks may not be passed on from food deficit areas to food surplus areas resulting in prices becoming increasingly volatile which might affect the purchasing power of consumers and hence their economic accessibility to food. The existence of poor market integration among spatially separated markets may also end with a decrease in the information on prices accessible to economic agents; this may limit the allocative efficiency and long run growth which in turn affects the availability and supply of food. According to Onyuma *et al.* (2006), most agricultural markets in Africa countries are poorly integrated and not efficient.

Spatial market integration can be used to indicate efficiency between markets that are situated in regions or location and this is important in closing the disparity gap, improving food security by ensuring food is readily available from food-surplus to food-deficit

regions, improving upon the standards of living of rural poor households, living standards of poverty stricken rural households, improving adoption of technologies and implementing effective macro-level policies; that ensure that welfare gains from implemented policies are realized (Ankamah-Yeboah, 2012). Perfect integration of markets and complete transmission of price shocks, with immediate adjustment to variation in prices caused by shocks from within or external to the system is essentially a marketing system that can be described as efficient. A system such as this would allow the market agents in the marketing chain to receive the greatest benefits. It would also aid in removal of unprofitable arbitrage and segmentation of markets that are separated by location and would make certain that allocation of resources across space and time is efficient (Nkang *et al.*, 2007). A farm marketing system that is efficient helps to increase the revenue levels of farmers and also promote the economic development of a nation (Aburajab, 1999).

Integration of markets measure the degree to which spatially separated markets for a homogenous commodity in the long run share common price or trade information. Spatial integration of markets improves successful trade between areas experiencing shortages in food supply and areas with an abundance of food. This results in specialization and economic growth. Integration of markets contributes greatly to food security and growth of the economy; it also enhances the social welfare of economic agents and speeds up the rate of effective transmission of changes in between markets with the support of market reforms (Goletti & Babu, 1994). However, poor integration of markets on the other hand reveals the presence of inaccurate information on prices, existence of government

policies, problems of infrastructure or institutional problems that affect the market decision of producers and the efficient flow of goods from one market to the other.

Price transmission of domestic regional markets is central in understanding the degree to which economic agents are integrated into the markets process. The nonexistence of integration among markets or the complete pass-through of changes in price from one market to the other has important repercussions for the welfare of the economy. Incomplete transmission of prices between markets that may arise due either to the cost of transactions or to trade and other policies, results in a decrease in information on prices accessible to economic agents resulting in decisions that lead to inefficient outcomes. Price transmission studies also help to provide understanding on how changes in prices are transmitted between markets and as such indicating the degree to which markets are integrated, as well as the degree to which these markets function efficiently.

To a large extent the performance of the agriculture sector depends on production or supply efficiency and also on marketing efficiency, chiefly for agricultural markets and price signal. Agricultural prices and hence agricultural markets significantly affect the speed and path of developments in agriculture, and given the significance of the agricultural sector to the Ghanaian economy, an increase in the level of efficiency of Ghanaian agricultural markets will help to improve upon the growth rate of the economy. Over the years FASDEP has concentrated on modernizing agricultural markets, so as to create connections in the value chain and highlights the use of resources with sustainability in mind and commercializing agricultural activities promote expansion of markets (FASDEP II, 2002; FASDEP II, 2008). Agriculture in Ghana is very important and as such a high level of efficiency in agricultural markets in the country will be

relevant for the development of the economy. The sustained efforts to develop and modernize markets for agriculture over the past years following the arrival of Ghana as a middle income country raises issues on the present state of performance and response of markets located at different location to each other.

Isolated or segmented markets may receive incorrect information on price changes that might alter the marketing decision of producers and cause the inefficient movement of commodities (Alderman & Shively, 1991). Markets that are integrated allow deficits or surpluses in a market to be passed on to another market through arbitrage; an improvement in the integration of markets situated at different locations will bring about a balance among food-deficit and food-surplus regions. In addition, it will ensure that prices of goods in markets situated at different locations follow each other and that price signals and information are passed on smoothly. As such governments may be interested in knowing how well their markets are functioning and the price movement relationships of staple foods in the various ecological zones as this helps to improve food security in the country by identifying areas in which government can concentrate its efforts.

Although a lot of studies have examined the integration of market integration and transmission of shocks to price in Ghana, most of them have focused on grains and cereals especially maize neglecting other important commodities such as fish which are also important to food security and development of the nation.

Fish plays a major role in supplying of animal protein and micronutrients to meet the protein requirement of human beings all over the world (Quaas et al., 2016). It is responsible for providing about 4.5billion consumers with at least 15 % of their average

per capita intake of animal protein (Béné *et al.*, 2015). Fish is also more nourishing than most staple foods such as cereals, providing in particular essential fatty acids and micronutrients and as such is very significant in improving the nutritional status of individuals, in particular those at risk such as children and women (Béné *et al.*, 2015).

The unique nutritional properties of fish make it essential to the health of billions of consumers in both developed and developing countries (Béné *et al.*, 2015). Fish is one of the most efficient converters of feed into high quality food and its carbon footprint is lower compared to other animal production systems (Béné *et al.*, 2015). With the increasing risk of becoming infected with a variety of diseases associated with meat consumption, more and more people are depending on fish to meet their protein needs. The annual per capita consumption of the world for fish has risen from 13 kg-19 kg between 2000 and 2012, respectively (FAO,2013). Demand for fish is expected to rise given the rapid increase in human population and the subsequent increase in demand for animal protein especially in developing countries.

It is estimated that fish contribute about 3% to the gross domestic product (GDP) and 5% to the agriculture GDP of the nation (Awity, 2005). The Fisheries sector in Ghana directly employs about 2.2 million people in the nation and contributes 4.4% to the GDP of the nation (Anon, 2008). This shows an increase in GDP from that reported by Awity (2005). Currently the sector accounts for 6.1% of the agricultural GDP (MOFA, 2016). In Ghana the average per capita fish consumption is around 20-25kg, which is higher than the world and Africa average of 19 kg and 10 kg, respectively average of 13kg (Anon, 2008). Fish still remains the number one and less expensive source of animal protein and making up about as much as 60 % of animal protein requirement in the diet of Ghanaian (FAO, 2016). This represents about 22.4 % of household expenditures spent on food. Most

Ghanaians prefer to consume fish in smoked form because of its taste and delicacy. Other methods for preserving and processing fish include drying, frying, salting and fermenting just to name a few.

In developing countries such as Ghana more than 80% of fish produced in the country is consumed as food while the leftover of 20% or less are used for other activities such as preparing feed for some animals and fish oil. As such it becomes necessary to develop an efficient network of marketing system to in the nation so that a large amount of the fish produced in the country can be efficiently managed and supplied to consumers, with the benefits of the fisherman in mind.

1.2 Problem Statement

Fish remains an important source of food, income and livelihood for millions of people around world including Ghana. Due to the continuous increase in the population of the country and the subsequent increase in the demand for fish combined with the decreasing fish stock may lead to food insecurity. One way to solve the problem of food insecurity is through the implementation of policies that improve the market efficiency and stability of prices in fish markets. There is however no empirical information on degree of the integration of market and transmission of changes in the price of fish to inform the designing of such policies.

The spatial market integration and price transmission of signals has become a general way for evaluating the performance of market in some countries. Spatial integration of markets looks at the degree to which markets located at different locations have information on price or trade of a similar commodity that are common to both markets in

the long-run. These markets are linked by arbitrage and this ensures that goods move from a region of high production to a region of low or no production. The importance of information on the integration of markets is in its use in formulating policies, and, on the extent to which market development may be promoted. Market integration will also help to understand the movement of equilibrium paths of demand and supply for processed fish. Segmented markets are more likely to transmit incorrect price information that might distort the marketing decisions of producer that may contribute to inefficiencies in the movement of goods. Such information is important in formulating policy strategies to prevent food insecurity (Goletti & Babu, 1994).

The movement of prices in the country could provide insights into on how the variations in the price of a good in one market can influence the price, output, consumption and social welfare of the same commodity in different market. This will also provide information on how producers and consumers will react to prices changes in another market.

Another concern of interest to stakeholders when dealing with the responses of markets to one another is whether the adjustment process between markets is characterized by symmetric or asymmetric relationships due to the possible influence of traders on market conduct. Ben-Kaabia *et al.* (2002) show that relationships characterized by symmetry can often be taken to represent a case of competitive markets, while relationship that are asymmetric in nature relationships on the other hand can be linked with the presence of some inefficiencies present in the market. The existence of asymmetry in the transmission of changes in price means that a number of market agents are experiencing a loss in welfare since the distribution of welfare under symmetric conditions could be different

(Wlazlowski *et al.*, 2009). Thus, under conditions of asymmetry in transmission of price shocks, the allocation of welfare effects across levels and among agents as a result of shocks in the marketplace will be distorted relative to the situation of price transmission under conditions of symmetry. On the other hand, adjustments to changes in prices under symmetry will result in efficient use of resources, increased revenues, enlarge markets for goods and service, indicate the extent of competitiveness, create jobs and promote value (Acquah & Owusu, 2012). According to Peltzman (2000) transmission of prices characterized by asymmetry is common in most markets, but says that, any economic analysis that does fails to account for the presence of asymmetry in price transmission is inadequate.

Most of the fish produced in the country is consumed in its processed form (smoked, fried and dried). It is in the light of this that the study seeks to carry out an analysis of price transmission and integration of processed fish markets in the country. This is because of the usefulness of such information in designing agricultural policies aimed at the stabilization and risk management of price and also food security.

The study does this by asking the following question.

1.3 Research Questions

1. What is extent of market integration among the selected processed fish markets in Ghana?
2. What is the extent of price transmission among selected processed fish markets in Ghana?

3. What is the extent of price asymmetry in selected processed fish markets in Ghana?

1.4 Research Objectives of the Study

The main objective of this study was to examine the efficiency of processed fish marketing system in Ghana

The specific objectives are to:

1. Analyse the extent of market integration among the selected processed fish markets in Ghana.
2. Analyse the extent of price transmission among selected processed fish markets in Ghana.
3. Analyse the extent of price asymmetry in selected processed fish markets in Ghana.

1.5 Justification of the Study

The examination of the extent of integration of market and transmission of processed fish prices in Ghana is important. This is because results of the extent of market integration will be useful in evaluating if processed fish markets are performing their function effectively and efficiently.

Information relating to the dynamics of price movement between the producer and the consumer markets may make policy formulation and implementation more successful as it provides information on the time taken or adjustment period for price policy to be transmitted across markets. The results of the study will also provide useful information

in the designing of policies and measures aimed at improving price transmission between markets and hence market efficiency.

Information on the extent of asymmetry in the transmission of prices in the processed fish sector will be important in understanding whether consumers and producers are benefitting from price decrease and price increases respectively.

Also most price transmission studies have focused on cereals crops neglecting other food sources such as fish which also feature in the daily diet of the average Ghanaian. This study will add to the growing literature on the integration of market and transmission of price shocks of other commodities.

1.6 Organization of the Study

This study is divided into five chapters. Chapter one provides an introduction to spatial integration of markets and price transmission analysis. This chapter also presents the problem statement, research objectives and justification of the study. Chapter two presents a review of literature on the economic importance of fish in Ghana, theoretical concept and empirical issues relevant to the studies on integration of market, models for estimating transmission of price changes and empirical evidence linked to integration of market and asymmetry in price transmission. Chapter three provides an idea of the theoretical framework, conceptual and empirical framework in price transmission, and the methods of analysis used in the study of price transmission that employs times series data. Chapter four present the result of the study while chapter five presents the summary and conclusions and policy recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a brief review of the various concepts and literature of importance to the study is presented in this chapter such as the theoretical concepts and empirical evidence related to agricultural price transmission studies.

2.1 Economic Importance of Fish in Ghana

The fishing sector in Ghana contributes considerably to the socio-economic development of Ghana in terms of creation of jobs, poverty reduction in both rural and urban communities and food security in the form of protein intake.

2.1.1 Contribution of Fish to Food Security

In terms of its contribution to food security, fish has been identified as the most important source to meet the animal protein needs of the Ghanaian population (Aggrey-Fynn, 2001). According to Kawarazuka & Béné (2011), fish is rich in Omega-3 fatty acids, minerals and micro-nutrients that can help to bring down blood pressure and aid in minimizing the possibility of having a heart attack or stroke. It is consumed by most Ghanaians in both urban and rural areas and supplies consumers with about 60 per cent of their animal protein requirement. The annual per capita consumption of fish was 24kg in 2014 and this has increased to 28kg, well above the global average of 18.9kg and 10.5kg for the African continent (Robadue *et al.*, 2018). Various species of fish are available in their fresh or processed form to suit the taste, preferences and buying power of the consumer. In Ghana, fish is commonly smoked or dried to improve its shelf life; it also becomes easier to transport the finished product to areas far away from production zones in coastal areas.

Small pelagic represent the most important locally produced fish supply and are an affordable and accessible protein source for poor households (Robadue *et al.*, 2018).

2.1.2 Contribution of Fish to Poverty Reduction

The fisheries sector also helps to reduce poverty in Ghana and this is important in the development and growth of the Ghanaian economy. Many poor and vulnerable people especially in the rural areas depend in one way or another on the fisheries sector for their livelihoods. The fishing sector offers a wide range of full-time or part time livelihood opportunity to many Ghanaians such as fishing, processing, transporting and marketing of fish (Mensah, 2012). Through these fish-related activities (fisheries and aquaculture but also processing and trading), fish contribute substantially to the income and therefore to the indirect food security of more than 10 % of the world population, essentially in developing and emergent countries (Béné *et al.*, 2015). According to Mensah *et al.* (2001), fisheries activities around the Volta Lake serve as a fall-back livelihood strategy for many migrants to the area. A study by Ofori-Danson (2013) showed that the poverty head count index for fishing communities in Ghana ranged between 60-80 percent for inland areas and 50-72 percent for coastal areas.

2.1.3 Contribution of Fish to Employment

The fishing industry in Ghana employs about ten percent of the total population in the country (FAO, 2016). Men in the fishing industry are mostly involved in the harvesting of fish and also undertake the main fishing activities in the various subsectors whereas women are mostly involved in post-harvest activities such as fish processing and storage and also in the marketing of fish. Many are also engaged in the frozen fish distribution trade as well as fish exports. The artisanal subsector supplies over 70 percent of the fish

produced in the country and has generated jobs for over 60 percent of the female population involved in the value chain for fishery (Bank of Ghana 2008). Fishers in the artisanal subsector number about 120 000. The marine subsector employs over 135 000 fishers including makers of the boats used in fishing, office workers for industrial fishing fleets and input suppliers (FAO, 2016). Those engaged mainly in the processing and distribution of fish are judged to be about 500 000 in number. The number of people depending directly on the Volta Lake for their daily survival numbered around 300 000 (FAO, 2016). Out of this number 26.66 percent representing 80 000 are fishermen and the rest are fish processors, traders (FAO, 2016). Some people are also involved in the packing, storing, loading, unloading and transporting of both fresh and processed fish and fish products. Others jobs also include the cannery workers, fishmeal producers and their staff and export processors.

2.2 Fish Marketing

In recent years, fish marketing in Ghana has become important due to the growing awareness of the health benefits derived from eating fish. Fish marketing in Ghana is mostly dominated by women in both the rural and urban communities. At the landing sites fishers sell their catch to traders residing in that community or to “migrant” traders who reside there for a brief period of time during periods of bountiful catch and lower prices. These migrant traders may choose to either process the fish locally before it is transported back to their area of residence or immediately transport it back to their home base to be sold to processors there. The choice by the migrant trader would normally depend on the relative prices of both freshly landed and processed fish, as well as cost of processing and transporting the fish, which are all subject to change depending on market

conditions. Fish is mainly sold in its fresh or processed state in domestic markets located all over the Ghana. Local supply of fish Ghana comes from the sea, lagoons, lakes, rivers, aquaculture and imports. Due to the higher demands for fish in the southern and middle portions of the country, fish marketing activities are most prominent in those areas (FAO, 2016) The capital city of Ghana, Accra is the most important local market and consumption centre for fish and fish related products areas (FAO, 2016) Other important consumption areas include Kumasi, Tarkwa, Tema and Sekondi-Takoradi.

Fish marketing is dominated by female fish traders popularly known as “fish mummies”. These fish mummies normally fund fishing trips beforehand and buy fish directly from those fishermen for onwards transportation to other actors in the fish value-chain (FAO, 2016). They also provide support in some cases, to processors by selling to them on credit (FAO, 2016). As such in most cases they may be able to dictate or influence the prices of fish both fresh and processed on the market. Fish mothers typically behave as a monopsonistic (one buyer) cartel: they restrict access to fish supply through pre-financing of fishing expedition (Gordon *et al.*, 2011). It is this ability of fish mothers to pre-finance fishing expeditions that give them unique access to fish landed for the day and is also the reason why they can come together to affect the price of fish in the market.

From Gordon *et al.* (2011) processors of smoked fish sell their products in various markets located in and around their district or region of origin. They normally sell their products in packs to retailers who also sell to consumers in the same markets or in nearby markets. Some traders also go directly to processors of fresh fish in the various localities to purchase fish which they then sell to retailers in central markets. Most Processors have a mutual agreement with each other whereby they sell on alternate market days so that

they do not flood markets with too much smoked fish. This would lead to a drop in the prices of smoked fish and hence profits. Most if not all traders and processors for smoked fish belong to an association for those involved in the smoking and trading of fish. Members belonging to such an association will usually assist one another when the need arises and also share information on the prevailing prices and supplies of processed fish in the country. The head of the association is normally referred to as “commodity queens”. They are responsible for implementing informal market rules and regulations as well as resolving conflicts between association members.

In the lean season, when supply of fish is low, retailers that are well off purchase frozen fish from cold stores in their various localities and process it themselves (Gordon *et al.*, 2011).

2.3 Processing of Fish

Due to the high water content in fish, it is an extremely perishable commodity. Fish begins to spoil as soon as it is taken out of the due to the activities of microbes, which result in an unpleasant taste and bad smell that deter consumers from purchasing it (Obodai *et al.*, 2009). The term fish processing refers to all the stages fish and fish products pass through from the time of capture to the time it finds its way to the final consumer. These methods include drying, frying, fermenting, smoking, salting, and a combination of these methods to prolong the shelf life of fish. Refrigeration is also another method for preserving fish. However, there are some bacteria that can survive in cold temperatures and are only eliminated by the application of heat (Bender, 1982). In Ghana; smoking is the most common method of fish preservation and processing. Smoking preserves fish by drying and depositing natural wood smoke chemicals like

phenols and aldehydes on the flesh of fish. These chemicals preserve fish by preventing the micro-organisms from surviving on the flesh of the fish (Garrow & James, 1994). It was observed that about 80 percent of the fish captured in the sea and from freshwater sources is eaten in smoked form (Samey, 2015). Fish smoking in Ghana is traditionally carried out by women in coastal towns and villages, along river banks and on the shores of Lake Volta. Often want to keep some of the fish in storage for some months to take advantage of a more favourable market. Fish Smoking is beneficial because it helps to reduce post-harvest losses during seasons of bountiful fish harvest (July to September) and also allows for the storage of fish against the lean season. Other benefits of food include an improvement in the taste, increase in the availability of protein to people throughout the year, ease in the packaging, transporting and marketing of fish.

2.4 The Concept of Markets

In the analysis of spatial price linkages, investigations on the spatial market integration of agricultural markets can be used to determine if agricultural markets are performing their functions efficiently. Oftentimes the integration of markets and the efficiency of markets are sometimes used interchangeably as such a look at the concepts of markets, market integration and market efficiency and the way in which they are related to one another is very important. A market can be defined as a place where buyers and sellers of a commodity interact with each other to facilitate the exchange of a commodity. Stigler (1969) defined market as "the area within which the price of a good tends to uniformity, allowance being made for transportation costs". A market involves all market actors spread out to perform marketing activities. Market structure, market conduct and market performance are important determinants of the extent of competition or marketing

efficiency. The degree of competition or efficiency of a market will usually influence the degree of the market and hence the prices that will be occurring in that market.

The extent of efficiency of a marketing system depends on the structure of the market, the market conduct and performance of the market. The concentration of sellers and buyers, the size of firms and the conditions for entry into the market are the principle elements of the structure of the market, influencing the degree of competition and pricing within the marketplace. McCorrison *et al.* (1989) was one of the earliest researchers, to model the structure of market as exerting some influence on the transmission of changes in prices. In their study in 1989, they show that market power reduced the extent of the transmission of price between the farm and retail stages. Thus, price transmission will be completed if markets are imperfectly competitive in nature. Market conduct can serve as an indicator of how agents in the market behave in relation to the determination of price, tactics to promote sales and to regulations introduced by the government. The way in which prices are formed is directly linked to these actions. When prices in the marketplace are formed based on the collusive activities of market agents imperfect price transmission will occur within that particular market or between that market and other markets. This will result in inefficiencies in the marketing system as a whole. Prices generated from the interactions of the forces of demand and supply is similar to that of a marketing system believed to be efficient.

The structure of a market together with the market conduct is representative of the performance of a market (Kanakaraj, 2010). Market performance is defined as how well a market uses the scarce resources available to meet the demand of consumers for goods and services. In an economy, where a price determined by a firm is just equal to its average

cost, the market can be considered to be efficient or is performing its functions adequately. In the same vein, a less profit margin can also be taken as an indication of market that is efficient in performing its function. In other words, one can determine the efficiency of a particular marketing system through the price and profit margin levels of prices and the level of profit

2.5 The Concept of Market Integration, Price Transmission and Spatial Arbitrage

The existence of integration among markets is a useful tool in measuring marketing efficiency in both temporal and spatial analysis. The focal point of a lot of studies on the integration of markets market can be found in the Enke-Samuelsson-Takayama-Judge (ESTJ) spatial equilibrium model (Enke, 1951; Samuelson, 1952; Takayama & Judge, 1971), in which the price differences for the same commodity in markets located at different location is bounded from above by the cost of arbitrage between the markets with no restrictions on the volume of trade and from below when volumes of trade volumes reach a critical value (Abunyuwah, 2007).

Spatial integration of market can be defined as a situation where the price of a good in markets located at different areas move together over time. Market integration is an evaluation of the extent to which shocks to demand and supply in a particular market are passed on to another market located in an area different from that of the other market (Negassa *et al.*, 2003). Barrett & Li (2002) defined the integration of markets in the context of contestability and tradability between markets which involves processes that clear the market, where supply, demand, and cost of transaction in different markets influence the flow of trade and prices together, and the movements of shocks to price between markets. Defining market integration in terms of tradability allows for flow in

trade to be a sufficient condition required to indicate spatial integration of markets but not necessarily resulting in equalization of prices which is consistent with Pareto-inefficient distribution (Barrett, 2005). That is to say two markets can be said to be integrated when they belong to the same network or when a government institution fixes prices to allow them to adjust to shocks at the national and/or regional level making it possible for price transmission to occur even when trade does not occur between the markets (Cirera & Arndt, 2006). On the other hand, contestability looks at markets that are competitive and the complete use of rents to arbitrage, as such two markets can be considered as being integrated when there is the presence of zero marginal profits to arbitrage which makes market participants unconcerned about trading thereby arriving at competitive equilibrium and a Pareto-efficient distribution (Barrett & Li, 2002).

Spatial market integration is important in agriculture due to the bulky and perishable nature of agricultural commodities; also the area of production of the produce and the area of consumption may be different possibly implying expensive cost incurred in the transporting the produce between locations (Sexton *et al.*, 1991). Markets that are not well integrated will often result in the transmission of information of price signals that are incorrect to all participants along the marketing chain that will likely end in production and marketing decision that do not benefit anyone (Goodwin & Schroeder, 1991). Also markets that are not integrated do not allow economic agents to enjoy benefit derived from lower prices or increased productivity. This is because in markets that are not integrated, the transmission of incentives of price and the positive impacts associated with welfare are restricted (Ankamah-Yeboah, 2012)

According to Goletti *et al.* (1995) integration among market can be attributed to the actions of traders as well as the environment in which they operate. These include marketing infrastructure such as communication, transportation, storage facilities and credit which generate large marketing margins due to the cost involved in the transfer of goods. The actions of government such as policies aimed at stabilizing prices, restrictions on trade and regulations on credit and transportation can affect the ways in which markets function (Ankamah-Yeboah, 2012). Rapsomanikis *et al.* (2006) also identify the oligopolistic and collusive behaviours among local traders as one of the determinant of integration of markets; thus traders may maintain price differences between markets at a level that is above that determined by transfer costs.

2.5.1 Price Transmission

Price transmission is thought to spring from three concepts (Balcombe & Morrison, 2002). The concepts are co-movement and completeness of adjustment, dynamics and speed of adjustment and the asymmetry of response. The notion of co-movement and completeness of adjustment implies that at any point in time variations in the prices of a commodity in a particular market are completely passed on to another market. The dynamics and speed of adjustment looks at the means by and speed at which, prices in a particular market is completely passed on to another market or level. Finally, the asymmetry of response component tries to identify if the price transmission process among markets are characterized by symmetric or asymmetric relationships in other words are shocks that increase prices passed on faster than those that decrease market prices. The rate of adjustment and the degree of completeness can be characterized by relationships that are asymmetric in nature.

From the above given notions, complete price transmission can only occur between two spatially separated markets when variations in the price of a commodity in one market is fully and instantly transmitted to the prices in the other markets for similar commodities, as postulated by the Law of One Price (LOP). This implies that the markets for a particular commodity are integrated. It also implies that when changes in prices are not passed on immediately, but after a certain period of time has passed, then the process of price transmission will be completed the long run and not the short run, as implicit in the conditions of spatial arbitrage. The separation of price transmission into short run and long run price component is very essential as is the rate of price adjustment to their long run relationship. This is fundamental in understanding the degree of market integration in the short run

2.5.2 The Concept of Spatial Arbitrage

Spatial Arbitrage is the process whereby traders transport commodities from one market to another whenever the difference in price between the two markets is larger than the cost involved in transporting a good between the markets. Spatial arbitrage can be represented mathematically by formula:

$$p_t^i + C_t^{ij} = P_t^j \quad 2.1$$

$$p_t^i + C_t^{ij} > P_t^j \quad 2.2$$

p_t^i denotes the price of a commodity in the export market i in period t p_t^j denotes the price of the same good in the import market j, and C_t^{ij} denotes the cost of transfers in the same period. Equation 2.1 represent the condition for trade to occur and equation 2.1

represent a disincentive to trade. Equations 2.1 and 2.2 are known as the spatial arbitrage conditions. When the variations in prices between two markets is greater than the cost of transaction, opportunities for arbitrage are created and arbitrageurs make use of such opportunities to make profit, by buying goods at lower price from surplus markets and moving them to deficit markets where prices are higher. This is done until the variations in price become equal to the transportation cost. If the difference in prices of a homogenous commodity between a pair of markets is consistently above than the cost of transportation, it is an indication that the markets are not working. This can be due to the action of government such as placing restrictions on trade, collusive behaviour of traders, lack of credit, lack of market information, or some other factors. The frequent occurrence of spatial arbitrage opportunities in markets is an important indicator of market efficiency.

The conditions of spatial arbitrage ensure that, in competitive markets that trade with one another differences in the prices of commodities should be equal to the cost of transaction, while at independence or self-sufficiency differences in prices between two locations is either lower than or equal to the cost of transaction (Tomek & Robinson, 2003). The spatial arbitrage conditions also allow for the law of one price to operate.

2.5.3 The law of One Price

The Law of One Price (LOP) follows directly from the spatial arbitrage condition. The LOP states that “in the assumed absence of transport costs and trade restrictions, perfect commodity arbitrage insures that each good is uniformly priced (in common currency units) throughout the world” (Isard, 1977). For instance, P_{jt} and P_{it} are the respective prices of a similar commodity traded between an export market j and an import market i in the same period. The LOP (in its weak form) requires that the price differences

between i and j for the homogenous commodity be equal to the transfer costs involved in transporting the commodity from market j to i . It stipulates that whenever the price difference exceeds the transfer costs, arbitrage processes work out to ensure equality between the inter-market price difference and transfer costs. The LOP mathematically states that:

$$P_t^i = P_t^j + C_t^{ij} + \mu_t \quad 2.3$$

Where, C_t^{ij} is the cost of transferring the commodity between market i and j whereas μ_t represents the deviations from the LOP in the short run due to immediate unexpected shocks (e.g. failure of transportation systems, natural disasters, policy incoherence). The equation (2.1) implies that:

$$\mu_t = P_t^i - P_t^j - C_t^{ij} \quad 2.4$$

Earlier analyses of market integration that emphasized the concept of the LOP in the above form mistook any inter-market price relationship that failed to fulfil the LOP as market segmentation. The “law of one price” (LOP) can be used to determine the market size, predict variations in price within a market and evaluate the efficiency in setting prices of goods in a marketplace (Kohls & Uhl, 1998). The LOP will fail to operate in regions not linked by arbitrage. Studies on the LOP by authors such as Baffles (1991) and Ardeni (1989) found the LOP to be a phenomenon occurring in the short-run. They did not find any evidence to indicate that the LOP was a long-run phenomenon. They suggested that the failure of LOP to be a long run phenomenon is due to price, institutional factors, cost of transaction and problems that are time-specific in nature.

This led to the modification of the concept of the LOP in co integration and regime-switching models in which nonlinearities in price series are explicitly accounted for.

2.6 Conditions for Efficient Market Arbitrage

Conditions for efficient market arbitrage can be grouped into necessary and sufficient conditions. The necessary conditions are satisfied when there is the exchange of information and goods across space, time and form between any pair of entities engaged in trade (Prajogo & Olhager, 2012). The sufficient conditions on the other hand are satisfied when the variations in the price between two markets in different locations is less than or equal to the cost of transaction (Prajogo & Olhager, 2012; Baulch, 1997). That is to say that the LOP is working in these markets.

Efficient arbitrage in markets will lead to markets that are efficient in performing their functions. When there is efficient arbitrage among spatially separated markets, higher prices occurring in deficit markets will result in the flow of goods from surplus markets to deficit markets (Negassa & Myers 2007). This will occur until prices in the two markets become equal. This shows that the markets for that commodity are efficient.

2.7 Techniques for Measuring Spatial Market Integration

Studies on spatial market integration try to answer questions on the characteristics of the price transmission process that occur among situated at different locations. This is done by answering questions on the patterns of causality among market pairs, dynamic interactions and the existence of a long-run equilibrium. Some of the methods used in answering such questions are briefly discussed below.

Studies on market integration started with by using static price relationships as a test for spatial integration among markets. This method involved estimating a bivariate correlation and regression coefficients of similar commodities in different markets (Hossain & Verbeke, 2010). This method was inspired by the idea prices in markets that are integrated will tend to move together. According to this method a high coefficient of correlation result was taken to imply market integration whereas a low correlation coefficient implied that the markets were segmented. The static approach is a fairly simple method; however, the model is plagued by weaknesses that can lead to the drawing of wrong conclusions from results obtained. Cirera & Arndt, (2006) identify the primary concern of this method be that correlation does not mean causality.

This procedure is not able to identify when the problem of heteroscedasticity is present in the price data under study. Also where a lag in reaction to price change is caused by lags in market information, a test of correlation will likely overestimate the absence of integration among markets (Barrett, 1996). Analysis of bivariate correlation also hides the masks the existence of factors such the effects of government policy effects and a general increase in the level of prices (Goletti *et al.*, 1995). The method also assumes that prices adjust instantly to shocks and as such it is not able to capture the ability of prices in markets to change. Results of price correlation coefficient are likely to misleading when the data analysed is non stationary in nature (Wyeth, 1992). Finally, the static price correlation method cannot be used to analyse the whole marketing system only pair wise market analysis.

The Delgado Variance Decomposition Approach so named after the researcher Delgado was developed in 1986 as an another model to measure market integration due to the

weaknesses of the bivariate model as mentioned above. According to Negassa *et al.* (2003), this approach allows the whole marketing system to be tested for the existence of market integration. This overcomes the shortcomings of the static price correlation method. Before the introduction of this method, tests for integration among market assumed that transaction and transport cost were constant and also allowed for the removal of familiar trends and seasonalities present in price series. This then ensured that the equality in spatial price spreads between markets pairs in a certain season could be taken to mean that the markets are integrated. The shortcoming of this method is that it does not allow for dynamic relationships among two markets in different locations. Also the method is based on price relationships that occur in the same period.

The Ravallion approach developed in 1986 became the most popular method for measuring integration among market. This was because of its ability to differentiate between integration and segmentation of market in both the long and short run after adjusting for seasonal changes, seasonality, trends and autocorrelation (Negassa *et al.*, 2003). Agricultural markets are slow to adjust when shocks that may call for substantial time lags are introduced into the markets. This slow adjustment of agricultural markets to such shocks is what informs the basis of the idea underlining this method. By linking dynamic considerations in this model researchers are able to dodge the danger of inference that is known to be present in the static model mentioned above. According to Cirera & Arndt, (2006) the Ravallion model assumes that the cost of transfer among market is constant and also neglects the possibility that there could be reversals in the flow of goods between seasons. In situation where the cost of transfers is complex or vary with time, any conclusion drawn will be prejudiced towards the inability to reject the

hypothesis of segmented markets. This method asserts that the nature of the structure of a market existing between a number of domestic markets and a principal market is radial in nature. This means that the prices formed in the domestic markets are controlled by trade with the central market.

Regression technique has been used to examine integration among markets (Alexander & Wyeth, 1994). The problem with this method was that regression analysis could only be applied to stationary data as its application to data that is non-stationary will lead to spurious regression. This shortcoming was resolved by using the first difference of the price series in the regression, but this resulted in the loss of long-run information. Cointegration techniques provided a way for analysing non-stationary time series data that did not produce spurious results. This helped to improve the strength of research findings as price series used in testing market integration are often non-stationary in nature. Cointegration was introduced by Engle & Granger (1987) and Engle & Yoo (1987). They define cointegration as the presence of a long-run relation between various price series. The nonexistence of a long-run relationship between prices in two different markets means that the market pairs are segmented, while its presence indicates that the market pairs are integrated with each other (Ankamah-Yeboah, 2012).

Cointegration analysis begins by first finding out what the order of integration of individual price series is by using a suitable unit root test. If all the individual price series are integrated of the same order, a co-integration regression is created and residuals from the regression are tested for the presence of unit roots. One of the weaknesses of the cointegration method introduced by Engle & Granger is that it did not enable one to test of all possible co-integrating vectors in a multivariate system. This then led to

Johansen (1988) coming up with a co integration approach which overcomes the shortcoming stated above. The Johansen method relies on maximum likelihood in testing for the existence of long run relationships among several economic series. Engle & Granger (1987) also proposed to use error correction models in analysing the short run dynamics if co integration was found to be present between the variables under study. The error correction representation explains the process of adjustment of both short-run and long-run reaction to variation in price which usually indicate arbitrage and efficiency in markets (Abunyuwah, 2007). Co integration and error correction models can also be used to explore ideas such as completeness, speed and asymmetry of price relationships and the path in which causality between a pair of markets will occur. According to Barret (1996) presence of long run relationship among prices is not a necessary or sufficient condition for integration between markets. When transaction costs are not stationary, lack of proof to support the presence of long run relations may be consistent with integration of markets. Cointegration is not sufficient because a negative sign of the coefficient of the price in the principal market implies divergence instead of co movement.

The Error correction model is an expansion of the co integration model. If there is the presence of a long run relationship among two price series p_t^i and p_t^j then the equilibrium relationship between them can be defined as: $\varepsilon_t = p_t^i - \beta p_t^j - \beta_0$ and the error term ε_t is presumed to follow an autoregressive (AR) process, then $\varepsilon_t = \alpha \varepsilon_{t-1} + e_t$ this shows that the equilibrium relationship between p_t^i and p_t^j can be defined as:

$$p_t^i - \beta p_t^j - \beta_0 = \alpha \varepsilon_{t-1} + e_t \quad 2.5$$

Equation 2.5 shows that co integration between p_t^i and p_t^j is a function of the autoregressive process ε_{t-1} where ε_{t-1} represents the deviation from equilibrium in the long run and is known as the error correction term (ECT). The ECT measures the response of p_t^i and p_t^j to deviation from equilibrium. The standard ECM has been expanded to asymmetric error correction model, vector error correction models (VECM) and switching vector error correction models (SVECM).

Parity Bound Models (PBM) was developed by Spiller & Haung (1986) and Spiller & Wood (1988). According to Abunyuwah (2007), the PBM was developed to try and use all market data to assess the efficiency between markets located in different regions. The model presumes that the cost of transaction plays an essential role in influencing the price efficiency band or parity bounds (Barrett & Li, 2002). The PBM evaluates the degree of integration among markets market integration by estimating the likelihood that an observation will belong to one of the three regimes (no profitable trade, efficient trade, and unexploited profitable trade opportunity). This approach is an improvement over the above error correction models as it takes into consideration transaction costs, trade reversals, and discontinuity (Barrett, 1996). The approach is, however, criticised for its static nature and data limitation on observable transfer costs, especially in a developing country setting

The threshold autoregressive models (TAR) was developed by Howell Tong, (1983). The TAR assumes that the cost of transactions must go beyond a certain threshold before price will begin to adjust towards equilibrium leading to integration of markets (Goodwin & Piggot, 1999). The threshold effects will usually happen when shocks above a significant threshold level result in responses that vary from those by shocks that lie below a

significant threshold. The thresholds are generally viewed as components of adjustment and transaction costs or economic risks that keep market operators from constantly adapting to variations occurring in markets (Rapsomanikis & Karfakis, 2007). Although the ability of the TAR to identify the cost of transaction constraints in measuring integration among markets market, the model still has some shortcomings. The limitation of the PBM is that it that the costs of transactions are constant and as such implies an unchanging neutral band over the study period (Abdulai, 2007). The addition of time trends to the threshold and parameters of adjustment and the subsequent specification of the threshold as a simple linear function of time is one of the attempts at trying to overcome the weakness of the PBM (Van Campenhout, 2007). Another attempt introduces sub-samples that are different in nature to show varying policy and economic setting to capture possible changes in the cost of transaction as a result of different policy regimes (Abdulai, 2007).

2.8 Asymmetry in price transmission

Asymmetry in price transmission exists when prices at different levels of a market respond differently to shocks. According to Rapsomanikis, (2006), the presence of asymmetries in the response of one price changes in another price shows that the adjustment process is non-linear in nature. A lot of researchers have used the asymmetric error correction model proposed by Granger & Lee (1989) or threshold co integration models developed by Enders & Granger (1998) to study asymmetry in the price transmission process.

Price asymmetry exist either in the speed or extent of adjustment or both. In terms of the extent of adjustment, elasticities in the short-run vary according to the direction of the

initial change whereas with the speed of adjustment it is the long run elasticities that vary (von Cramon-Taubadel, 1998). Asymmetry in price transmission can either be positive or negative. Positive asymmetry occurs when prices respond more quickly to shocks that increase price than to those that decrease prices. In other words, price adjustment that squeezes the margin is transmitted faster than those that widen the margin. Negative asymmetry is when prices respond faster to a decline in another price than to an increase. In other words, prices respond quickly to adjustment in price that will enlarge the margin. This usually can be used to determine the path followed in transferring welfare (Meyer & von Cramon-Taubadel, 2004). Vertical asymmetry is when asymmetry in price responses occur along the food supply chain whereas spatial asymmetry is when asymmetry occurs between markets located in different areas. APT means that markets actors are not enjoying the benefits they would have derived from reductions or increase in prices under conditions of symmetry. This is because under conditions of asymmetry the timing and/or size of the changes in welfare linked with changes in price are distorted (Meyer & von Cramon-Taubadel, 2004).

2.8.1 Causes of Asymmetry in Price Transmission

A possible cause of asymmetries in price transmission is market power. Market power is when some actors in the market are able influence the prices of commodities such that it remains over a certain competitive level (Amonde *et al.*, 2009). In agriculture especially, farmers and consumers often believe that imperfect competition in processing and retailing provides an opportunity for middlemen to abuse market power. It is expected that this will often result in positive asymmetry however; it is not the only effect emanating from market power. Ward (1982) point out that because of the fear on the part

of oligopolists in losing market share, they may be hesitant to increase the price of their output.

Adjustment costs are also considered as a cause of APT. Adjustment cost refers to the cost incurred by firms in altering the input or output prices or quantities. When the costs incurred are characterized by asymmetry in the increases or decreases associated with quantities or prices. APT can occur. In the situation of changes in prices we can refer to adjustment costs as menu costs (Meyer & von Cramon-Taubadel, 2004). Menu costs include the cost incurred when nominal prices are changed, cost of inflation and the cost of distribution information about changes in price. Asymmetric may be present in menu cost with respect to rising and falling price level. When there is continuous increase in the general price level menu cost can lead to the incidence of asymmetry (Ball & Mankiw, 1994). Under such conditions, Abdulai (2000) reported that firms respond more quickly to shocks that increase prices since positive shocks help them to correct for expected inflation.

Inventory management or stock behaviour of traders has been identified as another cause of APT in a lot of markets. Instead of decreasing the price of output when demand is low firms would rather increase their inventory level while in times when demand is high they increase the prices of their goods. These combined with asymmetry in costs associated with increases and decreases in the levels of inventory and the fear that stock will run out may lead to prices responding rapidly to increases than to a decrease (Reagan & Weitzman, 1982). Balke *et al.* (1998) also point out that methods of accounting such as FIFO (first in first out) can lead to APT.

Also the role of government can bring about asymmetry in price transmission. It is common in agriculture for governments to intervene by providing price support such as price floors. This is because such mediations by government can lead to APT if wholesalers and retailers are convinced that the decrease in the prices will not last for long especially since it will bring about government intervention, whereas increases in the prices is likely to have a lasting effect.

2.9 Empirical Studies linked to Market Integration Price Transmission in Ghana and Elsewhere

Ghanaian agricultural markets have been subjected to a lot of research on the behaviour of price and their responses to one another most especially in the maize market with very few studies delving into other markets such as the tomato, plantain and cassava.

In analysing price transmission between major maize markets in Ghana from 1980 to 1997, Abdulai (2000) utilized the threshold cointegration model. Results indicated that maize prices between the time periods in question in the Accra and Bolgatanga markets react faster to increases in the principal market price than to decreases. Abdulai (2000) also found out those markets in Accra react faster to changes in prices in the Techiman market prices than do markets in Bolgatanga.

Cudjoe *et al.* (2008) studied the effect of crisis on a global level on transmission of food prices and poverty in Ghana. The results of the correlation analysis found out that correlation between the price of rice imported into the country and the price of domestic staples such as cassava, maize, rice and yam high in the Tamale and Wa markets found in the northern region of the country. Coefficient of correlation was also found to be high between the global prices of rice and maize. Cudjoe *et al* also applied the Johansen co

integration test which revealed price transmissions in Ghana where heterogeneous in nature. No evidence of price transmission was found for root crops such as cassava and yam across different regional markets, however in the market for cereals the transmission of price was high in both the short and long run.

Amikuzuno (2010) employed TAR model to examine price transmission between four major markets for fresh tomato in Ghana. The results of the study revealed that while transmission of changes in prices improved for some pairs of market, while for other pairs it deteriorated from periods of high to low tariffs. The results also showed an improvement in the price adjustment, which assesses the price transmission level, and thresholds that represent the cost of transaction after the reduction in import tariffs. According to the author, other factors that can explain the observed signals of failure in markets need to be examined. Also options to help reduce volatility in prices and also enhance the competitiveness of fresh tomato in Ghana need to be considered.

Mensah – Bonsu *et al.* (2011) examined whether the plantain marketing system in Ghana between the periods 2004 to 2009 were efficient. The authors used the Johansen test for cointegration and error correction models to examine if plantain markets were integrated or not. The Accra market was used as the main consumption market; markets in Koforidua, Kumasi and Sunyani as assembling markets and finally the markets in Begoro, Goaso and Obogo were selected as producing markets. Results of the study identified short and long run relationship between markets studied implying that arbitrage works in the plantain marketing system. Results also show that the rate at which prices were transmitted between the Accra market and the other markets was 27.7% which was

moderately weak when likened to an ideal adjustment of 100% threshold. This result suggested that further integration especially in the short run is required.

Acquah *et al.* (2012), applied the Johansen co-integration and Granger Causality test and Autoregressive distributive lag model (ARDL) to examine the transmission of prices and integration of local cassava markets in Ghana. The study used weekly prices of cassava from August 2008 to April 2010. The results showed that although the price series were integrated of the same order; long run relationship among the price series studied was non-existent. The markets pairs under study were also found to be independent of each other. This suggested that transmission of price and integration of cassava markets under study was poor. The authors therefore recommended that the factors that influence spatial price transmission should be critically looked at.

Acquah & Owusu (2012) also examined spatial integration of market and transmission of prices of some markets for plantain in Ghana. Using co integration analyses and vector error correction modelling to provide an econometric analysis of plantain markets integration, the authors tested the degree of spatial market integration using prices from three markets namely Techiman, Accra and Kumasi. The test of co integration identified at least three co integrating relationships which showed that markets for plantain were joined together. The result of the VECM revealed that a shock introduced to the market in Techiman will be erased at rate 47% in the following period. This result suggested that the rate of adjustment of price to shocks between the Techiman market and the other markets was moderate given an ideal adjustment threshold of 100%.

Since most price transmission and market integration analysis in Ghana have focused more on grains such as maize and rice rather than on other essential commodity like fish which also plays an important role in the economic development of Ghana we look at market integration and price transmission studies undertaken outside Ghana most especially on the fishing sector.

Norman-López & Asche (2008) in studying the competition between tilapia imported into the United States (US) and domestic catfish market using the Johansen cointegration test found out that there was only one market in which for domestic catfish, fresh and frozen catfish fillets were sold for the period (1997–2006) under study. Results also showed that there were different markets for fresh and frozen tilapia fillets. No form of competition was found to exist between the fresh and frozen catfish and tilapia products. A study by Norman-López and Bjørndal in the following year confirms these results, by revealing that the tilapia products imported into the US from Africa, Asia, Central and South America were not co integrated with the US for the period 2002–2006. Also, no relationship was found to exist between whole frozen tilapia and frozen tilapia fillets in markets in the US.

Shinoj *et al.* (2008) studied the extent of price transmission and integration between the major coastal markets in India. The authors used monthly retail price data on important marine fish species for a ten-year period from January 1998 to December 2007. Markets in the Andhra Pradesh, Gujarat, Karnataka, Kerala, and Maharashtra, Orissa, Tamil Nadu and West Bengal states were chosen for the study. The fish species studied included Mackerel, Sardine, Pomfret and shrimp. Results revealed that the Mackerel market had the highest integration among the markets under study with the Shrimp markets appearing

to have the least market integration. Authors also discovered that the transmission of prices between the markets in Kerala and Tamil Nadu was nearly complete except for shrimp. Also the price movement in the market in Maharashtra was found to be independent of the other markets despite its status as a major landing centre in India. The study therefore suggested that strategies that will increase market integration be introduced so that producer and consumer can benefit from it.

In Nigeria, Bada & Rahji (2010) in studying the market delineation of market for fish in Nigeria for the period 1970–2005 using the Johansen Cointegration test showed that prices of locally produced North African catfish in Nigeria is influenced by Hake, Mackerel and Sardinella imports but not vice versa. The analysis also reveals that Catfish could be used as a substitute for fish imported into Nigeria. All the species were found to be in the same market and could be used as substitutes for each other. It was recommended that the effect of imported fish prices needs to be taken into account when designing fish production policies.

Adenegan & Bolarinwa (2010), examined the extent of price transmission and integration of markets local fresh and dried fish and imported iced and dried fish markets in the urban and rural area of Oyo State in Nigeria. The authors employed the use of the ADF test, test for Granger-causality and Market Concentration index to analyse monthly retail prices of fish for a period of five years. Data was obtained from the Oyo State Agricultural Development Project the result of the study revealed that all market pairs were well integrated except the market for rural and urban local fresh fish. This showed that prices of fresh fish in urban and local market did not move together in the long run. The granger causality test carried out for fifty-six markets pairs show that out twenty-five

market pairs did not granger cause each other, seventeen market pairs showed unidirectional causality and the remaining market pairs showed bi-directional causality. The market occupying the leadership position in forming price was found to be the urban fresh fish market. The market connection index showed that the markets studied showed that integration of markets was low in the short run. It was suggested that policies aimed at improving efficiency of fresh fish markets in the urban and rural area of the Oyo state be implemented.

Mafimisebi (2012) using a vector autoregressive approach looked at the spatial equilibrium, integration of markets and exogeneity in price for dry fish in Nigeria. Retail data on the monthly price of dried fish from January 1997 to December 2008 for twelve state capital markets was used in the study. The results of the study disclose that all the price series under study were integrated of the same order. The results of the VAR revealed that more than half of the market studied integrated in the long run. The markets in Akure, Bauchi, Kano and Makurdi were found to influence the prices in the other market location. Only the markets in Kano exhibited Kano exhibited very strong exogeneity. The study concluded that there the degree of spatial pricing efficiency in dry fish markets in Nigeria was low. Thus it was recommended that market infrastructures and the collection, collation and dissemination of information be enhanced. The author also recommended that policy reforms that target a reduction in the price at the retail level for identified leader markets be implemented, as a means to increasing spatial pricing efficiency in dry fish markets in Nigeria.

Sapkota *et al.* (2012), their paper titled “Price Transmission relationships along the seafood value chains in Bangladesh: aquaculture and capture fisheries” investigate the

causal and price transmission relationships existing between and retail prices of Catla, Hilsa, Pangas Rohu and Tilapia fish species in Bangladesh from October, 2005 to July, 2010 for Chittagong, Dhaka, Khulna and Rajshahi. The study employed the use of the Granger causality and the Houck and Ward approach as well as the von Cramon-Taubadel and Loy error-correction model for analysis. The results show in many of the value chains analysed retail prices were found to influence prices in the Bangladesh fish sector. The results also revealed in the short run; transmission of prices was characterized by symmetry while in the long run a mixture of symmetric and asymmetric relationships was observed. Variations in the transmission of prices between capture fisheries and aquaculture products were also identified from the results of the study.

Bukenya & Ssebisubi (2014) used the Johansen Cointegration test to analyse monthly price data from 2006 to 2013 in their study titled “Price integration in the farmed and wild fish markets in Uganda” revealed that wild harvested and locally farmed North African catfish in Uganda belong to the same market. Gordon & Ssebisubi (2015) in their paper titled “Vertical and horizontal integration in the Uganda fish supply chain” also produced a result similar to that of Bukenya & Ssebisubi (2014). They applied the Johansen cointegration test to monthly price data from Uganda for the period 2006–2010. The authors demonstrated that locally produced and wild-caught North African catfish in Uganda belong to the same market together with farmed and wild-caught Nile tilapia and wild-caught Bagrus. However, it was found out that Mukene and Nile perch caught in the wild did not follow the same trends.

2.8 Summary

Observations made from the reviewed literature suggest that agents in the market are able to make timely decisions when market information is easily accessible. To assess integration of markets and price transmission of various agricultural commodities numerous analysts have used various methodologies. Based on the law of one price, co-integration suggests that if two markets are considered to be integrated, then a price changes in one of the market is transmitted on a one for-one basis to the other market in the short run, or over time in the long run. To test the assumption, several techniques were identified in the literature, including co-integration, causality; symmetry; and an error correction mechanism. The framework for this study combined several techniques to better understand the degree of market integration. The notion of cointegration, which accommodates both the short and long run responses, has not yet been applied to the study of integration of processed fish markets in Ghana

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter deals with the models and procedures employed in carrying out this study. It discusses the basic theory underlying price transmission and market integration analysis. It also presents the empirical model employed in achieving the objectives set out in the study, the source of data for the study and a description of the study areas.

3.1 Theoretical Framework

The theory behind integration of markets and price transmission analysis lies in understanding how prices among markets in different locations interact with each other. Understanding how prices interact in markets situated at different location that is the spatial integration model, predicts that the difference in price for a pair of markets for a homogeneous commodity under competitive conditions will approximately equal the cost incurred in moving the homogenous commodity from one market to the other. The law of one price as explained in chapter two is of two forms, the strong which says that the difference in prices should equals the cost of moving the homogenous commodity from one location to another and the weak places the price difference to vary by at most the cost of transportation. The weak form of LOP is known as spatial arbitrage.

$$P_i - P_j = C^{ij} \tag{3.1}$$

According to Chirwa (2000), LOP assumes that changes in prices in markets that are integrated will be transferred instantly on a one-for-one basis to among them. The

principle of spatial integration predicts that under competitive conditions, differences in prices for a pair of market for a homogenous commodity will be nearly equal to the cost of transactions. This is a long run concept; however, prices can move away from each other in due to a variety of shocks in the short run. Price signals will stimulate the price transfer of commodities between excess and surplus markets if a situation of disequilibrium arises as such equilibrium will then be established in the long run. The existence of a situation like this suggests a stationary term which can be defined as the temporal and stochastic deviation from equilibrium. A common feature of stationary series is that they constantly return to and fluctuate around their mean. This feature can be referred to as a long run affinity (Rico, 2009). This in simple terms means that provided the series is stationary, values like its mean and variance may change but as time goes on will revert back to their average values. Such conducts are closely related to the economic understanding of equilibrium which is also a long run concept.

Based on this theory it is expected that prices in surplus (producer) and deficit (consumer) markets will be equalized in the long run even if there are deviations in the short run.

3.2 Conceptual Framework

Under competitive conditions, price differences between two regions in the same economic market environment for a homogeneous commodity should approximately equal to the inter-regional transportation costs. Market integration thus involves a test of price efficiency by examining how food markets in different regions respond jointly to supply and demand forces. If price movements in different parts of the country tend to behave similarly, reflecting the cost of transferring the product between two regions, then markets are said to be integrated. The price movement in the different markets provides an

important indicator as to whether the markets are integrated or not. If the prices in the different markets for the same commodity move in identical patterns, those markets can be considered to be well integrated.

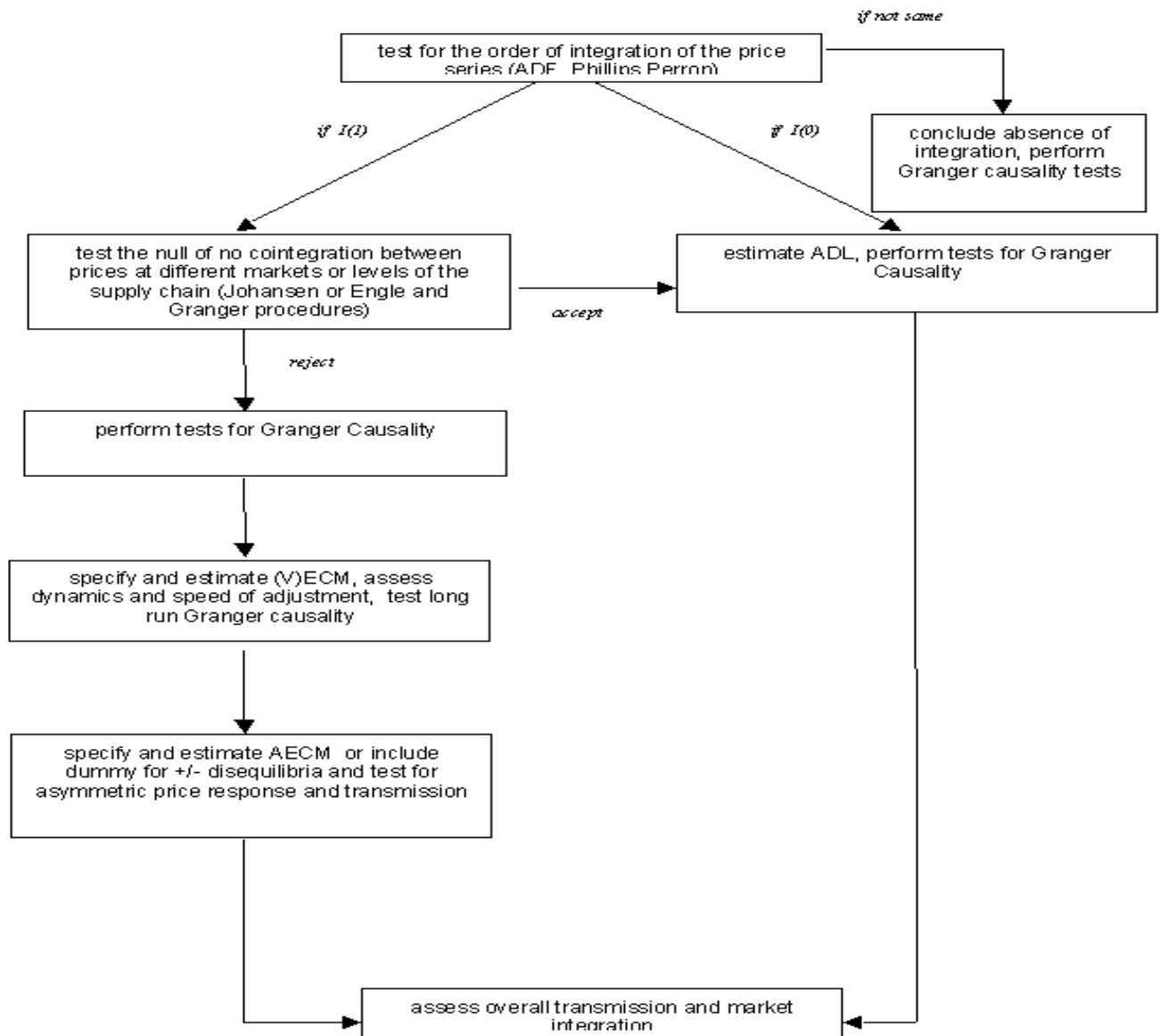
Since market integration is important in indicating transmission of price signals and shocks among commodities over time, the model underlying market integration postulates, that there exist linkages among markets and stable relation among prices in different localities. If two markets, a surplus market (x) and a deficit market (y) are integrated then supply and demand shocks will cause food to flow from the surplus market x to deficit market y where prices are higher, thereby decreasing the food supply in market x . The prices in market y would go down because of the increased supply from market x and this would eventually lead to the prices in market x also going up due to the decreasing food supply in market X . This co-movement of prices gives a degree of market integration among the markets.

3.3 Empirical Framework

The definition of price transmission provided in the chapter two earlier contains within its meaning the situation of perfect integration among markets, the inbuilt dynamic interactions of market that crop up due to inactivity or interruptions in trade, as well as nonlinearities that come to light as a result of policies and other distortions in arbitrage. Even more important, is the identification of hypotheses, through its various elements, that can be tested within a co integration–error correction model framework. A variety of time series procedures exist to enable one assess each of the mechanisms involved in the transmission of prices and eventually assess the degree of transmission of price changes

and integration between these markets. These procedures are depicted in the diagram below.

Figure 3.1 Empirical framework for assessing price transmission



Source: Adopted from Rapsomanikis *et al.* (2006)

From figure 3.1, each price series is first tested to determine its order of integration using the Augmented Dickey-Fuller (Dickey & Fuller, 1979) or the Phillips & Perron tests

(Phillips & Perron, 1988). If the price series are found to have been integrated of varying orders, the study concludes that the markets are not integrated and carry out a test for granger causality. If it is determined that the price series are stationary or integrated of order zero $I(0)$, the study assesses the dynamics of the price relationship that exist between the series by means of Autoregressive Distributed Lag (ARDL) model and then proceeds to test for Granger Causality.

In the case where it is determined that the price series were not stationary or integrated of the same order that is higher than zero, the study test for the null of no cointegration in contrast to the alternative hypothesis of at least one cointegration relationship using the Johansen approach (Johansen 1988, 1991). The rejection of the null hypothesis indicates co-movement of prices and that markets under study are integrated. If the study is unable to obtain evidence against the null hypothesis, the study concludes that the markets are not integrated and/or that that transmission of prices along the supply chain may be incomplete. An ARDL model can then be used to analyse the dynamics of price relation in such series.

After rejection of the null of no cointegration among price series a Vector error correction model is used to analyse the dynamics of prices in short and long run, the adjustment speed and the direction of long or short run Granger causality.

Finally based on the results on causality direction, an Asymmetric error correction model is specified and tests the null of symmetry against the alternate of asymmetry. After which we discuss the results and touch on the characteristics of transmission of price changes and shocks and integration of market.

The frame work described above does not show the factors responsible for the integration of markets and transmission of prices. That is the study is unable to point out whether price transmission and integration of markets is influenced by the cost of transaction, policies undertaken to insulate local markets, or the extent of market power wielded by participants in the supply chain.

3.4 Method of Analysis

This section presents the methods used to analyse the data for the study.

3.4.1 Analyzing the extent of market integration

To analyse the extent of market integration among markets, a unit root test is first performed using the Augmented Dickey-fuller test. Studies on integration of markets first begin with testing for unit root in price variables in order to determine if the co-integration approach will be an appropriate tool the appropriate tool (Fossati *et al.*, 2007). The number of lags to be in the unit root test is chosen to ensure the absence of serial correlation using suitable information criterion test. Lovendal *et al.* (2007), recommends that, before the estimating a model, the existence of unit roots must be examined using Dickey-Fuller tests to test for stationarity the data sets in order to avoid the issue of spurious regressions and its related problems. The unit root test is performed first at level then at first difference to check if the price variables are stationary or not and also their degree of integration.

Mathematically stationarity can be shown as:

$$P_t = \phi P_{t-1} + \mu_t \tag{3.2}$$

where μ_t is a random walk with its mean, variance and co variance being equal to zero. The process tests the null of presence of unit root, that is, $H_0: \phi = 1$ against the alternate hypothesis of stationary, that is, $H_a: \phi < 1$. Rejecting the null hypothesis implies that the time series data is stationary.

After determining that their price series do not possess unit roots, we then move on to specify the Johansen's co integration to find out if the system of equations are co integrated or not.

3.4.1.1 Johansen Cointegration

Co integration can exist between two or more variables if each variable on its own is non stationary but a linear combination of the variables may be stationary (Gopal *et al.*, 2009). If two prices are found to be cointegrated it means prices in the long will follow the same path or move together. The presence of Cointegration also show that granger causality must exist in at least one direction among the variables and also that the co integrated variables can be expressed in an error correction form. Cointegration can also be thought of as a special case where a regression of series that are not stationary does not result in spurious regression results.

The first step to consider before carrying out a cointegration analysis is to determine the order of integration of the variables since this is an important because Cointegration can only be carried out series with the same order of integration or in other words non stationary. The order of integration is specified by the number of times a series needs to be differenced in order for it to become stationary, it can be written as I (d) where d represents the number of times the series was differentiated before becoming stationary.

The Johansen Full Information Maximum Likelihood test by Johansen & Juselius (1990) is preferred to that proposed by Engle & Granger (1987). The test proposed by Engle & Granger (1987) has the major disadvantage of assuming a single co integrating vector for the regression. As such in the likelihood of there being more than one co integrating vector this method becomes unsuitable for co integration analysis and the Johansen test becomes the more suitable option. This study therefore adopted the Johansen Full Information Maximum Likelihood test for its co integration analysis due this advantage. The Johansen maximum likelihood approach is based on the vector auto-regressive (VAR) approach to cointegration which assumes all variables are endogenous. The test tells as what and how many co integrating vectors are in a set of I (1) series

Johansen & Juselius (1990) propose two methods to estimate the number of cointegrating vector namely the Maximum Eigenvalue test which tests the null of r co-integrating vectors against the alternative of r+1 co integrating vectors. The test statistics are computed as:

$$\lambda_{\max} = -2Ln(Q : r + 1) = -TLn(1 - \lambda_{r+1}) \quad 3.3$$

The Trace test which examines the null of r co integrating vectors against the alternative of r > 1 co-integrating vectors, the trace test statistics is specified as:

$$\lambda_{\text{trace}} = -2LnQ = -T \sum_{i=r+1}^p Ln(1 - \lambda_i) \quad 3.4$$

The trace test carries out a joint test for the eigenvalues whereas the maximum eigenvalue test carries out individual tests for the eigenvalue. The Trace and Maximum eigenvalue test most of the time provides similar results, however in the situation where they differ,

the results of trace test are chosen over those of the maximum eigenvalue test (Alexander, 2001). If a long-run equilibrium relationship is found to exist between time series data, then a vector error correction model (VECM) is used to assess the features of the co-integrated series in the short run. A VAR or ADRL model can be employed to evaluate the price dynamics in the short run if the time series data is not co-integrated. Moreover, the Johansen test also allows for the testing of restrictions on the cointegration relations β and the adjustment speeds α in the VEC model.

The Cointegration approaches proposed by both Johansen and Engle and Granger assume the adjustment mechanism is linear and symmetric and as such in the presence of asymmetric adjustment these test for cointegration and their augmentations become incorrectly specified and have low power (Enders & Siklos, 2001; Enders & Granger, 1998).

3.4.1.2 Test for Granger Causality

Granger causality is important in showing the direction of the causal relationship after performing co-integration tests. A processed fish market price series can be said to granger cause another processed fish market series if the present and past values of the former improve the prediction of the latter price series. Rashid (2004) argues that causality measures the ability of prices to be predicted i.e. the movement of price in one market can be used to predict changes in price in other markets which can be tested within Johansen's co-integration framework.

Granger causality in markets can be manifested in three major ways i.e. unidirectional, bidirectional or as independent price series (Gordon *et al.*, 2011). Unidirectional

represents those markets in which shocks in one market cause prices in the other market but there is no reverse or feedback effect. The market which granger-causes the other in a unidirectional causality situation can be referred to as the exogenous market (Mafimisebi, 2012). Bidirectional causality on the other hand implies that shocks in a particular market are passed on to another market and vice versa. In the bidirectional causality, prices are said to be determined by a Simultaneous Feed Back Mechanism (SFM) that is there is feedback from mechanism operating between the markets (Mafimisebi, 2012). However, in a situation where none of the markets is granger causing the others there is independent causality. In this scenario shocks in a particular market are not transmitted to other markets unless under special conditions. Granger causality was conducted in this study to determine which market caused the other. The Granger causality models applied in this study are specified in the equations below:

$$P_t^i = \sum_{k=1}^n e_k P_{t-1}^j + \sum_{k=1}^n f_k P_{t-1}^i + \varepsilon_{1t} \quad 3.4$$

$$P_t^j = \sum_{k=1}^n g_k P_{t-1}^i + \sum_{k=1}^n h_k P_{t-1}^j + \varepsilon_{2t} \quad 3.5$$

Where P^i is the consumer market and P^j the producer market. The equations (3.4-3.5) postulate that P^i is dependent on P_{t-1}^j and P_{t-1}^i ; while P^j is also dependent on P_{t-1}^j and P_{t-1}^i . The error terms are assumed to be uncorrelated error. For equation 3.4 and 3.5 rejection of the null hypothesis by a suitable F-test indicates that prices in the market on the RHS granger-cause prices in markets on the LHS which implies that past

values of the series on the right hand side are adding information on the actual values of the series on the left hand side, in addition to what is provided by its own past values.

Before Granger causality is carried the it is important to first determine the number of lags to be used in the test as the direction of causality may be depend critically on the number of lags (Gujarati, 2008). The granger causality test assumes that the variables are stationary and that the error term is uncorrelated.

This Granger test in a price transmission analysis is important because it allows us to understand which of the two prices acts as a source of information for the other and enables us a gain qualitative understanding of the results, in terms of the causality direction and the extent of market integration.

3.5 Extent of Price Transmission

The extent of price transmission among the markets was assessed using the Asymmetric vector error correction model and the Autoregressive distributive lag model.

3.5.1 Extent of Price Transmission in Processed Fish Market (ARDL)

In running a regression involving time series data, if the regression model includes the current and lagged (past) values of the explanatory variables, it is referred to as a distributed-lag model. On the other hand, if the model includes one or more lagged values of the dependent variable as explanatory variables in addition to the current and lagged (past) values of the explanatory variable, it is called an autoregressive model (Gujarati, 2008). This model runs a regression with the explanatory variables and their lagged values as well as the lagged values of the dependent variable on the left hand side of the equation. In integration of market analysis, the ARDL is used as alternative test if we do

not reject the null of no cointegration. Since the price series were of a unit root and were not integrated, their first difference was used to run the regression of the form:

$$Y_t = \alpha + \beta X_t + \beta_1 X_{t-1} + \gamma Y_{t-1} + u_t \quad 3.6$$

Where Y_t is the current price of the reference market (Makola), X_t is the current price in the other market and Y_{t-1} and X_{t-1} are the lagged prices in the reference and other market respectively.

3.5.2 Extent of Price Transmission in Processed Fish Market (VECM)

The Vector Error Correction Model (VECM) was used to analyse the extent of Price Transmission in the processed fish Market. VECM is a suitable model for variables found to have one or more co integrating relationship vectors since it adjusts to both Short run and Long run. The VECM is applied to measure adjustments in price induced by deviations from the long-term equilibrium (ECT). The Error correction term (ECT) is assumed to be a continuous and linear function of the magnitude of the deviation from long-term equilibrium. As such any small deviations from the long-term equilibrium will always lead to an adjustment process in each of the market. The VECM model is embedded in the Asymmetric vector error model (AVECM), this is because in the AVECM the ECT of the VECM is spilt into a positive and negative component. Due to this the AVECM was used in analysing the extent of market integration and asymmetry of cointegrated price series.

3.6 Estimation of Extent of Asymmetry in processed fish Market

The asymmetric error correction model is used to analyse the extent of asymmetry in processed fish markets. Early studies on asymmetric price transmission a variant of the variable splitting technique developed by Wolfram (1971) and later improved on by Houck (1977) and Ward (1982). The technique involves splitting a variable X_t into a positive component such that $X_t^+ = X_t$ for all $X_t \geq 0$ and a negative components such that $X_t^- = X_t$ for all $X_t \leq 0$. The variable splitting technique refined by Houck (1977) has been used in Market integration and price transmission analysis in an effort to explain asymmetric adjustments. In this framework, the response of a price P_1 and to another price P_2 is estimated with the following equation:

$$\sum_{t=1}^T \Delta P_{1t} = \beta_0 + \beta^+ \sum_{t=1}^T \Delta P_{2t}^+ + \beta^- \sum_{t=1}^T \Delta P_{2t}^- + \varepsilon_t \quad 3.7$$

Where ΔP^+ and ΔP^- represent the positive and negative changes in P respectively. β_0 , β^+ and β^- are coefficients and T is the current time period. Asymmetry is tested in the model by determining whether $\beta^+ = \beta^-$. Some analyst introduce long-run term in ΔP_{2t}^+ and ΔP_{2t}^- to distinguish between short-run and long-run asymmetry. Long run symmetry is tested by determining if the sum of the co-efficient in the polynomials is equal, whereas short-run symmetry is tested by determining if the polynomials are identical. Von Cramon–Taubadel & Loy (1996) provide evidence to show that the model is basically not compatible with Cointegration between two price series. Granger & Lee (1989) extended the Error Correction Model specification to allow for asymmetric adjustments by splitting the ECT into positive and negative components. The resulting Asymmetric vector error correction model is

$$\Delta P_{1t} = \alpha_0 + \sum_{i=1}^n \phi_1 \Delta P_{1,t-1} + \sum_{i=1}^n P_{2,t-1} + \beta_2^+ ECT_{t-1}^+ + \beta_2^- ECT_{t-1}^- + \varepsilon_t \quad 3.8$$

$$\Delta P_{2t} = \alpha_1 + \sum_{i=1}^n \phi_1 \Delta P_{1,t-1} + \sum_{i=1}^n P_{2,t-1} + \beta_2^+ ECT_{t-1}^+ + \beta_2^- ECT_{t-1}^- + \varepsilon_t \quad 3.9$$

Where $\varepsilon_t \dots N(0, \sigma^2)$, ECT_{t-1}^+ and ECT_{t-1}^- measure adjustments to positive and negative shocks respectively. Since $ECT_1^+ + ECT_1^- = ECT_t$ we can thus see that the standard symmetric VECM is embedded in the AVECM and the F-test to test the null hypothesis of symmetry is given by $H_0 = \beta_2^+ = \beta_2^-$. If this is rejected, then price transmission process among the market is asymmetric. This extended model of AVECM was used for this study and in this case the variables being modelled are prices at different markets that are spatially related which imply that a positive (negative) ECT indicates that the marketing margin is above (below) its long run equilibrium. The idea that increases in producer price are passed on faster than decreases in producer price can then be formulated into a testable hypothesis that positive ECT values are corrected more rapidly than negative ECT values.

The speed of adjustment parameters can also be expressed as a half-life T_{half} , which shows how long it will take for half of the deviation from long-run equilibrium to be corrected. The half-life is computed using the following formula: $T_{half} = Ln(0.5) / Ln(1 + \beta)$, where β is the adjustment parameter estimate from the AVECM. In all the estimates, since the time of observations is monthly, the values of T_{half} are calculated in months.

3.7 Study Area and Data Source

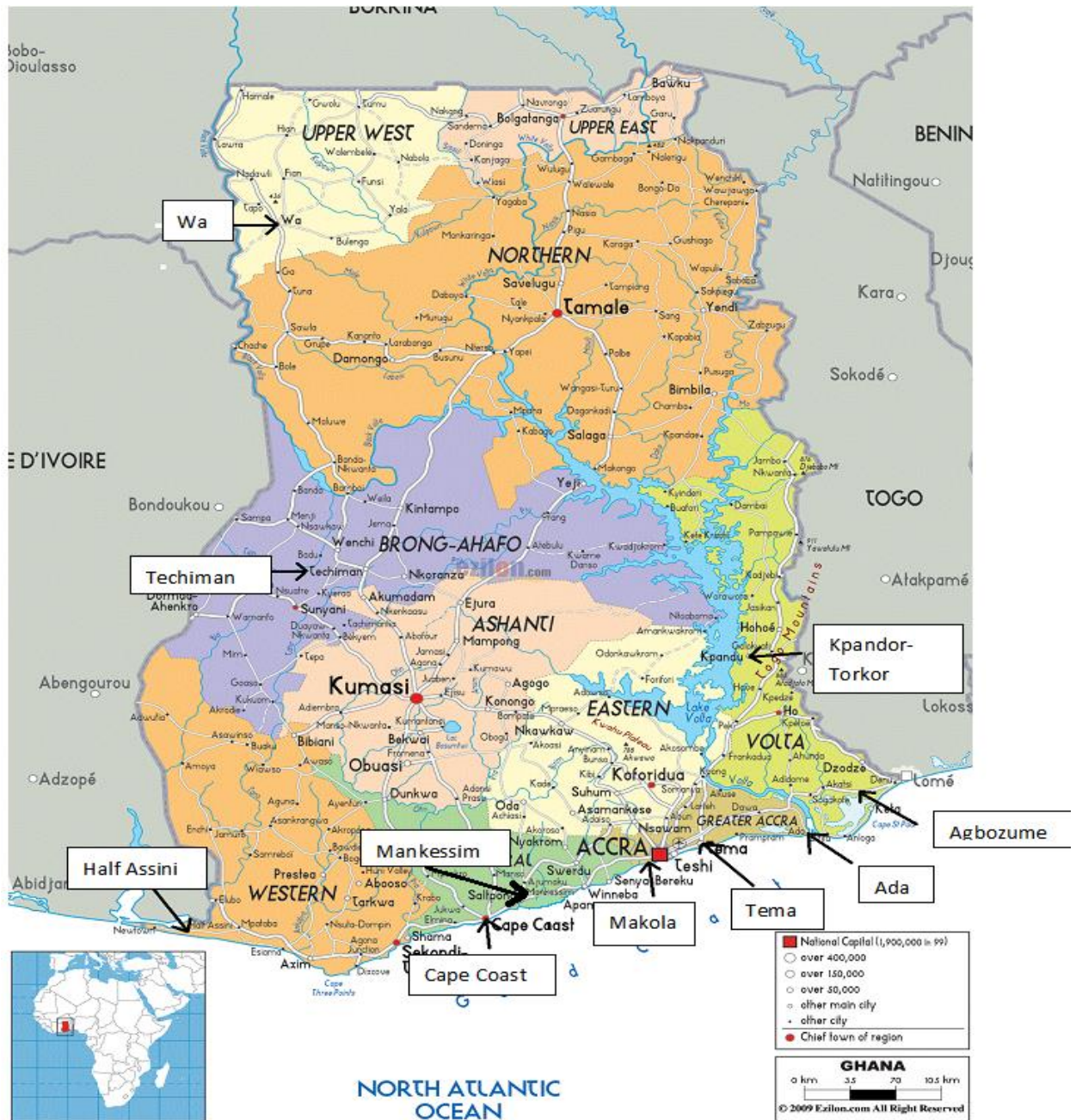
Secondary data on the price information of koobi, smoked herrings and Kpala from the markets being considered were used in the study. The secondary data used in the analysis is presented in appendix 1, 2 and 3. Ten processed fish markets namely Ada, Agbozume, Cape Coast, Half-Assini, Kpandu, Makola, and Mankessim. Techiman, Tema and Wa were selected for the study. The locations were selected based on the availability of data and geographical location of markets. Most markets were located close to the sea with a few of them being far from the coast. This was done to see how prices are transmitted among markets close to and far from the source of fish (sea) and if such markets were well integrated with one another.

The markets are located in Greater Accra Region, Upper West Region, Central Region, Western Region, Volta Region and Brong-Ahafo Region. Among the Regions, Greater Accra is the most important domestic fish market and consumption centre in Ghana (Fishery and Aquaculture Country Profile. Ghana. 2016). The Greater Accra region has the Makola market as one of its most important market. Hence, the Makola market is taken as the principal market. The data was obtained from the Ghana Statistical Service (GSS). The study used price information from January 2012 to December 2017, a total of 72 observations.

Markets that were missing two or more consecutive and recurring price values were dropped especially in the case of the Kpala markets. The unit of measurement for the price data collected from GSS were for GH¢/kg of koobi, smoked herrings, and Kpala. Log transformations of all the price series was carried out to make it easier to interpret parameters and also because of the chance to reduce the heteroscedasticity in the price

information. Since the prices were compared at the same market level and for the same commodities deflation of the price series was not done.

Figure 3.2: Map of Ghana showing the locations of the market under study



Source: Ezilon Maps (<http://www.ezilon.com/>).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

Discussion of the results emanating from the study is presented in this chapter. The discussion on the variability and movement of processed fish prices is presented in section 4.1. The stationarity analysis of the time series on the price data and the test of cointegration are discussed in section 4.2 and Section 4.3 respectively. Section 4.4 presents discussions on results of Granger causality test. Section 4.5 present discussions on the short- run and long-run dynamic interrelationship between the processed fish market pairs. The results of asymmetry in price transmission in the processed fish market pairs are discussed in section 4.6

4.1 Descriptive Analysis of Processed Fish Markets

Changes observed in agricultural prices at different points in time may often be attributed to fluctuations in yield, production, seasonality, condition of infrastructure, government policies and the behaviours of consumer and other market participants. It is imperative that we have a clear idea of the nature of variability in agricultural prices over time and across space and the sources of these variations before we analyze price linkages (Ankamah-Yeboah, 2012). Table 4.1 shows summary statistics of processed fish prices in the study areas.

4.1.1 Descriptive Statistics of Processed Fish Prices

Across the markets, the highest maximum price and highest average price of Koobi was observed in the Makola market at GHC19.60/Kg and GHC15.28/kg respectively while both the lowest minimum price and lowest average price of Koobi was observed in the

Cape Coast market at a value of GHC8.50/Kg and GHC11.87/kg respectively. The Cape Coast and Half Assini had the highest variation of 17.35 and 16.83 respectively. Variability in average Koobi Prices was quite low for between 2012 and 2017. It varied between 8.16% for Tema to 17.35% for Cape Coast with the average variability being computed at 14.09%. This implies that the price of Koobi in the markets analyzed did not fluctuates widely from 2012- 2017. Table 4.1 presents the descriptive analysis of monthly Koobi prices for the period 2012-2017.

Across the Kpala markets, the highest maximum price and highest average price of Kpala was observed in the Cape Coast market at GHC18.93/Kg and GHC17.91/kg respectively. The Lowest minimum price was observed in the Wa market at a value of GHC 8.33/kg with the average price of GHC 11.59 /Kg observed in the Techiman market being the lowest. Cape Coast and Half Assini had the highest variation of 17.35 and 16.83 respectively. Variability in Average Kpala prices was also quite low for the period (2012-2017) under study. It varied between 5.35% for Makola to 9.60% for Ada with the average variability being computed at 7.26%. Table 4.1 presents the descriptive analysis of Kpala fish prices for the period 2012-2017.

In the smoked herring market, the Makola market had the highest maximum price and the highest average price observed at GHC19.21/Kg and GHC15.08/kg respectively while the minimum price was observed in the Kpandu market at GHC 7.62/kg and minimum average whole sale price of GHC 11.77/kg was observed in the Cape Coast market. For the smoked herrings, the Half-Assini and Kpandu market experienced the highest variability in price at 16.91% while the least was 11.52% observed in the Tema market.

The average variability in smoked herring prices was recorded at 14.80%. Table 4.1 presents the descriptive analysis of smoked herring prices for the period 2012-2017.

The low variability in all the markets for processed fish implies that the price of Smoked Herrings, Kpala and Koobi in the markets analyzed did not fluctuates widely from 2012-2017. This means that changes in Smoked Herrings, Kpala and Koobi prices have been quite stable for the time periods under study and in the markets analyzed. This can be attributed to the ability of the processed fish to have a long shelf life than it fresh counterparts making it available all year round. A high variability index would mean that the prices of Koobi, Kpala and Smoked herring in the markets looked at fluctuated widely between 2012 and 2017. High variability in prices means that producer incomes would be unstable which is capable of causing unfavourable effects on production and production planning (Mafimisebi, 2001). The effect of poor planning in production is can be harmful to the welfare of consumers especially in countries like Ghana where poverty is still a problem and expenditure on food makeup a larger portion of household's disposable income. This low variability in the prices of processed fish benefits both producers and consumers of Smoked Herrings, Kpala and Koobi in the long run. Producers receive stable incomes which positively influences the production and production planning process which in turn improve the welfare of the consumer. These variations in prices can be attributed to price fluctuations in the various markets under study which normally give rise to temporal deficit from time to time.

Table 4.1 Descriptive statistics of monthly processed fish prices (2012-2017)

Markets	Koobi					Kpala					Smoked Herring				
	Max	Min	Mean	SD	CV	Max	Min	Mean	SD	CV	Max	Min	Mean	SD	CV
Ada	17.58	10.50	13.76	2.25	16.35	13.04	8.91	12.08	1.16	9.60	17.32	9.61	13.98	2.16	15.45
Cape Coast	15.42	8.50	11.87	2.06	17.35	18.93	16.25	17.91	1.00	5.58	15.30	9.72	11.77	1.87	15.89
Half Assini	18.00	10.50	13.54	2.28	16.83	13.56	10.31	11.76	1.04	8.84	17.60	10.84	13.25	2.24	16.91
Makola	19.60	11.80	15.28	2.40	15.70	13.65	10.64	12.52	0.67	5.35	19.21	11.87	15.08	2.23	14.78
Mankessim	18.80	11.80	14.93	2.26	15.11	13.65	10.64	12.60	0.65	5.76	18.73	11.87	14.86	2.20	14.80
Techiman	17.80	11.00	14.33	1.74	12.14	13.06	10.13	11.59	0.79	6.81	15.17	10.28	13.37	1.54	11.52
Tema	15.20	11.00	13.74	1.10	8.16	13.18	9.57	12.06	0.83	6.88	15.69	10.31	13.17	1.60	12.15
Wa	17.00	11.10	13.49	1.71	12.67	12.91	8.33	11.67	1.08	9.25	17.35	10.59	13.42	1.76	13.11
Agbozume	17.80	10.80	13.70	2.25	16.42	-	-	-	-	-	18.75	10.53	14.00	2.31	16.50
Kpandu	22.20	10.80	12.73	1.30	10.21	-	-	-	-	-	16.25	7.62	13.25	2.24	16.91

Source: Author's own computation from price data

4.1.2 Monthly Trend among markets for Processed Fish

Based on information on the prices of a product in the past, producers and consumers are able to have an idea of what the price of a particular product will be in the future. Figure 4.1 shows the visual plot of the monthly average of prices of Koobi from January 2012 to December 2017 across all regional markets considered.

The trend plots of Smoked herring, Koobi and Kpala show that these prices generally follow the same path. They show a steady increase in the prices of processed fish over time. The bumper harvest in fishing begins in July and ends around October sometime extending to November. Prices in the market for Koobi, Kpala and smoked herring are characterized by periods of sharp increases followed by periods where the prices remain constant and then jump again. This is surprising considering we expect the price of processed fish to be low in the bumper season this however was seen to occur mostly just in the Makola market for Processed fish. The Makola market in Accra had the highest prices for both smoked herrings and Koobi. This may be due to population and Accra serving as the capital of country and also may be due to Accra being an area of high production and consumption of fish. In the case of the Kpala market, the Cape Coast market experienced the highest prices.

The prices in the Cape Coast market were extremely high when compared to the prices of Kpala prevailing in the other markets. This may be due to the Cape Coast market for Kpala not being well-integrated with the other markets for Kpala. Thus the Cape Coast it is inefficient and consumers for Kpala in Cape Coast are at a disadvantage compared to consumers in the other markets. The jump in prices of processed fish can be attributed to the actions of processed fish traders in general who intentionally hold back some of the processed fish during bumper periods

in order not to flood the market with too much fish and also have some to sell during the minor fish season when prices are high thereby effectively controlling the prices of processed fish. Figure 4.1, 4.2 and 4.3 show the trend plots for the monthly prices of Koobi, Kpala and smoked herrings for the period under study

Figure 4.1: Trend plot of monthly prices of Koobi.

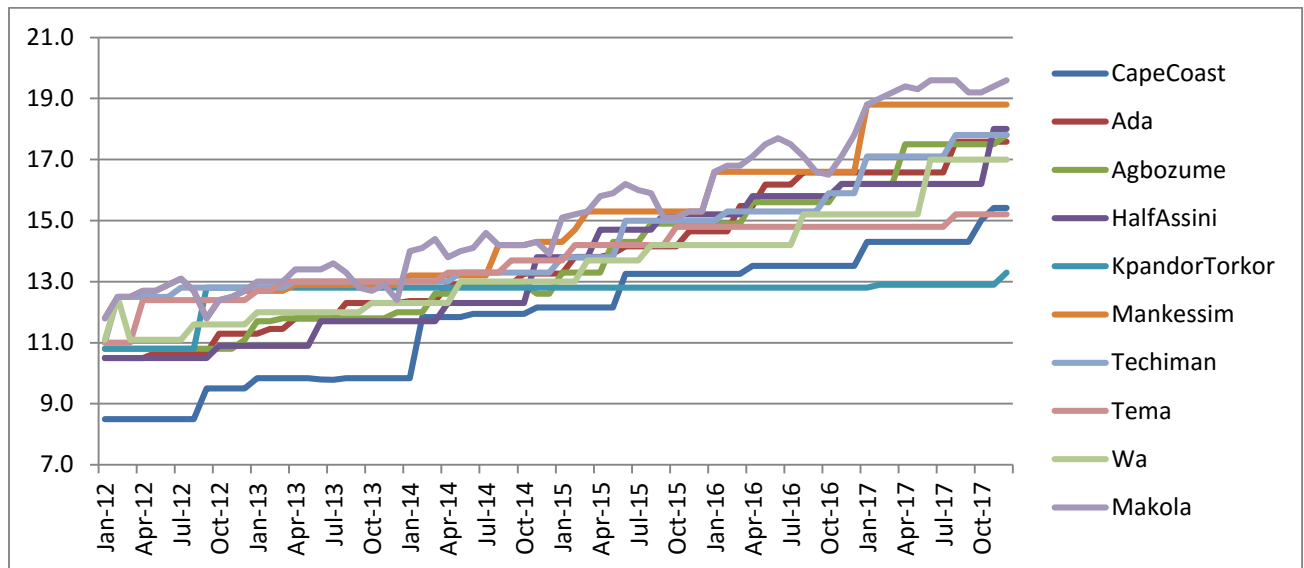


Figure 4.2: Trend plot of monthly prices of Kpala.

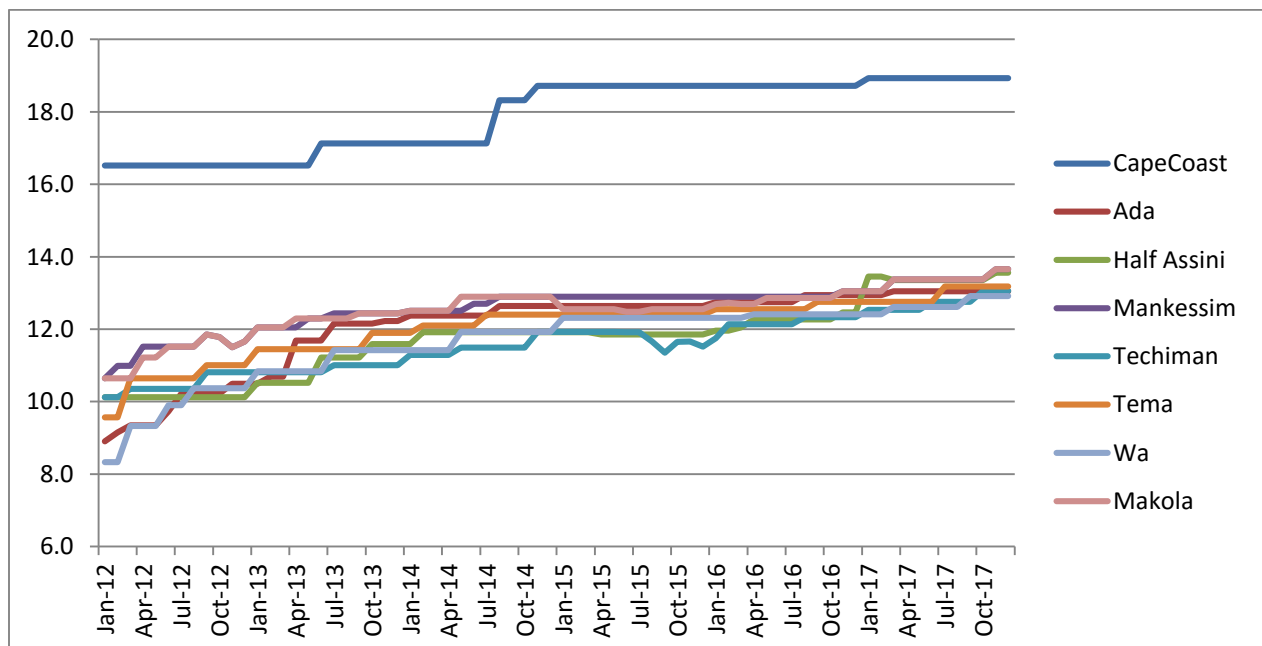
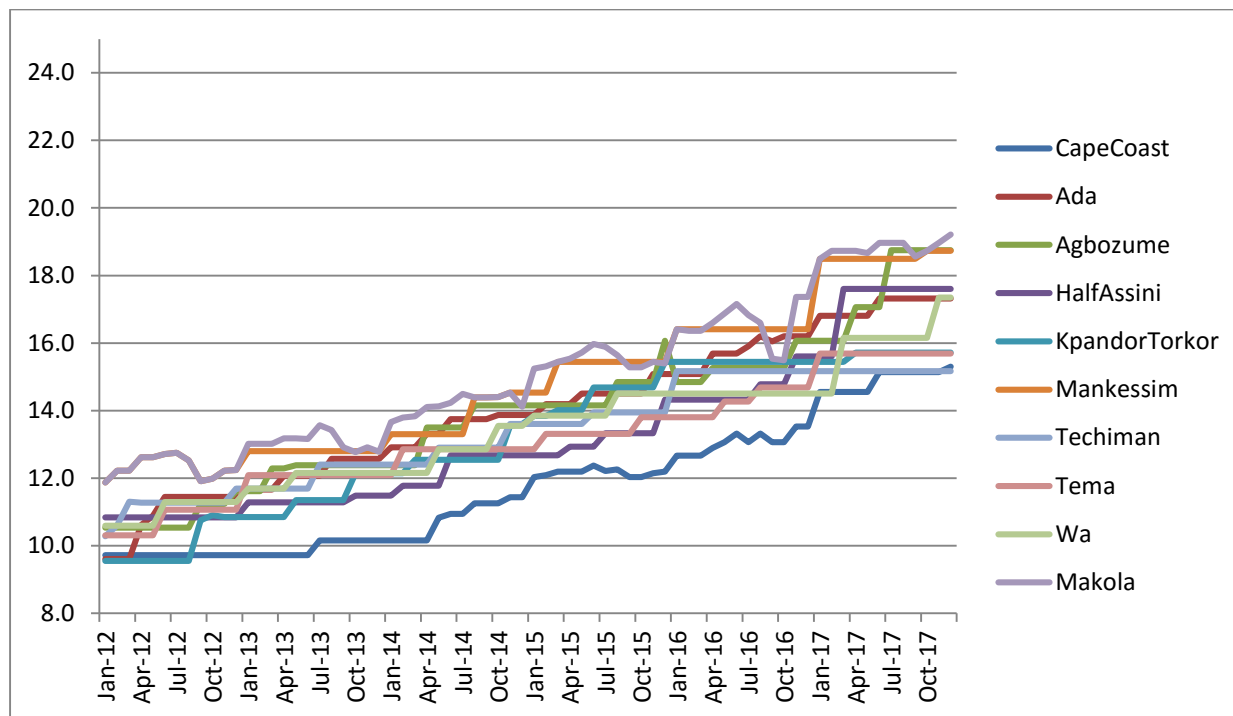


Figure 4.3: Trend plot of monthly prices of smoked herrings.



Source: Own computation from price data from Ghanaian Statistical Service.

4.2 Unit Root Test Results

All the price data for Kpala, Koobi and Smoked herring from 2012 to 2017 were tested for stationarity as a prerequisite for Cointegration analysis. The Augmented Dickey Fuller (ADF) test was used to test the null hypothesis of non-stationary for all the price series. Table 4.2 presents the results of the stationarity test for the markets in the sampled period. The appropriate lag length was selected based on the comparison of the Hannah-Quinn criterion, Akaike Information Criteria and Schwarz Bayesian Criterion.

4.2.1 Unit Roots Test Results for Processed Fish

The results of the ADF test show that at the 1% critical values of -3.552, the null hypothesis of unit root in the Koobi market cannot be rejected for all price series except in the case of Kpandu.

The null hypothesis of non-stationarity is rejected after testing the first difference of all price series for the presence of unit root. The null hypothesis of no unit roots (that is the series is stationary) in the level of the price series at the 1% and 5% significance levels is strongly rejected for all markets except Kpandu which was already Stationary at level, but cannot reject the null hypothesis at the first difference of the price series. The results therefore show that all the price series of Koobi were created by the same stochastic processes and therefore display the propensity toward achieving equilibrium in the long run except the Kpandu price series (Chirwa, 2001; Mafimisebi, 2001). Cointegration can however be tested for between Makola and the other markets except in the case of the Kpandu market. The different order of integration between the Makola market and the Kpandu markets lead to the conclusion of an absence of integration between them (Rapsomanikis *et al.*, 2006).

The Null hypothesis of non-stationarity at the conventional level of 5% could not be rejected for all price series in the Kpala market at their level except for the price series of the Ada, Tema and Wa markets. This implies that the prices of Tema, Ada and Wa were found to be stationary at their levels. After taking a first difference and testing for stationarity the null hypothesis is rejected except in the case of the Tema, Ada and Wa markets. The prices series in the Kpala market were found to be integrated of order one $I(1)$ except for Ada, Tema and Wa which were integrated of an order zero. The Kpala markets prices series were integrated of different orders. . in the case of the Kpala market too, the price series created by similar stochastic processes also display the propensity to achieve a long-run equilibrium (Mafimisebi, 2012; Nielsen, 2006).As such cointegration analysis between Makola and the other markets can be carried out for all price series except the Ada, Tema and Wa. We conclude the absence of integration between the

Makola market and the Ada, Tema and Wa markets as they were integrated of different orders (Rapsomanikis *et al.*, 2006).

In the case of the smoked herring market, the results of the ADF test reveals that the null hypothesis of unit root, $H_0:\rho = 0$ that is the price series is non-stationary, cannot be rejected for all price series at 1%, 5% and 10% critical values. The null hypothesis is however rejected after taking a first difference of all price series and testing for the presence of unit roots. The price series under study are thus a first-difference stationary process which implies that they have unit root or are integrated of order one $I(1)$ (Gujarati, 2008). The result shows that the price series of smoked herrings were created by the same stochastic processes and therefore show the tendency to move towards achieving equilibrium in the long run. This allow for co-integration tests for the testing of the long run equilibrium relationship to be carried out.

This result of the unit root for Koobi, Kpala and smoked herring is backed by previous findings that price of most food commodity are non-stationary in nature at their levels and stationary after first-differencing (Okoh & Egbon, 2003; Chirwa 2001; Mafimisebi, 2001 and Oladapo, 2003). This could be due to the trends in the series caused by inflation and cyclical variations from season leading to mean non-stationarity.

Table 4.2: Results of ADF tests on the monthly processed fish price series

Markets	ADF (Koobi)		ADF (Kpala)		ADF (Smoked Herring)	
	Levels	First Difference	Levels	First Difference	Levels	First Difference
Ada	0.183	-6.746***	-3.871***	-5.928	-1.746	-6.488***
Cape Coast	-0.561	-6.510***	-1.029	-6.148***	1.056	-5.614***
Half Assini	0.404	-6.122**	-0.445	-6.182***	0.747	-6.745***
Mankessim	0.029	-6.571***	-2.477	-6.612***	0.043	-6.358***
Techiman	0.772	-7.346***	-0.747	-7.705***	-1.529	-7.202***
Tema	-2.576	-6.397***	-3.943***	-9.716	-0.954	-6.920***
Wa	0.890	-6.983***	-5.363***	-7.541	0.346	-6.518***
Makola	-0.137	-5.370***	-2.751	-6.932***	-0.196	-5.733***
Agbozume	0.443	-7.002***	-	-	0.388	-7.579***
Kpandu	-4.577***	-9.716	-	-	-1.909	-9.576***

Source: Author's own computation from price data

*** means rejection of the null hypothesis at the 1% significant level

4.3 Cointegration Test Results

With the confirmation of the price series being stationary in their first difference, the existence of co integration among the selected markets pairs was tested using the Johansen's multiple co integration method. As indicated in chapter 3 Co-integration between two non-stationary price series implies that a linear combination of the two series is stationary and the prices, therefore, tend to move together or follow the same path in the long-run. Since the results from the ADF test revealed different orders of integration for some of the price series in the Koobi and Kpala market when compared to the Makola market. Cointegration analysis could not be carried out for all market pairs.

4.3.1 Extent of Market Integration between Processed Fish Market

Cointegration was used to determine the extent of market integration for the processed fish under study. The result for the test of cointegration among the Smoked Herring, Koobi and Kpala markets reveal that out of the nine market pair subjected to a cointegration test only two were found to be cointegrated. Evidence of cointegration was found to exist between the Makola-Mankessim and Makola-Kpandu market pairs. This implied that 22.22% of smoked herring market pairs were co-integrated of the order one $I(1)$ at the 1% significance level. This shows the number of smoke herring market pairs that have prices which follow the same path in the long run despite divergence in the short-run.

In the markets for Koobi, out of the eight market pairs subjected to a cointegration test, only one market pair rejected the null hypothesis of no co-integration at the 1% significant level. Cointegration was found to exist only in the Makola-Mankessim market pair at the 1% significance level. This means that only 11% of Koobi markets were found to have prices which co-move in the long run despite divergences that occur in the short-run due to price shocks. Eight

instead of nine market pairs were tested for cointegration due to the conclusion of an absence of integration between the Makola-Kpandu pair. This was done following the framework of Rapsomanikis *et al.* (2006). The results of the Johansen cointegration test for smoked Koobi are presented in table 4.3.

Out of a possible a seven market pairs that could have been tested for cointegration, only four market pairs were subjected to the test. This was because of the different orders of integration between the Makola-Ada, Makola-Tema and Makola-Wa hence an absence of integration (Rapsomanikis *et al.*, 2006). There was no evidence of cointegration among the market pairs for Kpala. This implies that 0% of the markets for Kpala had their prices co-moving together in the long run. The results of the Johansen cointegration test for Kpala are presented in table 4.3.

Thus, there is a long run relationship among the Makola-Mankessim and Makola-Kpandu markets pairs for smoked herring and among the Makola-Mankessim market pair for Koobi. In other words, in the event of a price shock, prices in the cointegrated market may differ from each other in the short run but will not drift apart in the long run. This suggests that those market pairs may be efficient since market integration has been used as a measure of market efficiency. The findings imply that similar stochastic processes, possibly induced by efficient information flow, drive the dynamics of prices in the system of markets (Motamed *et al.*, 2008). The results also reveal that most of the markets for processed fish are not integrated or interact with each other. The co-movement of price in markets over period of time can serve as indications of well integrated markets, which imply that the markets are functioning proper and are efficient. The nonexistence of integration in markets may pass on incorrect price signals that might alter the marketing decisions taken by producers resulting in inefficient product movement (Goodwin & Schroeder, 1991). In a common domestic processed fish market in Ghana, prices between

markets adjust towards achieving long-run equilibrium. This however, was not the case for most of the processed fish markets analyzed. Causality of the price series was evaluated with the Granger causality test at 1 lag for all the markets for processed fish after the test of cointegration. The results for the test for cointegration among the processed fish markets pairs is presented in table 4.3.

Table 4.3 Johansen cointegration test Statistics for processed fish markets

Market Pairs	Null Hypothesis	Trace Statistics (Smoked herring)	Trace Statistics(Koobi)	Trace Statistics (Kpala)
Makola-Cape Coast	$r = 0$	18.09	6.99	12.53
	$r \leq 1$	0.48	0.02	4.424
Makola-Half Assini	$r = 0$	16.45	8.89	17.20
	$r \leq 1$	0.39	0.23	0.95
Makola-Mankessim	$r = 0$	24.01***	22.25***	17.35
	$r \leq 1$	0.00	0.03	4.94
Makola-Techiman	$r = 0$	8.18	15.68	11.94
	$r \leq 1$	1.40	0.06	1.39
Makola-Ada	$r = 0$	13.94	10.19	Absence of integration
	$r \leq 1$	0.51	0.07	
Makola-Tema	$r = 0$	14.33	11.95	Absence of integration
	$r \leq 1$	0.06	0.64	
Makola-Wa	$r = 0$	11.63	13.64	Absence of integration
	$r \leq 1$	0.21	0.00	
Makola-Agbozume	$r = 0$	12.93	15.64	-
	$r \leq 1$	0.15	0.16	
Makola-Kpandu	$r = 0$	26.18***	Absence of integration	-
	$r \leq 1$	0.12		

Source: Own computation from processed fish price data for 2012-2017.

*The asterisks *** denote rejection of the null hypothesis of no cointegration vector at the 1%. The critical values for $r = 0$ and $r = 1$ at the 1% significance levels are 20.04 and 6.65*

4.4 Direction of causality in Processed Fish Market

Granger causality is important in showing the direction of the relationship after performing co-integration tests. This section shows the various casual relationships for all the price series. Table 4.4 shows the causal relationship between processed fish markets from 2012 to 2017 by applying the granger causality test.

4.4.1 Result of Granger-causality Test for Processed Fish Markets

The granger causality test for Koobi revealed that five markets exhibited unidirectional causality, 3 markets exhibited bidirectional causality and 1 market exhibited independent causality. For the Smoked herring market, five market pairs exhibited unidirectional causality and 4 exhibited bidirectional causality. There was no independent causality in the smoked herring markets. In the markets for Kpala three markets pairs exhibited unidirectional causality, 2 exhibited bidirectional causality and two exhibited independent causality.

The presence of bidirectional causality in some of the markets for processed fish implies that those markets are strongly integrated with each other, experiencing physical arbitrage to settle any disequilibrium between the markets. In the market links that showed a unidirectional (one way) granger-causality that is there is no significant causality from the other market (Hendry, 1986). As reported in Fackler (1996), Gupta & Mueller (1982) argue that the failure of one price to be predictive of another when the second is predictive of the first (unidirectional causality) is an indication that the second price is not incorporating the price information from the first region. Unidirectional causality is therefore taken to indicate that a market is inefficient in terms of information. The independent causality implies that the market pairs are therefore independent and autonomous do not incorporate the price information from one another in setting their prices suggesting that these markets may be inefficient. The presence of independent causality among

the market pairs does not imply a total absence of price transmission in the market links. This might just mean that price signals are transmitted instantaneously under special conditions like storage, inventory holding and delays in transportation. Results of the granger-causality are presented in table 4.4 below.

Table 4.4: Result of granger-causality test for processed fish markets

Null Hypothesis	Koobi		Smoked Herring		Kpala	
	F-Stats	Comment	F-Stats	Comment	F-Stats	Comment
MK-AD	2.15	Unidirectional	6.39**	Unidirectional	3.93**	Unidirectional
AD-MK	8.08***		2.26		0.47	
MK-CC	3.50**	Bidirectional	1.28	Unidirectional	5.77**	Unidirectional
CC-MK	3.49**		6.33**		0.06	
MK-HA	1.16	Unidirectional	4.56**	Bidirectional	3.92**	Bidirectional
HA-MK	8.19***		8.44***		5.60**	
MK-MN	2.37	Unidirectional	4.67**	Bidirectional	1.72	Independent
MN-MK	7.42***		5.67**		0.14	
MK-TE	9.62***	Unidirectional	1.09	Unidirectional	1.53	Independent
TE-MK	1.61		3.40*		2.70	
MK-TM	6.30**	Unidirectional	3.50*	Bidirectional	3.10*	Bidirectional
TM-MK	1.66		3.26*		7.78***	
MK-Wa	8.47***	Bidirectional	10.47***	Unidirectional	2.50	Unidirectional
Wa-MK	4.26**		2.68		2.80*	
MK-AG	4.08**	Bidirectional	5.64**	Bidirectional		
AG-MK	8.59***		7.44***			
MK-KP	0.28	Independent	0.07	Unidirectional		
KP-MK	1.28		6.13**			

Source: Own computation from Koobi price data for 2012-2017.

***, **, * represents rejection of null hypothesis at 1%, 5% and 10% significance level

4.5 Price Transmission between Processed Fish Markets in Ghana.

The evidence of significant cointegrating vectors between the market pairs for processed fish is a necessary condition for using the VECM to determine the effects of price shocks on price adjustment. However since the VECM is embedded in the AVECM, the AVECM will be used to evaluate the impact of price shocks on price adjustment as well as the presence and extent of asymmetry. The Absence of such significant cointegrating vectors requires the specification of a ARDL model to analyze price adjustment. The results of the econometric estimation of the VECM for the producer and consumer market pairs are presented in Table 4.5 and that of the ARDL in table 4.6.

4.5.1 Results of the Asymmetric Vector Error Correction Model

It is believed that markets are characterized by asymmetry in the price transmission process where traders react faster to shocks that reduce their marketing margin than to those that stretch them. The evidence of asymmetry in transmission of price signals between the central market and consumer markets for processed fish was estimated using the Asymmetry Vector Error Correction Model and the results are presented in Table 4.5.

In the Smoked Herring Market, the Makola-Mankessim market pair, following a positive shock that creates disequilibrium, 50 % of such shocks will be eliminated within a month and it will take only 1.01 months for the system to return to equilibrium. In the events of a negative shock 46% of such deviations will be corrected within a month and the system returns to equilibrium in 1.13 months. The results also reveal that there is asymmetry occurring in the price transmission between the Makola- Mankessim market pair implying that positive shocks were transmitted faster than negative shocks and not vice versa. This observation from the analysis confirmed the assertion of farmers that producer price increases are passed on faster to consumers than producer

price decreases. The causes of asymmetry in price transmission between some of the markets may depend on the characteristics of the smoked herring market. However, considering the abilities of traders and their associations to influence the conduct of the market by determining how much to release into the market (Langyintuo, 2010), inventory management and stock behaviour potentially stands as a motivating cause of asymmetry.

Abdulai (2000) rules out menu cost as a cause of asymmetry in the smoked herring market since prices in the markets are determined through personal negotiation between producers/traders and consumers. This is the case in most markets for agricultural produce. In the case of menu and search cost as a cause of asymmetry the rapid increase in the use of mobile phones and computers makes it easier for information to be accessed online and transmitted at a faster rate than was the case in the past and as menu and search cost incurred by consumer are drastically reduced making information asymmetry a minimal option in causing asymmetry in price transmission in Ghana.

Also, the government has not been actively or directly involved in trading and pricing of smoked herring. However the Government of Ghana is actively seeking international cooperation to assist the country in further aquaculture development in the country. Efforts are being made to modernize the fisheries sector and this might have an effect on price in the coming years as such government intervention is not a suitable candidate for causing asymmetry in price transmission.

In The Makola-Kpandu market pair, 52% of the disequilibrium caused by positive shocks is corrected in a month and the system returns to equilibrium in 0.95 months. In the case of negative shocks to the system 67% of the created disequilibrium is corrected in month and the system returns to equilibrium in 0.41 months. The absence of asymmetry in the markets can be taken to

mean the nonexistence of imperfections present in the market Ben-Kaabia *et al.* (2002). Thus the Makola-Kpandu market for smoked herrings is efficient.

The speeds of adjustment for positive and negative deviations in the Makola-Mankessim and Makola-Kpandu for smoked herring are higher than that of Mensah-Bonsu *et al.* (2011). Mensah-Bonsu *et al.* (2011) found a speed of adjustment of 27.73% and summed up that there is weak integration among the markets. Thus it can be concluded that there is a relatively strong integration among the markets. As such cointegrated smoked herring markets may be able to respond more quickly to market shocks, and market channel members can efficiently and effectively distribute processed fish from surplus to deficit markets.

In the Koobi Market, the Makola-Mankessim market pair, following a positive shock that creates disequilibrium, 39 % of such shocks will be eliminated within a month and it will take only 1.42 months for the system to return to equilibrium. In the events of a negative shock 24% of such deviations will be corrected within a month and the system returns to equilibrium in 2.92 months. The results also reveal that there is symmetry occurring in the price transmission between the Makola- Mankessim market pair implying that positive and negative shocks to price were transmitted at the same speed and time. The existence of asymmetry in the transmission of price shocks means that there is some loss in welfare for a number of market participants since the distribution of welfare could be different under symmetry (Wlazlowski *et al.*, 2009). This is however not the case in the Makola-Mankessim market pair for Kpala which was characterized by symmetric relationship.

From Table 4.5 the speed of adjustment of 39% for positive shocks and 24% for negative deviations in the Makola-Mankessim for Koobi indicate there is weak integration among the

markets. This is the same as the conclusion drawn by Mensah-Bonsu *et al.* (2011). Mensah-Bonsu *et al.* (2011) found a speed of adjustment of 27.73% and summed up that there is weak integration among the markets. Thus, an improvement in the accuracy of information to market participants will improve market integration. This will cause Koobi markets to respond more quickly to market shocks, and market channel members can efficiently and effectively distribute Koobi from surplus to deficit markets improving upon food security.

Table 4.5 Results of the AECM Model

Market Pairs	Smoked Herrings					Koobi				
	ECT_{t-1}^-	$T_{\square alf}$	ECT_{t-1}^+	$T_{\square alf}$	Asy	ECT_{t-1}^-	$T_{\square alf}$	ECT_{t-1}^+	$T_{\square alf}$	Asy
Makola-Mankessim	-0.46**	1.13	-0.50***	0.41	0.01	-0.24	2.92	-0.39**	1.42	0.17
Ma kola-Kpandu	-0.67***	1.01	-0.52**	0.95	0.22					

Source: Own computation from processed fish price data (2012-2017).

****, **, * represents the significance of the coefficients at the 1%, 5% and 10 % significance level*

4.5.2 Evidence of Price Transmission (ARDL Model)

The results of the ADRL reveal that in the Koobi market only the coefficient of the previous price of Makola, Current and previous price of Techiman and the current price of Agbozume were significant. This implies that only these prices explain the current prices of Makola. A 1% increase in the previous price of Makola will increase the current price of Makola by 0.62%. A 1% increase in the current price of Techiman will increase the current Makola price by 0.59% whereas in the previous price of Techiman will decrease the Makola price by 0.37%. In the Agbozume market a 1% increase in the current price will increase the current Makola price by 0.41%. The effect of the other prices on the current Makola price was insignificant. Thus at any

point in time, pricing of Koobi depends on the prevailing market condition and the previous price of Makola, Current and previous price of Techiman and the current price of Agbozume since those values gives an explanation of the current prices of Koobi in the Makola market.

In the Kpala market, only the previous price of Makola, current and previous price of Mankessim, current price of Cape Coast and current price of Techiman explain the current price of Makola. A 1% increase in the previous price of Makola will increase the current Makola price by 0.50%. A 1% increase in the current Mankessim price increases Makola price by almost 1% whereas the previous price of Mankessim will decrease the Makola price by 0.28%. A percent increase in the current prices of Techiman will increase the price of Makola by 0.18%. An increase in current Cape Coast prices for Kpala will reduce the current prices prevailing in Makola by 0.18%. As such, at any point in time, pricing of Kpala depends on the prevailing market condition and only the previous price of Makola, current and previous price of Mankessim, current price of Cape Coast and current price of Techiman since those values explain the current prices of Kpala in the Makola market. Acquah *et al.* (2012) found out that only the present prices of cassava in the Kumasi market give an explanation of the present prices prevailing in the Techiman market at 5 percent level of significance. The past price values of all the markets were insignificant showing that they were not useful in explaining the current prices of cassava in Techiman market revealing.

In the market for smoked herring, the previous price of Makola, current and previous price of Cape Coast, current price of Ada and current price of Tema influence the current price of Makola. A 1% increase in the previous price of Makola will increase the current Makola price by 0.53%. A 1% increase in the current price of Cape Coast will increase the current Makola price by 0.80% whereas the previous price of Cape Coast will decrease the current Makola price by 0.52%. A

percent increase in the current price of Ada will decrease the price of Makola by 0.37%. An increase in current Tema prices for Smoked Herrings will lead to a 0.30% rise in the current prices prevailing in the Makola market. Thus at any point in time, pricing of Smoked herring will depend on the conditions prevailing in the market and also on the previous price of Makola, current and previous price of Cape Coast, current price of Ada and current price of Tema since those values explain the current prices of Koobi in the Makola market. These results are similar to a study by Acquah *et al.* (2012) on the market integration and price transmission of cassava markets in Ghana.

Table 4.6 Results of the ARDL model

Markets	Koobi	Smoked Herring	Kpala
	Coef.	Coef.	Coef.
Makola L1.	0.62***	0.53***	0.50***
_cons	0.07	0.02	0.20
Mankessim	-	-	0.90***
Mankessim L1	-	-	-0.28**
Cape Coast	-0.07	0.80***	-0.18*
Cape Coast L1.	0.08	-0.52**	-0.07
Techiman	0.59**	0.05	0.18**
Techiman L1.	-0.37*	-0.01	-0.07
Half Assini	0.03	0.16	0.03
Half Assini L1.	-0.03	-0.11	-0.01
Ada	0.08	0.20	
Ada L1.	0.04	-0.37**	
Agbozume	0.41*	-0.03	
Agbozume L1.	-0.21	0.05	
Tema	-0.01	0.30*	
Tema L1.	-0.03	-0.05	
Wa	-0.11	-0.02	
Wa L1.	-0.03	0.02	
Kpandu	-0.03	-	
Kpandu L1.	0.03	-	

Source: Authors' construct.

***, **, * represents the significance of the coefficients at the 1%, 5% and 10 % significance level

CHAPTER FIVE:

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The study is summarized in this chapter. Conclusions based on the research results are also presented in this chapter. Policy recommendations based on the findings and conclusions of the study are also presented in this chapter.

5.1 Summary and Major Findings

This study sought to examine market integration and price transmission between some processed fish markets in Ghana. The main objective of this study was to examine the efficiency of processed fish marketing system in Ghana. The specific objectives being to analyze the extent of Market integration among the selected processed fish markets in Ghana, to analyze the extent of price transmission among selected processed fish markets in Ghana and to analyze the extent of price asymmetry in selected processed fish markets in Ghana using monthly processed fish prices data between 2012 and 2017. The Stata 14 and JMulti softwares were used to analyze the data.

A descriptive analysis of the data shows that in both the market for Koobi and smoked herring the highest average values for monthly prices was found in the Makola market while the lowest value was observed in the Cape Coast Market. However in the Market for Kpala the highest average values for monthly prices was found in the Cape Coast market while the lowest value was observed in the Techiman Market. The variability in processed fish market prices as estimated by the coefficient of variation was on the average was found to be 14.09% for Koobi, 14.80% for smoked herring, 7.26% for Kpala. The low fluctuations in mean prices indicate that processed fish prices were relatively stable. A trend analysis of all the markets for processed fish

showed a steady and persistent increase in prices with very little variation over the period 2012 to 2017.

All the price series in the Koobi market were integrated of the order one $I(1)$ meaning that similar stochastic processes created these series except the price series for Kpandu which was stationary at level. Those of Kpala were all integrated of order $I(1)$ except in the case of Wa, Tema and Ada. The price series for smoked herrings were all integrated of the order one $I(1)$ at the 1% level also indicating they were created by similar stochastic processes. Evidence of cointegration was found to exist in the Makola-Mankessim market pair for Smoked herring and Koobi and Makola-Kpandu market for smoked herring. There was no cointegration found in any of the market pairs for Kpala. The presence of bidirectional causality indicates that some of the markets are well integrated with the Makola market. Unidirectional causality in the markets links for processed fish show the markets are not strongly integrated the presence of independent causality among some market pairs in the Koobi and Kpala markets indicate some inefficiency in those market pairs.

The results of the AVECM indicate that Positive shocks were corrected faster than negative shocks in the Makola-Mankessim market pair for smoked herring and Koobi and in the Makola-Kpandu market for smoked Herring. The speed of adjustment in the smoked herring markets when compared to a perfect adjustment of 100% threshold was relatively Strong. The case of the Koobi market was relatively weak. Also the adjustment mechanism for these markets after a shock was characterized by asymmetry in the Makola-Mankessim market pair for smoked herring. The other market pairs had adjustment mechanisms that were characterized by symmetric relationships. The results of the ARDL indicate that in the short run, the lagged values of the Makola price had a positive and highly significant effect on the current price of processed fish in

the Makola market. In the Koobi market only the current price of Techiman and Agbozume and the previous price of Techiman had a significant effect on the current Makola price previous price of Ada and current price of Tema. The current prices of Kpala in Mankessim, Cape Coast and Techiman and the previous price of Mankessim had a significant effect on the current price of Kpala in the Makola market. For the smoked herring markets, the current price of Makola was influenced by the current price of Cape coast and Tema, and the previous price of Cape Coast and Ada.

5.2 Conclusions

Low variability in prices imply that price of processed fish did not fluctuate widely across seasons in all markets analyzed. This translates into stable producer incomes mostly for the women who are engaged n the processing of fish.

The results revealed all the price series of smoked herring, nine out of ten for koobi and five out of eight for Kpala markets in Ghana are integrated of order one. The results of the Johansen cointegration analysis show that most of the market pairs for all the processed fish studied are not cointegrated. The absence of cointegration therefore indicates that transmission of price signals is poor among the processed fish markets in Ghana, leading to market inefficiencies that need to be addressed. Additionally, there is a mixture of bidirectional, unidirectional and independent causality between Makola the other markets implying that some of the markets are not very well integrated. Overall the results of the extent of market integration analysis obtained by the Johansen Maximum Likelihood approach indicate that the markets for smoked herring, Kpala and koobi were not well integrated.

From the results of the AECM, there is relatively weak integration/adjustment in the Koobi market as compared to a relatively strong adjustment for smoked herring. As such in the Koobi market there is the need for further market integration to improve the price transmission process. Also asymmetry was found only in the Makola-Mankessim market for smoked herrings. The results of ARDL also show that most of the current and previous prices of the markets did not influence the current prices in the Makola market. Thus in most cases, the price of the processed fish depends on the condition prevailing in the market at that point in time. The previous price of the Makola market was however significant in explaining the current price of Makola for Koobi, Kpala and Smoked Herring.

In markets that were cointegrated, the adjustment mechanism after a shock was characterized mostly by symmetry. There was therefore no asymmetry in the markets, thus these particular markets are efficient and well-integrated. Overall it can be concluded from the results that the markets for processed fish are not very efficient. There is therefore the need to improve the efficiency of these markets through improving market integration and price transmission of processed fish markets. This will ensure fish moves from surplus areas to deficit areas thus improving food security.

5.3 Policy Recommendations

Most of the markets for processed fish in Ghana were found to be mostly inefficient in performing their functions. Thus it is recommended that the Ministry of Road transport and the Ministry of Communication together can improve marketing infrastructures such as roads and communication facilities. This will greatly reduce transaction costs and improve price transmission and market integration in the processed fish market thus increasing market efficiency.

Since the adjustment mechanism after a shock for the Makola-Mankessim market pair for Smoked Herring was characterised by asymmetry which are signals market failure, redistribution and net welfare losses to producers and consumers. It is recommended that the potential causes of asymmetry such as the ability of fish mummies to influence prices and the inventory and stock behaviour of traders be looked into. This can be done through investing in storage facilities such Cold storages or processing plants by the Government and the Ministry of Fishery and Aquaculture Development given the seasonal nature of the commodity.

Also since the Ghana Statistical Service collects market information on the prices of processed fish in the various markets, the information should be timely and made available to the producers of processed fish. This will allow them to know which markets offer remunerative prices for their products and lead to efficient arbitrage between markets. This will lead to market systems that are efficient in performing their functions; where most markets are integrated with each other ensuring processed fish is delivered to consumers at competitive cost.

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APPENDICES

APPENDIX 1: NOMINAL KOOBI PRICE DATA (2012-2017) FROM GSS

Year	Cape Coast	Ada	Agbozume	Half Assini	Kpandu	Mankessim	Techiman	Tema	Wa	Makola
2012m1	8.5	10.5	10.8	10.5	10.8	11.8	11.0	11.0	11.1	11.8
2012m2	8.5	10.5	10.8	10.5	10.8	12.5	12.5	11.0	12.5	12.5
2012m3	8.5	10.5	10.8	10.5	10.8	12.5	12.5	11.0	11.1	12.5
2012m4	8.5	10.5	10.8	10.5	10.8	12.7	12.5	12.4	11.1	12.7
2012m5	8.5	10.7	10.8	10.5	10.8	12.7	12.5	12.4	11.1	12.7
2012m6	8.5	10.7	10.8	10.5	10.8	12.9	12.5	12.4	11.1	12.9
2012m7	8.5	10.7	10.8	10.5	10.8	13.1	12.8	12.4	11.1	13.1
2012m8	8.5	10.7	10.8	10.5	10.8	12.7	12.8	12.4	11.6	12.7
2012m9	9.5	10.7	10.8	10.5	12.8	11.8	12.8	12.4	11.6	11.8
2012m10	9.5	11.3	10.8	10.9	12.8	12.4	12.8	12.4	11.6	12.4
2012m11	9.5	11.3	10.8	10.9	12.8	12.5	12.8	12.4	11.6	12.5
2012m12	9.5	11.3	11.1	10.9	12.8	12.7	12.8	12.4	11.6	12.7
2013m1	9.8	11.3	11.7	10.9	12.8	12.7	12.8	12.7	12.0	13.0
2013m2	9.8	11.5	11.7	10.9	12.8	12.7	12.8	12.7	12.0	13.0
2013m3	9.8	11.5	11.8	10.9	12.8	12.7	12.8	13.0	12.0	13.0
2013m4	9.8	11.8	11.8	10.9	12.8	12.9	13.0	13.0	12.0	13.4
2013m5	9.8	11.8	11.8	10.9	12.8	12.9	13.0	13.0	12.0	13.4
2013m6	9.8	11.8	11.8	11.7	12.8	12.9	13.0	13.0	12.0	13.4
2013m7	9.8	11.8	11.8	11.7	12.8	12.9	13.0	13.0	12.0	13.6
2013m8	9.8	12.3	11.8	11.7	12.8	12.9	13.0	13.0	12.0	13.3
2013m9	9.8	12.3	11.8	11.7	12.8	12.9	13.0	13.0	12.0	12.8
2013m10	9.8	12.3	11.8	11.7	12.8	12.9	13.0	13.0	12.3	12.7
2013m11	9.8	12.3	11.8	11.7	12.8	12.9	13.0	13.0	12.3	12.9
2013m12	9.8	12.3	12.0	11.7	12.8	12.9	13.0	13.0	12.3	12.4
2014m1	9.8	12.4	12.0	11.7	12.8	13.2	13.0	13.0	12.3	14.0
2014m2	11.8	12.4	12.0	11.7	12.8	13.2	13.0	13.0	12.3	14.1

2014m3	11.8	12.4	12.6	11.7	12.8	13.2	13.0	13.0	12.3	14.4
2014m4	11.8	12.9	12.6	12.3	12.8	13.2	13.0	13.3	12.3	13.8
2014m5	11.8	12.9	12.9	12.3	12.8	13.2	13.3	13.3	13.0	14.0
2014m6	11.9	12.9	12.9	12.3	12.8	13.2	13.3	13.3	13.0	14.1
2014m7	11.9	12.9	12.9	12.3	12.8	13.2	13.3	13.3	13.0	14.6
2014m8	11.9	12.9	12.9	12.3	12.8	14.2	13.3	13.3	13.0	14.2
2014m9	11.9	12.9	12.9	12.3	12.8	14.2	13.3	13.7	13.0	14.2
2014m10	11.9	13.3	12.9	12.3	22.2	14.2	13.3	13.7	13.0	14.2
2014m11	12.2	13.3	12.6	13.8	12.8	14.3	13.3	13.7	13.0	14.3
2014m12	12.2	13.3	12.6	13.8	12.8	14.3	13.3	13.7	13.0	13.9
2015m1	12.2	13.3	13.3	13.8	12.8	14.3	13.8	13.7	13.0	15.1
2015m2	12.2	13.8	13.3	13.8	12.8	14.7	13.8	14.2	13.0	15.2
2015m3	12.2	13.8	13.3	13.8	12.8	15.3	13.8	14.2	13.7	15.3
2015m4	12.2	13.8	13.3	14.7	12.8	15.3	13.8	14.2	13.7	15.8
2015m5	12.2	13.9	14.3	14.7	12.8	15.3	13.8	14.2	13.7	15.9
2015m6	13.3	14.2	14.3	14.7	12.8	15.3	15.0	14.2	13.7	16.2
2015m7	13.3	14.2	14.3	14.7	12.8	15.3	15.0	14.2	13.7	16.0
2015m8	13.3	14.2	14.9	14.7	12.8	15.3	15.0	14.2	14.2	15.9
2015m9	13.3	14.2	14.9	15.2	12.8	15.3	15.0	14.2	14.2	15.1
2015m10	13.3	14.2	14.9	15.2	12.8	15.3	15.0	14.8	14.2	15.1
2015m11	13.3	14.6	14.9	15.2	12.8	15.3	15.0	14.8	14.2	15.3
2015m12	13.3	14.6	14.9	15.2	12.8	15.3	15.0	14.8	14.2	15.3
2016m1	13.3	14.6	14.9	15.2	12.8	16.6	15.0	14.8	14.2	16.6
2016m2	13.3	14.6	14.9	15.2	12.8	16.6	15.3	14.8	14.2	16.8
2016m3	13.3	15.5	14.9	15.2	12.8	16.6	15.3	14.8	14.2	16.8
2016m4	13.5	15.5	15.6	15.8	12.8	16.6	15.3	14.8	14.2	17.1
2016m5	13.5	16.2	15.6	15.8	12.8	16.6	15.3	14.8	14.2	17.5
2016m6	13.5	16.2	15.6	15.8	12.8	16.6	15.3	14.8	14.2	17.7
2016m7	13.5	16.2	15.6	15.8	12.8	16.6	15.3	14.8	14.2	17.5
2016m8	13.5	16.6	15.6	15.8	12.8	16.6	15.3	14.8	15.2	17.1
2016m9	13.5	16.6	15.6	15.8	12.8	16.6	15.3	14.8	15.2	16.6

2016m10	13.5	16.6	15.6	15.8	12.8	16.6	15.9	14.8	15.2	16.5
2016m11	13.5	16.6	16.2	16.2	12.8	16.6	15.9	14.8	15.2	17.1
2016m12	13.5	16.6	16.2	16.2	12.8	16.6	15.9	14.8	15.2	17.8
2017m1	14.3	16.6	16.2	16.2	12.8	18.8	17.1	14.8	15.2	18.8
2017m2	14.3	16.6	16.2	16.2	12.9	18.8	17.1	14.8	15.2	19.0
2017m3	14.3	16.6	16.2	16.2	12.9	18.8	17.1	14.8	15.2	19.2
2017m4	14.3	16.6	17.5	16.2	12.9	18.8	17.1	14.8	15.2	19.4
2017m5	14.3	16.6	17.5	16.2	12.9	18.8	17.1	14.8	15.2	19.3
2017m6	14.3	16.6	17.5	16.2	12.9	18.8	17.1	14.8	17.0	19.6
2017m7	14.3	16.6	17.5	16.2	12.9	18.8	17.1	14.8	17.0	19.6
2017m8	14.3	17.6	17.5	16.2	12.9	18.8	17.8	15.2	17.0	19.6
2017m9	14.3	17.6	17.5	16.2	12.9	18.8	17.8	15.2	17.0	19.2
2017m10	15.0	17.6	17.5	16.2	12.9	18.8	17.8	15.2	17.0	19.2
2017m11	15.4	17.6	17.5	18.0	12.9	18.8	17.8	15.2	17.0	19.4
2017m12	15.4	17.6	17.8	18.0	13.3	18.8	17.8	15.2	17.0	19.6

APPENDIX 2: NOMINAL KPALA PRICE DATA (2012-2017) FROM GSS

Year	Cape Coast	Ada	Half Assini	Mankessim	Techiman	Tema	Wa	Makola
2012m1	16.5	8.9	10.1	10.6	10.1	9.6	8.3	10.6
2012m2	16.5	9.1	10.1	11.0	10.1	9.6	8.3	10.6
2012m3	16.5	9.3	10.1	11.0	10.4	10.6	9.3	10.6
2012m4	16.5	9.3	10.1	11.5	10.4	10.6	9.3	11.2
2012m5	16.5	9.3	10.1	11.5	10.4	10.6	9.3	11.2
2012m6	16.5	9.7	10.1	11.5	10.4	10.6	9.9	11.5
2012m7	16.5	10.2	10.1	11.5	10.4	10.6	9.9	11.5
2012m8	16.5	10.2	10.1	11.5	10.4	10.6	10.4	11.5
2012m9	16.5	10.2	10.1	11.9	10.8	11.0	10.4	11.9
2012m10	16.5	10.2	10.1	11.8	10.8	11.0	10.4	11.8
2012m11	16.5	10.5	10.1	11.5	10.8	11.0	10.4	11.5
2012m12	16.5	10.5	10.1	11.7	10.8	11.0	10.4	11.7
2013m1	16.5	10.5	10.5	12.0	10.8	11.4	10.8	12.0
2013m2	16.5	10.7	10.5	12.0	10.8	11.4	10.8	12.0
2013m3	16.5	10.7	10.5	12.0	10.8	11.4	10.8	12.0
2013m4	16.5	11.7	10.5	12.0	10.8	11.4	10.8	12.3
2013m5	16.5	11.7	10.5	12.3	10.8	11.4	10.8	12.3
2013m6	17.1	11.7	11.2	12.3	10.8	11.4	10.8	12.3
2013m7	17.1	12.2	11.2	12.4	11.0	11.4	11.4	12.3
2013m8	17.1	12.2	11.2	12.4	11.0	11.4	11.4	12.3
2013m9	17.1	12.2	11.2	12.4	11.0	11.4	11.4	12.4
2013m10	17.1	12.2	11.6	12.4	11.0	11.9	11.4	12.4
2013m11	17.1	12.2	11.6	12.4	11.0	11.9	11.4	12.4

2013m12	17.1	12.2	11.6	12.4	11.0	11.9	11.4	12.4
2014m1	17.1	12.4	11.6	12.5	11.3	11.9	11.4	12.5
2014m2	17.1	12.4	11.9	12.5	11.3	12.1	11.4	12.5
2014m3	17.1	12.4	11.9	12.5	11.3	12.1	11.4	12.5
2014m4	17.1	12.4	11.9	12.5	11.3	12.1	11.4	12.5
2014m5	17.1	12.4	11.9	12.5	11.5	12.1	11.9	12.9
2014m6	17.1	12.4	11.9	12.7	11.5	12.1	11.9	12.9
2014m7	17.1	12.4	11.9	12.7	11.5	12.4	11.9	12.9
2014m8	18.3	12.6	11.9	12.9	11.5	12.4	11.9	12.9
2014m9	18.3	12.6	11.9	12.9	11.5	12.4	11.9	12.9
2014m10	18.3	12.6	11.9	12.9	11.5	12.4	11.9	12.9
2014m11	18.7	12.6	11.9	12.9	11.9	12.4	11.9	12.9
2014m12	18.7	12.6	11.9	12.9	11.9	12.4	11.9	12.9
2015m1	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m2	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m3	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m4	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m5	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m6	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m7	18.7	12.6	11.9	12.9	11.9	12.4	12.3	12.5
2015m8	18.7	12.6	11.9	12.9	11.7	12.4	12.3	12.5
2015m9	18.7	12.6	11.9	12.9	11.4	12.4	12.3	12.5
2015m10	18.7	12.6	11.9	12.9	11.7	12.4	12.3	12.5
2015m11	18.7	12.6	11.9	12.9	11.7	12.4	12.3	12.5
2015m12	18.7	12.6	11.9	12.9	11.5	12.4	12.3	12.5
2016m1	18.7	12.7	12.0	12.9	11.8	12.6	12.3	12.7

2016m2	18.7	12.7	12.0	12.9	12.1	12.6	12.3	12.7
2016m3	18.7	12.7	12.0	12.9	12.1	12.6	12.3	12.7
2016m4	18.7	12.7	12.3	12.9	12.1	12.6	12.4	12.7
2016m5	18.7	12.7	12.3	12.9	12.1	12.6	12.4	12.9
2016m6	18.7	12.7	12.3	12.9	12.1	12.6	12.4	12.9
2016m7	18.7	12.7	12.3	12.9	12.1	12.6	12.4	12.9
2016m8	18.7	12.9	12.3	12.9	12.3	12.6	12.4	12.9
2016m9	18.7	12.9	12.3	12.9	12.3	12.8	12.4	12.9
2016m10	18.7	12.9	12.3	12.9	12.3	12.8	12.4	12.9
2016m11	18.7	12.9	12.5	13.0	12.3	12.8	12.4	13.0
2016m12	18.7	12.9	12.5	13.0	12.3	12.8	12.4	13.0
2017m1	18.9	12.9	13.5	13.0	12.5	12.8	12.4	13.0
2017m2	18.9	12.9	13.5	13.0	12.5	12.8	12.4	13.0
2017m3	18.9	13.0	13.4	13.4	12.5	12.8	12.6	13.4
2017m4	18.9	13.0	13.4	13.4	12.5	12.8	12.6	13.4
2017m5	18.9	13.0	13.4	13.4	12.5	12.8	12.6	13.4
2017m6	18.9	13.0	13.4	13.4	12.8	12.8	12.6	13.4
2017m7	18.9	13.0	13.4	13.4	12.8	13.2	12.6	13.4
2017m8	18.9	13.0	13.4	13.4	12.8	13.2	12.6	13.4
2017m9	18.9	13.0	13.4	13.4	12.8	13.2	12.9	13.4
2017m10	18.9	13.0	13.4	13.4	13.1	13.2	12.9	13.4
2017m11	18.9	13.0	13.6	13.7	13.1	13.2	12.9	13.7
2017m12	18.9	13.0	13.6	13.7	13.1	13.2	12.9	13.7

APPENDIX 3: NOMINAL SMOKED HERRING PRICE DATA (2012-2017) FROM GSS

Year	CapeCoast	Ada	Agbozume	HalfAssini	Kpandu	Mankessim	Techiman	Tema	Wa	Makola
2012m1	9.7	9.6	10.5	10.8	9.6	11.9	10.3	10.3	10.6	11.9
2012m2	9.7	9.6	10.5	10.8	9.6	12.2	10.6	10.3	10.6	12.2
2012m3	9.7	9.6	10.5	10.8	9.6	12.2	11.3	10.3	10.6	12.2
2012m4	9.7	10.6	10.5	10.8	9.6	12.6	11.3	10.3	10.6	12.6
2012m5	9.7	10.9	10.5	10.8	9.6	12.6	11.3	10.3	10.6	12.6
2012m6	9.7	11.4	10.5	10.8	9.6	12.7	11.3	11.1	11.3	12.7
2012m7	9.7	11.4	10.5	10.8	9.6	12.8	11.3	11.1	11.3	12.8
2012m8	9.7	11.4	10.5	10.8	9.6	12.5	11.3	11.1	11.3	12.5
2012m9	9.7	11.4	11.2	10.8	10.8	11.9	11.3	11.1	11.3	11.9
2012m10	9.7	11.4	11.2	10.8	16.2	12.0	11.3	11.1	11.3	12.0
2012m11	9.7	11.4	11.2	10.8	10.9	12.2	11.3	11.1	11.3	12.2
2012m12	9.7	11.4	11.6	10.8	10.9	12.2	11.7	11.1	11.3	12.2
2013m1	9.7	11.7	11.6	11.3	10.9	12.8	11.7	12.1	11.7	13.0
2013m2	9.7	11.7	11.6	11.3	10.9	12.8	11.7	12.1	11.7	13.0
2013m3	9.7	11.7	12.3	11.3	10.9	12.8	11.7	12.1	11.7	13.0
2013m4	9.7	12.1	12.3	11.3	10.9	12.8	11.7	12.1	11.7	13.2
2013m5	9.7	12.1	12.4	11.3	11.4	12.8	11.7	12.1	12.2	13.2
2013m6	9.7	12.1	12.4	11.3	11.4	12.8	11.7	12.1	12.2	13.2
2013m7	10.2	12.1	12.4	11.3	11.4	12.8	12.4	12.1	12.2	13.6
2013m8	10.2	12.6	12.4	11.3	11.4	12.8	12.4	12.1	12.2	13.4
2013m9	10.2	12.6	12.4	11.3	11.4	12.8	12.4	12.1	12.2	12.9
2013m10	10.2	12.6	12.4	11.5	12.1	12.8	12.4	12.1	12.2	12.8
2013m11	10.2	12.6	12.4	11.5	12.1	12.8	12.4	12.1	12.2	12.9
2013m12	10.2	12.6	12.4	11.5	12.1	12.8	12.4	12.1	12.2	12.8
2014m1	10.2	12.9	12.4	11.5	12.1	13.3	12.4	12.1	12.2	13.7
2014m2	10.2	12.9	12.4	11.8	12.1	13.3	12.4	12.9	12.2	13.8
2014m3	10.2	12.9	12.4	11.8	12.5	13.3	12.4	12.9	12.2	13.8
2014m4	10.2	13.3	13.5	11.8	12.5	13.3	12.4	12.9	12.2	14.1

2014m5	10.8	13.3	13.5	11.8	12.5	13.3	12.9	12.9	12.9	14.1
2014m6	10.9	13.7	13.5	12.7	12.5	13.3	12.9	12.9	12.9	14.2
2014m7	10.9	13.7	13.5	12.7	12.5	13.3	12.9	12.9	12.9	14.5
2014m8	11.3	13.7	14.1	12.7	12.5	14.4	12.9	12.9	12.9	14.4
2014m9	11.3	13.7	14.1	12.7	12.5	14.4	12.9	12.9	12.9	14.4
2014m10	11.3	13.9	14.1	12.7	12.5	14.4	12.9	12.9	13.6	14.4
2014m11	11.4	13.9	14.1	12.7	13.5	14.5	13.6	12.9	13.6	14.5
2014m12	11.4	13.9	14.1	12.7	7.6	14.5	13.6	12.9	13.6	14.1
2015m1	12.0	13.9	14.1	12.7	13.8	14.5	13.6	12.9	13.9	15.2
2015m2	12.1	14.2	14.1	12.7	13.8	14.5	13.6	13.3	13.9	15.3
2015m3	12.2	14.2	14.1	12.7	14.0	15.4	13.6	13.3	13.9	15.4
2015m4	12.2	14.2	14.1	12.9	14.0	15.4	13.6	13.3	13.9	15.5
2015m5	12.2	14.5	14.1	12.9	14.0	15.4	13.6	13.3	13.9	15.7
2015m6	12.4	14.5	14.1	12.9	14.7	15.4	13.9	13.3	13.9	16.0
2015m7	12.2	14.5	14.1	13.3	14.7	15.4	13.9	13.3	13.9	15.9
2015m8	12.3	14.5	14.8	13.3	14.7	15.4	13.9	13.3	14.5	15.6
2015m9	12.0	14.5	14.8	13.3	14.7	15.4	13.9	13.3	14.5	15.3
2015m10	12.0	14.5	14.8	13.3	14.7	15.4	13.9	13.8	14.5	15.3
2015m11	12.1	15.1	14.8	13.3	14.7	15.4	13.9	13.8	14.5	15.4
2015m12	12.2	15.1	16.1	14.3	15.4	15.4	13.9	13.8	14.5	15.4
2016m1	12.7	15.1	14.8	14.3	15.4	16.4	15.2	13.8	14.5	16.4
2016m2	12.7	15.1	14.8	14.3	15.4	16.4	15.2	13.8	14.5	16.4
2016m3	12.7	15.1	14.8	14.3	15.4	16.4	15.2	13.8	14.5	16.4
2016m4	12.9	15.7	15.3	14.3	15.4	16.4	15.2	13.8	14.5	16.6
2016m5	13.1	15.7	15.3	14.3	15.4	16.4	15.2	14.3	14.5	16.9
2016m6	13.3	15.7	15.3	14.3	15.4	16.4	15.2	14.3	14.5	17.2
2016m7	13.1	15.9	15.3	14.3	15.4	16.4	15.2	14.3	14.5	16.8
2016m8	13.3	16.2	15.3	14.8	15.4	16.4	15.2	14.7	14.5	16.6
2016m9	13.1	16.1	15.3	14.8	15.4	16.4	15.2	14.7	14.5	15.5
2016m10	13.1	16.2	15.3	14.8	15.4	16.4	15.2	14.7	14.5	15.5

2016m11	13.5	16.2	16.1	15.6	15.4	16.4	15.2	14.7	14.5	17.4
2016m12	13.5	16.2	16.1	15.6	15.4	16.4	15.2	14.7	14.5	17.4
2017m1	14.6	16.8	16.1	15.6	15.4	18.5	15.2	15.7	14.5	18.5
2017m2	14.6	16.8	16.1	15.6	15.4	18.5	15.2	15.7	14.5	18.7
2017m3	14.6	16.8	16.1	17.6	15.4	18.5	15.2	15.7	16.2	18.7
2017m4	14.6	16.8	17.1	17.6	15.7	18.5	15.2	15.7	16.2	18.7
2017m5	14.6	16.8	17.1	17.6	15.7	18.5	15.2	15.7	16.2	18.7
2017m6	15.1	17.3	17.1	17.6	15.7	18.5	15.2	15.7	16.2	19.0
2017m7	15.1	17.3	18.7	17.6	15.7	18.5	15.2	15.7	16.2	19.0
2017m8	15.1	17.3	18.7	17.6	15.7	18.5	15.2	15.7	16.2	19.0
2017m9	15.1	17.3	18.7	17.6	15.7	18.5	15.2	15.7	16.2	18.6
2017m10	15.1	17.3	18.7	17.6	15.7	18.7	15.2	15.7	16.2	18.7
2017m11	15.1	17.3	18.7	17.6	15.7	18.7	15.2	15.7	17.4	19.0
2017m12	15.3	17.3	18.7	17.6	15.7	18.7	15.2	15.7	17.4	19.2

