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Analysis on Ethiopian Sesame Seed Export

Addis Abera Ayalew

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Analysis on Ethiopian Sesame Seed Export

Addis Abera Ayalew

Supervisor:	Yves Surry , Swedish University of Agricultural Sciences, Department of Economics
Examiner:	Rob Hart , Swedish University of Agricultural Sciences, Department of Economics

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Abstract

This study investigates how the Ethiopian sesame seed export market is integrated to selected reference markets in China and the US. Cointegration and vector error-correction model (VECM) are employed using monthly data over the period 2010 to 2018. The empirical findings indicate that the Ethiopian sesame seed export market has a long-run equilibrium relationship with the Chinese sesame oil, the Chinese soybean import and the US soybean domestic markets. Market shocks with in the first two reference markets have permanent effects on the Ethiopian export price in the long run, while the latter has a transitory effect. Furthermore, the Ethiopian sesame seed export market has a price adjustment speed of 12% in the integration process implying that it takes less than nine months to restore to the long-run equilibrium after a shock. There is also a strong evidence of a short-run price transmission from the Ethiopian sesame seed export price to the Chinese sesame oil domestic price. Overall the empirical findings indicate the presence of market integration, but with asymmetric price transmissions across the markets.

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Acronyms

CBOT Chicago Board of Trade

CNGOIC China National Grain and Oils Information Center

CSA Central Statistical Agency of Ethiopia

DCE Dalian Commodity Exchange

ECX Ethiopia Commodity Exchange

ETB Ethiopian Birr Currency

ERCA Ethiopian Revenue and Customs Authority

FAO Food and Agriculture Organization of the United Nations

IFPRI International Food and Policy Research Institute

MoFED Ministry of Finance and Economic Development, Ethiopia

NBE National Bank of Ethiopia

NYSE New York Stock Exchange

OECD the Organization for Economic Co-operation and Development

UNCTAD United Nations Conference on Trade and Development

UNDP United Nations Development Programme

USAID the United States Agency for International Development

VECM Vector Error Correction Model

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1. INTRODUCTION

1.1 Background of the Study

Commodity dependence remains among the major challenges of most developing economies in the world. About two-thirds of developing countries gain the majority of their export earnings from exports of primary commodities such as agricultural commodities & foods, fuels and minerals (UNDP, 2011). On the other side, such exports are usually coupled with imports of highly valued goods from the developed economies.

Commodity dependence of either form jeopardizes developing countries through terms of trade imbalance, fiscal and monetary policy stresses, and impact on domestic consumers and producers - as their economies are susceptible to the global commodity price shocks and volatility. It also leads the countries to record low levels of development and high poverty rates, thereby exacerbating the livelihood condition of their poor households. Overall, it may cause potentially harmful impacts and affect all dimensions of sustainable development (UNCTAD and FAO, 2017).

Ethiopia is no exception to the challenge and risk of export commodity dependence that is being witnessed in the developing economies. The country's domestic export markets, particularly of the primary agricultural commodities are potentially exposed to international shocks and price volatility. The main purpose of this study is, therefore, to analyze and provide valuable findings on the overall performance and market integration of one of Ethiopia's most valuable export commodities, sesame seed in the global oilseeds market settings.

According to UNCTAD (2017), Ethiopia's commodity exports share out of its total merchandise value was 92% during the year 2014/15. This makes the country among the most commodity-export-dependent countries in the world. UNCTAD labels a country as 'strongly commodity export dependent' when a country's commodity exports value is more than 80% of its total merchandise exports value. Thus, the sustainability of recently-on-fast-growing economy of Ethiopia also hinges on confronting this particular challenge and risk of commodity dependence, among others.

The Ethiopian export sector is structurally dependent on primary agricultural commodities. Coffee, oilseeds, hides and skins have long been the major manifestations of the sector. Through time, as new items such as khat[1], cut flowers, and electricity joined the country's export portfolio, the relative share and dominance of these major exports have declined, despite the fact that their trade volumes have been increasing in absolute terms.

[1] *A stimulant plant widely chewed in East Africa and Arabian Peninsula countries.*

During the last three years, i.e. 2014/15 – 2016/17[2], average annual export value of the country was approximately 3 billion USD, of which the top export commodities' shares were: coffee (27.1%), oilseeds (15.2%), gold (9.3%), khat (9.2%), pulses (8.3%), and cut flowers (7.4%). Further breakdown of the oilseed exports indicate that sesame seed has overwhelmingly dominated the subgroup. During the same period, the average annual export value of sesame seed was more than 400 million USD. This is about 10% of the country's total export value or more than 90% of the total oilseeds' export value. Niger seed, castor seed and linseed in this order are the next top export oilseeds (ERCA, 2017; NBE, 2017).

The export of some of the above agricultural commodities are transacted through Ethiopia Commodity Exchange (ECX), a state owned enterprise located in Addis Ababa. The ECX was established in April 2008 with the aim of providing a centralized trading mechanism within which offers to sell and bids to buy are conducted on a physical trading floor with open outcry bidding system. Since then, the Exchange has been providing different services of grading and product certification, warehousing, clearing and settlement, and dissemination of transactions information. In July 2015, the Exchange also started an online trading system with a plan of completely replacing the often-called 'traditional trading', the open outcry bidding system. Currently, six agricultural commodities, namely coffee, sesame seed, haricot bean, maize, wheat and mung bean, are traded at the Exchange. The first three commodities' export trading in the country is only allowed through the Exchange on regular trading days, whereas the remaining commodities are traded at both the Exchange and the customary markets.

On the other hand, over the last decade the country has embarked on series of policy initiatives to transform its economy. The policy priorities are mainly directed towards agricultural sector growth, promotion of manufacturing sector and export diversification (MoFED, 2010). The current, second phase of the national development plan, also known as *'the Growth and Transformation Plan II'*, for instance underscores on the necessity of making a shift in export sector through addressing the supply side factors of limited productive capacity, limited diversification of the economy and industrial development.

1.2 Statement of the Problem

Since the year 2000, the sesame seed export demand of Ethiopia has showed two major distinguishing features. Firstly, its trade value has increased remarkably by more than twenty fold, which as a result it has become the second most important export commodity next to coffee. Secondly, it has increasingly become over dependent on the Chinese market, to where more than 50% is directed.

[2] *Ethiopian fiscal year starts in July and ends in June.*

Currently, Ethiopia is the second top sesame seed exporting country in the world, with the global market share of around 20% (FAO, 2016). Studies assert that the sesame seed markets in Ethiopia are highly linked with changes in the supply and demand conditions of the international oilseeds market. The international market shocks' concomitant effect on domestic market actors is therefore conceivable, especially on hundred thousands of smallholder farmers who are contributing the large share of the country's sesame seed production. Similarly, the international market fluctuation effect is understandable on the country's hardly gained foreign currency, to which the sesame alone contributes up to 10% of the total export earnings.

Moreover, the sesame seed market price at the ECX has also been through significant variations. For instance, in 2013/14 crop year, the price has historically jumped above 2,000 USD per ton - only to go down in the latter periods by more than 50%, and show again a rising tendency. Likewise, significant fluctuations have been witnessed in export volume and value.

The world oilseeds demand, on the other hand, is overwhelmingly dominated by China, where Ethiopia's sesame seed is mostly channeled to, as well. China is among the world's top producers of both sesame and soybean. Yet unable to meet its rising domestic demand, the country imports 40% and 60% of the world's sesame and soybean trade, respectively (FAO, 2016; USDA, 2017). China oilseeds demand is dependent on major oilseeds markets in the US and in other top producing countries. For instance, there is strong integration among soybean markets in China, Brazil and the US. Accordingly, it is possible to presume Ethiopia's sesame export link in the global oilseeds market network, given the robust linkage of sesame trading Ethiopia has with China, and also the significant role soybean plays in China's oilseeds market and hence its potential substitution impact on China's sesame seed demand.

Nevertheless, there are virtually no studies which have specifically examined the market interdependence of Ethiopia sesame seed market with the international oilseeds market settings. Few available studies are limited to domestic value chain assessment or export performance analysis. Thus, the long-run relationship of market variations between the Ethiopian sesame seed export prices and reference (international) oilseeds markets require a due investigation.

The main purpose of this study will therefore be to fill this literature gap and examine the market integration and price transmission of Ethiopia's sesame seed export market over a recent seven-year period, since the ECX commenced a regular daily trading in November 2010.

The study will specifically seek answers to the following research questions:

i. How is the vertical market integration between Ethiopia's sesame seed export market and China's sesame oil domestic market?
ii. How is the cross-commodity market integration between Ethiopia's sesame seed export market and soybean reference markets in China and the US?

1.3 Research Hypotheses

This study assumes that Ethiopia's sesame seed domestic market is connected to the global oilseeds market network, and that its price variations are interdependent with the global market conditions. Particularly, it assumes that the export market at the ECX is integrated to sesame oil domestic market in China and to soybean markets in China and the US. Figure 1.1 provides a summary of the research hypotheses.

The reference international markets are chosen from two perspectives. Firstly, China is the major destination of Ethiopia's sesame seed, where more than 60% is shipped to during the study period, and where the commodity is primarily used for edible oil processing purposes. From China's side, Ethiopia is also a major sesame trading partner that accounts up to 20% of its total sesame seed import. Thus, a two-way, strong interdependence is predicted between these two markets.

Secondly, soybean has a predominant role in the global oilseeds market. The two exchanges in the US and China - the Chicago Board of Trade (CBOT) and the Dalian Commodity Exchange (DCE), respectively - are the top leading market places in the world. Studies also show that there is a strong market interdependence between these two exchanges in particular (Fung et al., 2003; Han et al., 2013). In addition, soybean is the major source of edible oil in China, which makes it a relevant substitute for China's sesame demand - including indirectly for Ethiopian exports. In this case, the role of Ethiopia's sesame market could be viewed as marginal, and this study predicts a one-sided integration in which the dominant soybean markets affect the long-run trend of Ethiopia's sesame seed export price.

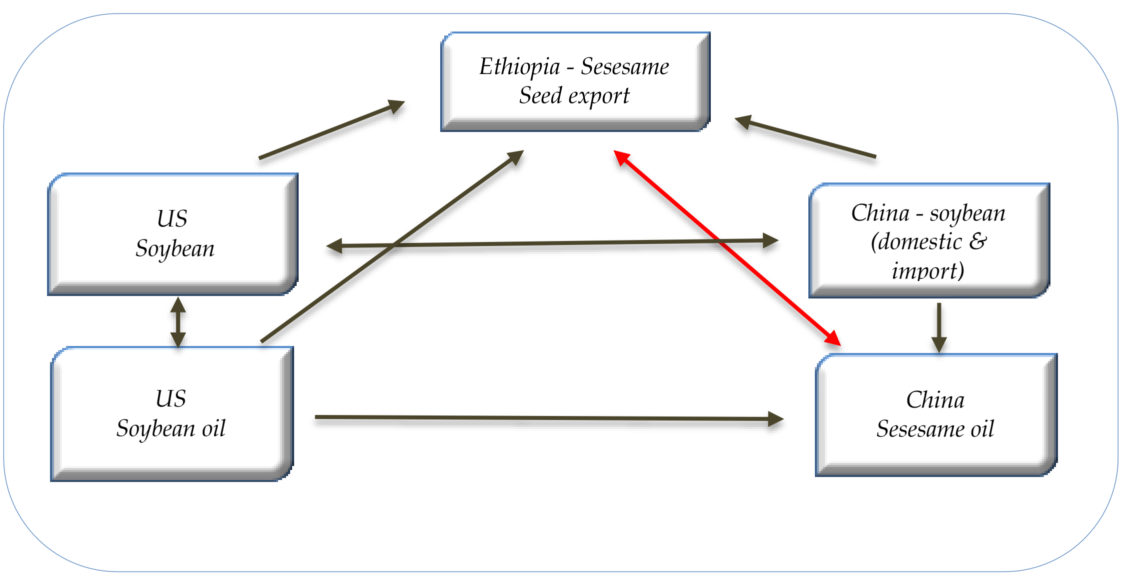


Figure 1.1: A schematic representation of market linkages: Ethiopia's sesame seed export and international markets

Besides, this study supposes the broader definition of the market integration concept in which two markets could be integrated through third markets without any direct flows of goods between them (Barrett & Li, 2002; Fackler & Goodwin, 2001). Therefore, considering the common global oilseeds trading network, and in particular the middle role the Chinese markets would play, the study also attempts to examine the possible integration that the Ethiopia sesame seed market would have with the soybean market in the US, even though the two countries are not direct trading partners in these two commodities respect.

However, there are underlying factors, which could affect the assumed integrations among the identified markets. Some of these factors include transport and transaction costs, infrastructural bottlenecks, trade policies and regulations, and exchange rates. The study therefore uses time series analysis techniques of cointegration and the vector error-correction model (VECM) to verify its hypotheses.

1.4 Objectives of the Study

The general objective of this study is to find out to what extent that Ethiopia's sesame seed export is integrated with the international oilseeds market, and assesses its implications on the export performance forecast of the country.

The specific objectives of the study are:

i) To calculate the price co-movements between ECX sesame seed price and China sesame-oil domestic wholesale price.
ii) To calculate the price co-movements between ECX sesame seed price and the domestic soybean reference markets in China and the US.
iii) To compare and analyze the reference markets' linkages and relative effects on Ethiopia's sesame seed export market.

1.5 Scope and Limitations

This study specifically focuses on market integration and price transmission analyses. The study covers the national sesame seeds export (i.e. the raw commodity) of Ethiopia. Processed or semi-processed sesame products are not included since the country's sesame export is totally made up of the raw seeds. The study period covers only from November 2010 to January 2018, for a reason that a regular daily trade data started at the Exchange since that specific period on, even if the Exchange officially commenced sesame trade in October 2009. It is important to remind here that sesame export in the country is only allowed to be transacted through the ECX, except for rare conditions.

The study is also susceptible to certain limitations. However, these limitations do not affect the internal model validity and the overall reliability of the study. In this regard, the first limitation is that the study only covers sesame seed export price and couldn't incorporate producers' (i.e. smallholder farmers') selling price in primary rural markets of Ethiopia as such data are not easily accessible, if not available. There are also few empirical literatures in Ethiopia on the specific topic of market integration of oilseeds. But most importantly, the major challenge of this study was that the limited literature on the Chinese sesame seed processing industry. For instance, price data of China's domestic sesame seed market couldn't be accessed. Thus, the analysis couldn't cover a spatial market integration analysis of the same commodity between the two countries.

1.6 Organization of the Study

The study is structured in six chapters. The second chapter next to this introductory one provides a brief overview on the sesame seed commodity. The third chapter is a review of literature, which it is sub-sectioned into concepts and methods review, empirical literature review, and summary on the literature. Then follow the data and methodology chapter. Under this chapter, data and methods of analysis are explained and the applicable econometric model specifications are outlined. Chapter five discusses on the study's findings, where the pertinent hypothesis' tests and the econometric model results are provided with interpretations. Finally, chapter six concludes the study by pointing out relevant policy implications.

2. SESAME - COMMODITY BACKGROUND

This chapter provides a brief overview on the commodity under study. The first section highlights on the cultivation and production of sesame seed in Ethiopia. Then follows on the utilization and commercialization. It is under this section, Ethiopia's sesame seed export performance and supply trend are discussed. Thirdly is a brief discussion on the global sesame seed trade with emphasis on African export and China's market. The final, fourth section summarizes the chapter.

2.1 Cultivation and Production

In Ethiopia, the sesame (*Sesamum indicum L.*) seed grows mainly in Northwestern and Western parts of the country (see Figure 2.1). The agro-ecological zone of these regions, which is a relatively high temperature and moderate rainfall, makes them suitable for sesame cultivation. The country has also a huge potential of sesame production in its semi-arid Southern and Eastern parts. The sesame plant best grows in tropical and semi-tropical climates with well-drained, fertile sandy soils and moderate rainfall.

Figure 2.1: Major sesame growing areas in Ethiopia.
Source: Google Maps, retrieved in 2018.

The main growing areas in the country are Metema, Humer, Wollega and Metekel, which altogether cover more than 80% of the total sesame seed production. Particularly, Metema and Humera areas are the production hubs that cover about 45% and 20% of the national production, respectively.

Regarding the planting season, sesame is largely sown in these potential areas from June to mid-July and harvesting runs from mid-October through November. The months of November through June are pick sesame seed supply seasons at the ECX.

On the other hand, the production is totally dominated by smallholder farmers, with few exceptions of private investors. The national average of landholding of the sesame growers is just more than 2 hectare, which still makes it better compared to the average national holdings of 0.5 hectare. However, the overall farm practice by the smallholders is very traditional with total dependency on rainfall feed system and very limited application of modern farm inputs like fertilizer, high yielding seeds and tools. According to CSA (2017), during the 2016/17 crop year 756 782 growers have produced 267 867 tons of sesame seed from the total cultivated 337 927 hectares of land. During the year, the national productivity was almost 0.85 ton per hectare.

Generally, the area coverage and production of sesame seed in Ethiopia have been increasing in the last two decades, mainly due to its importance as a major export commodity. There is also a vast potential to expand the production in the future through cultivation of additional new land and also enhancing the already cultivated ones through better agronomical practices and new technologies. A cursory look at the historical production trend shows that over the years 2001/02 to 2005/06, annual sesame production has remarkably showed a quadruple increment. The ever increasing lucrative international market opportunities and favorable weather conditions are mentioned as major reasons. Since the year 2005/06, the production has been growing by 8% annually, and has now stood around 270 000 tons. It is a triple increment from where it was during the benchmark five years' average of 91 000 tons (CSA, 2018).

2.2 Utilization and Commercialization

Sesame is highly demanded across the world for its edible, industrial and pharmaceutical uses. But above all, the commodity is primarily demanded for its edible oil that more than two-thirds of the world sesame seed is processed for this purpose. Besides, it has various uses as a meal (animal feed), paste, confections and bakery products. Sesame has also non-culinary applications as an ingredient in soap, cosmetics, lubricants and medicines. It is due to its nutritionally rich oil and its versatile nature to other uses that sesame is usually dubbed as *'queen of oilseed crops'* (Bedigian, 2010; Pal et al., 2010).

In Ethiopia, sesame has a very low domestic utilization. More than 95% of the national production is supplied to the export market (ERCA, 2017; NBE, 2017). Processed or semi-processed sesame exports are almost non-existent. Surprisingly enough the country is net importer of sesame oil, even though its trade value is very low. The general supply chain description of the country's sesame seed export is illustrated in Figure 2.2.

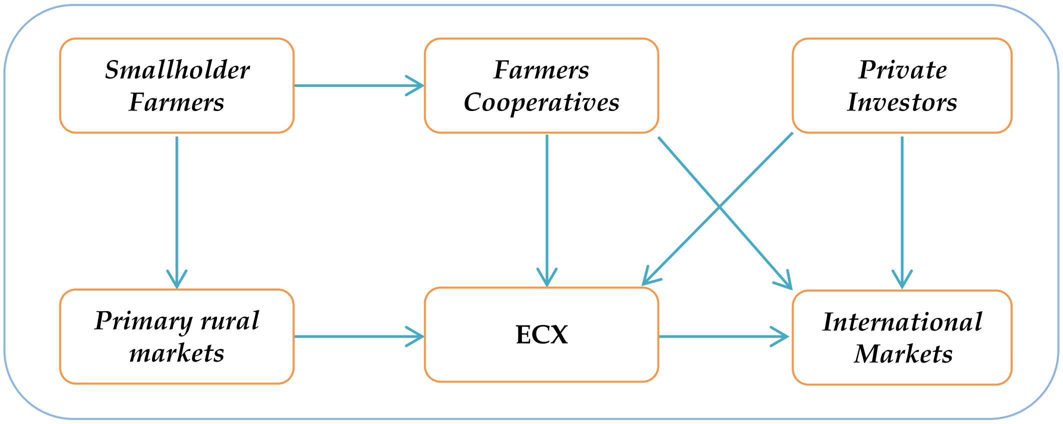


Figure 2.2: A general supply chain description of sesame seed export in Ethiopia

With regard to product quality and standard, the sesame demand in the international market is mainly determined by its seeds colour, purity and dryness. The ECX, which has the mandate of quality grading and certification in the country, broadly classifies sesame seed into three categories based on seed colour and geographical areas: Whitish Humera Gondar, Witish Wollega and Reddish. During the study period, 70% of the total sesame trade at the EXC was of Whitish Humera type and the rest all was almost Whitish Wollega. Reddish type, which grows in the North central parts, is very low with below 1% share.

Table 2.1: Sesame seed export quantity and value (2009/10-2016/17)

Year	Quantity (tons)	Unit value-FOB Djibouti (USD)	Exports value (million USD)		
			Sesame	Country-total	Share
2009/10	248,424	1,289	320.2	1,986.6	16%
2010/11	234,550	1,395	327.1	2,669.9	12%
2011/12	306,721	1,310	401.8	3,130.9	13%
2012/13	221,041	1,799	397.7	3,059.7	13%
2013/14	239,842	2,255	540.9	3,235.2	17%
2014/15	290,081	1,586	460.2	2,954.3	16%
2015/16	-	1,074	438.1	2,800.8	16%
2016/17	284,095	1,082	307.3	2,812.9	11%
Average	**260,679**	**1,474**	**399.2**	**2,831.3**	**14%**

Data sources: ERCA and NBE

During the study period, Ethiopia has been exporting nearly an average 260,000 ton of sesame seed per year while the corresponding average price (FOB Djibouti) was 1,474 USD (see Table 2.1). The FOB price is basically the ECX price plus additional costs of inland transport, handling and packing, transit and associated logistics services, and profit margin. During the same period, the top trading partners were China, Israel and Turkey, to where 60%, 15% and 5% of the total export was shipped, respectively. Figure 2.3 below illustrates Ethiopia's sesame export demand and the corresponding China's demand and share since the year 2000.

Figure 2.3: Ethiopia's sesame seed export demand and China's share
Data source: ERCA and NBE

The Ethiopian sesame commodity is primarily used in these major importing countries for edible oil processing. The commodity has a premium quality in the global market and usually used as one of the international reference prices for sesame seed. Further discussion on the price trend is included in section 4.1.

2.3 The Global Context: African Export and China's Market

The global sesame trade has been increasing steadily during the recent few decades, primarily associated with its in-demand nutritious edible oil and the increasing world population. However, sesame's share in the international oilseeds market is very negligible compared with other oilseeds such as soybean, rapeseed and groundnut.

According to FAO (2016), the world production of sesame seeds is estimated at 6 million tons, of which 60 per cent is consumed in the producing countries themselves. Africa and Asia continents produce more than 95% of the global sesame seeds. Tanzania, Myanmar, India, China, Sudan, Nigeria and Ethiopia are the major producing countries, which together cover more than 80% of the global total. Correspondingly, the annual global trading volume is estimated at 1.8 million metric tons, valued more than $2 billion.

One noticeable feature of the global sesame seed trade is that the dominant role and strong trade ties that China and African countries have together. China is the fourth top sesame seed producer in the world, but the country cannot meet its domestic demand and imports two-fifth of the global export supply – of which 85% is covered from Africa. In fact, China's role in the international oilseed market dominance is so visible in other oilseeds such as soybean and rapeseed that it imports 60% and 25% of the global demand, respectively (USDA, 2017). Studies link this Chinese role to its increasing urban population and to the subsequent demand for oilseeds and meat products. China primarily uses oilseeds for edible oil and meals (animal feeds) purposes. On the other hand, Africa is estimated to cover one-third of the global sesame seed export. Four of the top five exporting countries in the world are from Africa (see Figure 2.4).

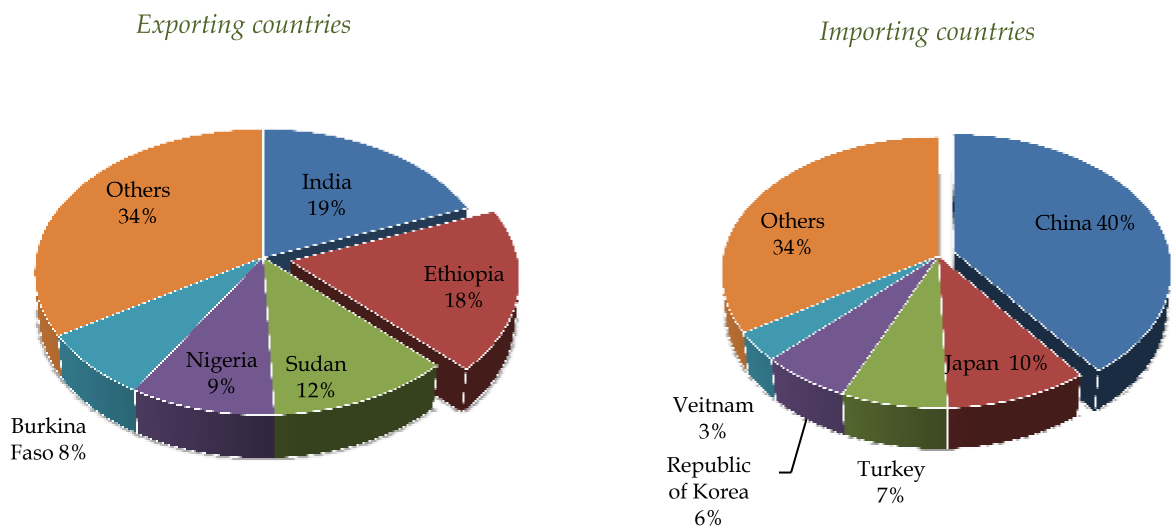


Figure 2.4: Major exporters and importers of sesame seeds
Data source: FAO (2016)*, estimated from the average of 2012–2016*

To add more on the Sino-African trade relations in the study's context, Nowak (2016) mentions the early 2000s as key years of the bilateral relation, when debt servicing, investment promotion and custom procedures improvement, concessional loan and preferential export credits services to Africa were pledged in consecutive high-level forums. More importantly, the year 2003 was when China announced zero-tariff treatment to products it imports from some African countries including Ethiopia. The Information Office of the State Council of the People's Republic of China (2013) specifically states that China's imports of sesame seeds from Africa have grown rapidly, driven by the zero-tariff policy that was implemented in 2005. Sure enough, this period coincides with Ethiopia's sesame seeds export surge to China in 2005 from nowhere in the years before (See Figure. 2.3).

China is also a favorable destination of other African export products, and in turn is source of cheap manufacturing and industrial import products. Besides, the country participates in various infrastructural projects and manufacturing investments across the continent. In Ethiopia, for example, the presence of China is observable in hydroelectric projects, road constructions, telecoms, railways, and manufacturing. In what is related to this, Levitt (2013) specifically reports that Ethiopia uses sesame seeds to repay loans on Chinese-built infrastructure. This whole political and economic relation between the two regions is however under continuous debate and subject area of many studies that revolve around the mutual nature of the trade benefit.

2.4 Summary on Commodity Background

Sesame seed is the second most valuable export item in Ethiopia, next to Coffee. It covers more than 10% of the country's annual export earnings. Hundred thousands of smallholder farmers also support their life through cultivating this commodity.

During the study period, from 2009/10 to 2016/17, the country exported an average 260 000 tons of sesame seed per year, valued nearly 400 million USD. China, Israel and Turkey are the top export destinations to where 60%, 15% and 5% of the total sesame seed export was shipped, respectively. Sesame is little known in Ethiopia's cuisine and by the domestic food processing sector; hence almost the entire marketable surplus is exportable.

The sesame trading in the country is only allowed through the Ethiopia Commodity Exchange (ECX) on regular trading days. The ECX has also the mandate of sesame seed quality grading and certification in the country. The Exchange broadly classifies the commodity into three categories based on seed color and geographical areas: Whitish Humera Gondar, Whitish Wollega and Reddish. The commodity mainly grows in the Northwestern and Western parts of the country. The Ethiopian sesame has a premium quality in the global market and usually used as one of the international reference prices.

With regard to the global trade, sesame seed trade has been increasing steadily during the recent few decades primarily associated with its in-demand nutritious edible oil and the increasing world population. Yet, its share in the international oilseeds market is very negligible compared with other oilseeds. Besides, the dominant role and strong trade ties that China and African countries have together is one of the major characteristics of the global sesame market. China imports two-fifth of the global export supply – of which 85% is covered from Africa. Ethiopia is the world's second top, and Africa's leading exporter with a global share of 18%.

3. REVIEW OF LITERATURE

This chapter is structured into three sections. The first deals with a review of concepts and methods that are relevant for this study. Under this section, the market integration and associated basic concepts are discussed. The methods of testing market integration and price transmission are also briefly summarized. Especially, the cointegration concept, the foundation of the applicable model of the study, is reviewed as a background for the next data and methodology chapter. Then follows the second section, review of some selected empirical studies on commodity market integration. The final section draws a summary of lessons from the reviewed literatures.

3.1 Concepts and Methods

3.1.1 The concept of market integration

The concept of market integration has no definitive explanation as different studies have different contexts based on their area of focus and methods of analysis. However, broadly speaking the market integration concept is commonly used to describe market linkage or interdependence across space, time, and form. It is also interchangeably referred as price integration.

Fackler and Goodwin (2001) define market integration as a measure of the degree to which demand and supply shocks arising in one region are transmitted to another region. Simply put, it is measured by the "price" ratio (R_{AB}) associated with a market shock. Mathematically:

$$R_{AB} = \frac{\partial P_B / \partial \varepsilon_A}{\partial P_A / \partial \varepsilon_A} \qquad (3.1)$$

Where P_A and P_B refer prices in region A and B, respectively; ε_A represents hypothetical shock in region A; and ∂ stands for the first order derivative of respective price to the market shock.

The authors also emphasize the market integration concept as a degree rather than a specific relationship, which its unit ranges from zero to one for completely separated and perfectly integrated markets, respectively.

In this regard, market integration is associated with price transmission, a situation in which a change in one price causes another price to change. Thus, there are three cases of price transmissions and hence market integration types. The first one is spatial integration between two markets for the same commodity. The second one is vertical integration which refers to a price transmission along the value chain. This mainly refers market integration between the raw material and the final product prices. In this study's case, the price interdependence between the Ethiopian sesame seed export price and China's sesame oil domestic price is a good example here. Thirdly is cross-commodity integration between two different commodities. The price interdependence between the Ethiopian sesame seed export price and soybean prices of the international markets as in the case of this study represent this latter type of market integration. Accordingly, the type and degree of market integrations differ based on the commodity types and price relationships with in assumed markets.

The basics of market integration rest on the concepts of spatial arbitrage and the Law of One Price (LOP). Spatial arbitrage implies the condition that profit-seeking traders (price arbitrageurs) will transport a commodity from lower price regions to higher price regions if the price difference exceeds the marginal transportation and handling costs. Consequently, the arbitrage transportation or shipment will raise the price in the lower price region and will decrease it in the higher price region, until the price difference is reduced to the marginal transportation cost. On this basis, the LOP states that regional markets that are linked by trade and arbitrage will have a common, and unique price except for a transactions costs difference. For this reason, the LOP gives rise to a specific set of price relationships at a particular point in time, which it in turn gives rise to a high degree of price integration over time. Thus, market integration basically refers to a situation in which arbitrage causes prices in different markets to move together (see also Fackler & Goodwin, 2001; Rapsomanikis et al., 2003; Vercammen, 2011).

On the same note, the spatial arbitrage condition comprises price relationships that lie between the two extreme cases of the strong form of the LOP (i.e. perfect market integration) and the absence of market integration (i.e. market segmentation). The strong LOP condition refers a free market regime scenario when the price of a commodity with in two markets will equal except the transport cost (C) difference, as represented by Equation 3.2 below (see also Barrett, 2008; Barrett & Li, 2002; Fackler & Goodwin, 2001; Rapsomanikis et al., 2003; Ravallion, 1986).

$$\mathrm{P_{1t} = P_{2t} + C} \qquad (3.2)$$

$$\mathrm{P_{2t} - P_{1t} \leq C} \qquad (3.3)$$

The whole notion here is therefore, through arbitrage and price transmission the market integration process should adhere to a long-run statistical equilibrium or a cointegration relationship. However, in a real world situation things are not straightforward since there are many imperfections that affect price transmission between markets. This implies that market integration between two regions can arise for many other confounding factors, outside of respective commodities pure trading links. Similarly, prices that satisfy strong price links may not be detected for movement together for different other reasons. Equation 3.3 represents the weak form of the LOP; an imperfect condition in which the difference between the market prices is beyond the transportation cost and includes costs of other deterring factors.

In this regard, Rapsomanikis *et al.* (2003) identify six main factors that can affect price transmissions. They are as follows: transport and transaction costs, market power, increasing returns to scale in production, product homogeneity and differentiation, exchange rates, and border and domestic policies. The effect of these factors however varies with the nature of the market integration type and some other socioeconomic and political situations. For example, developing countries are often characterized by poor infrastructures, inefficient trading mechanisms, and unstable political environments that hamper market integration.

As discussed earlier, the concept of market integration by itself is strongly integrated to the notion of price transmission. However, the price transmission associated definition of market integration as defined by expression (3.1) is too simplistic and fails to capture the complex nature of market and its price dynamics. Thus, in the broader context of market integration, the concept of price transmission is commonly used to measure a wide range of ways on how prices are related. For instance, Balcombe and Morrison (2002) and Rapsomanikis *et al.,* (2003) identify three components of the concept of price transmission. Firstly is the co-movement and completeness of adjustment. It implies how price changes in a given market are fully transmitted to the other. Second is dynamics and speed of adjustment which implies that the rate at which the price changes occur. Third is the asymmetry of response which indicates whether the price changes are symmetrically or asymmetrically transmitted.

3.1.2 Methods of testing market integration

Literatures on the market integration topics have been using various methods of testing based on the nature of their study. At the same time, the testing methods of market integration have been evolving through different stages and improvements. Overall, the methods can be grouped into simple regression and correlation analysis, dynamic regression models, and recent models that include regime-switching and threshold VEC models.

The early methods of testing market integration include price transmission elasticity, correlation coefficients and simple regression analysis. The assumption here is that if the price percentage ratio (elasticity), or correlation coefficient or regression parameter is higher, then higher integration is expected between the market prices. Nevertheless, except for their simplicity these methods have serious drawbacks. Most importantly, they all lack to consider non-linear relationships among market variables and fail to exclude common exogenous factors that affect all markets. In the first case, they underestimate the integration as they assume static conditions and consider no lag adjustments. In the latter case, they overestimate integration as the parameters do not purely show the extent to which markets are linked through trade in a specific commodity, by excluding the exogenous common factors. These common factors may include climate patterns (seasonality), inflation, policy changes, or population growth.

The dynamic regression models as their name imply try to capture the dynamic nature of markets and the arbitrage activities. These models which vary depending on the nature of market integration under study and the price data in use include among them the following ones: Granger causality test, Ravallion-Timmer models, impulse response analysis, cointegration analysis, and error-correction models (Baulch, 1997; Fackler & Goodwin, 2001; Ravallion, 1986). All these models or quantitative approaches are variants of the dynamic regression methods of testing market integration. Fackler and Goodwin (2001) state these models usually use some version of a vector auto-regressive model (VAR) as represented below:

$$\mathrm{A}_0 P_t = \sum_{k=1}^{n} \mathrm{A}_k P_{t-k} + DX_t + e_t \qquad (3.4)$$

,where P_t is a vector of prices, X_t a vector of exogenous factors affecting prices, the A_i are matrices of coefficients, and e_t is a vector of error terms.

Of all alternatives of the dynamic models, the cointegration technique and the associated vector error-correction (VEC) model, which are applied in this study, are the most dominant methods of analysis for their unique advantage over 'spurious regression' problem[3] (von Cramon-Taubadel, 2017). Nevertheless, dynamic regression models including the aforementioned two (i.e. cointegration technique and VEC model) do not solve all the problems confronting market integration and price transmission analysis. Particularly, regarding the two dominant models, the linearity assumption (i.e. the assumption of same error correction mechanism over time) is their major drawback. This assumption is more problematic to study cases of seasonally-varying transportation costs between market places, and asymmetric price transmission along the marketing chain (Fackler & Goodwin, 2001; von Cramon-Taubadel, 2017). New models such as regime-switching (Parity Bounds) and threshold VEC are among recent improvements that primarily try to incorporate such cases of non-linearity using empirical adjustment parameters and alternative analysis methods.

3.1.3 The concept of cointegration

The concept of cointegration is essentially a method of detecting a long-run equilibrium relationship between non-stationary time series variables. Within the study's context of commodity market, the basic notion of cointegration is that when there is information flows between two commodity markets, traders are able to act on the information and share a long-run relationship, which is an indication of market integration. The absence of cointegration in contrary indicates market segmentation.

[3] *The notion of spurious regression problem vis-à-vis the cointegration technique is discussed in the next section.*

But first, it is vital to look at the stationarity property of time series variables, a basic concept in the cointegration analysis. Time series variables are called stationary if their respective probability distribution does not change over time. Two or more variables are also said to be jointly stationary if the joint distribution is similarly time invariant. Stationary series have constant means, and finite variances and covariance through time. Simply put, stationarity requires the future to be like the past (Stock & Watson, 2011). On the other hand, non-stationary series is a random walk process where the value of the variable is dependent on the previous value plus an error term. Non-stationary series have different means at different points in time and their variances increases with the sample size.

Economic variables often have a non-stationary property with no clear tendency to return to a constant value. The standard regression analysis like Ordinary Least Square (OLS) fails when dealing with non-stationary variables, leading to 'spurious regressions' that suggest relationships even when there are none. Granger and Newbold (1974) are the first to point out that test of such a regression with spurious results. On this basis, Granger (1981) later introduces the concept of cointegration as a remedy for the spurious regression problem (see also Asteriou & Hall, 2011; Harris & Sollis, 2003; Maddala & Kim, 1999).

The key concept of cointegration based on Maddala and Kim (1999) and Stock and Watson (2011) is as follows. Suppose that P_{it} and P_{jt} are independent non-stationary (price) series, integrated of order one and the common regression equation is as specified in expression (3.5). If ε_t is integrated of order zero, i.e. becomes stationary series ($\sim I(0)$), then P_{it} and P_{jt} are said to be cointegrated, and the coefficient β_1 is called the cointegrating coefficient. If the two series are cointegrated, then they have the same common stochastic trend.

$$P_{it} = \beta_0 + \beta_1 P_{jt} + \varepsilon_t \qquad (3.5)$$

From the equation above, since P_{it} and P_{jt} are uncorrelated non-stationary series, the straight forward expectation is that the coefficient of determination (R^2) for the regression equation (3.5) would tend to be zero. However, if the two time series have growing or decreasing trends in common over time, they can be correlated even if the changes in each series are uncorrelated. This is the scenario which often leads to a problem of spurious regression if the non-stationary series are regressed under the regular OLS procedure. According to Harris and Sollis (2003), results from a spurious regression suggest that "there are statistically significant long-run relationships between non-stationary variables in the regression model when in fact all that is obtained is evidence of contemporaneous correlations rather than meaningful causal relations" (pp. 37).

One way of resolving spurious regression problem is to difference the series sequentially until stationarity is achieved and then use the stationary series for regression analysis. Equation (3.6) represents a regression equation of the first difference of variables P_{it} and P_{jt}.. Accordingly, this modified regression model partially resolves the spurious problem as its parameters α_0 and α_1 give the better estimates than the spurious parameters β_0 and β_1 of the other, un-differenced equation.

$$\Delta P_{it} = \alpha_0 + \alpha_1 \Delta P_{jt} + \eta_t \qquad (3.6)$$

A series can be differenced multiple (say d) times before it becomes stationary. And it is said to be integrated of order d or contains d unit roots, denoted *I(d).* In our case, series P_{it} and P_{jt} are differenced one time and then assumed their error term ($\eta_t \sim \Delta\varepsilon_t$) is a stationary series. Therefore, the two series are considered as integrated of order one, or having a unit root. Thus, number of times the series needs to be differenced in order to become stationary is equivalent to number of roots and order of integration of the series. Stationary series have zero unit roots and are represented as $\sim I(0)$.

Now coming back to the cointegration concept, according to Asteriou and Hall (2011), if there is a genuine long-run relationship between non-stationary time series variables, then despite the variables changing over time, there will be a common trend that links them together. The idea here is that even though the cointegrated series themselves may contain stochastic trends (i.e., non-stationarity) they will nevertheless move closely together over time and the difference between them is constant (i.e., stationarity). Harris and Sollis (2003) also explain that the concept of cointegration mirrors the existence of a long-run equilibrium to which an economic system converges over time, and the error term can be interpreted as the disequilibrium error i.e., the distance that the system is away from equilibrium at time.

However, the first difference method of resolving spurious regression problem, as specified in Equation (3.6), is still a half way through and only represents the short-run relationship between the two non-stationary series. The method fails to include the long-run relationship despite the fact that the concept cointegration is essentially a long-run relationship. Hence comes the idea of error-correction model, which aims at incorporating the short run and long run relationship of the non-stationary series in a single model equation.

According to the Granger Representation Theorem in Engle and Granger (1987), if a set of variables is cointegrated, then there exists an error-correction representation of the variables (pp. 255-256). Thus, broadly speaking, the error-correction model is the process of using a valid 'error-correction' representation into regression analysis. As specified in equation (3.7), the long-run equilibrium error, ε_{t-1} (the residual from the levels regression, $P_{it-1} - \beta_0 - \beta_1 P_{jt-1}$)[4] is now included in the model together with the short-run dynamics captured by the differenced terms.

$$\Delta P_{it} = \alpha_0 + \alpha_1 \Delta P_{it-1} + \alpha_2 \Delta P_{jt-1} + \pi\varepsilon_{t-1} + e_t \qquad (3.7)$$

[4] *For further discussion on the long-run equilibrium model parameterization see Asteriou and Hall* (2011) *and Harris and Sollis* (2003).

The error-correction model analysis comprises of the relevant tests of stationarity and cointegration. Hence, the elements of the model: ΔP_{it-1}, ΔP_{jt-1} and ε_{t-1} are all stationary series. Parameters α measure the short run effects, while π is the cointegrating parameter that describes the long-run equilibrium relationship between the two prices. The speed in which the market returns to its equilibrium depends on the proximity of the cointegrating parameter (π) to one.

To put in nut shell, a standard OLS regression of non-stationary series is spurious unless the series are cointegrated and their long-run relationship is handled through the techniques of cointegration. If the variables are not cointegrated, the econometric analysis becomes meaningless in either alternative. A valid cointegration econometric result requires of the non-stationary series to be integrated of the same order or have the same unit root(s). If the series are stationary trends from the very beginning, then the standard OLS regression procedure is valid.

3.2 Empirical Evidences

Empirical findings on regional and international markets overall show that export commodities like the sesame seed case in Ethiopia are highly tending to be integrated to related international markets as compared to less tradable, and domestic-supply dependent commodities. However, this assertion requires at least two considerations. The first one is that the specific factors (both global and local) that would play an important role in the determination of the market integration. The second one has to do with the unique circumstances of the Ethiopian sesame seed export market and prices compared to other commodities.

There have been a few empirical works on the topics of market integration dealing with Ethiopia. However, these studies are very limited to major crop commodities such as coffee, *teff*[5], wheat, maize and sorghum. The studies on the food crops focus on the price transmission between domestic markets, while for coffee the main focus is largely on the domestic and international markets interdependence.

To my knowledge, there are virtually no studies that have specifically examined the market integration of Ethiopia's oilseeds or sesame seed export markets. Few other studies available are limited to domestic value chain assessments or export performance analyses. There are also very few empirical literature on the international sesame seeds market. Consequently, this review is compelled to focus on empirical findings of some other related export commodities, which have strong ties with the international trade, or in one way or the other related to cases of the sesame seeds commodity under the study.

However, the other value chain and export performance assessment related studies still assert that sesame seed markets in Ethiopia are highly linked to changes in the supply and demand conditions of the international market (Alemu & Meijerink, 2010; Wijnands et al., 2009). This is

[5] *Staple food crop, endemic to Ethiopia*

in fact, in contrast to Admassie (2013) and Minot (2011) assertion on the aforementioned agricultural crops for which Ethiopia has negligible net trade with the rest of the world. The later authors argue that the price changes of agricultural food commodities in Ethiopia are not significantly affected by international prices.

Studies overall show that those countries with significant net trade with the rest of the world are strongly integrated to the international market conditions (Baquedano et al., 2011; Haile et al., 2016; Minot, 2011; Zakari et al., 2014). Seen from the wider global perspective, this conclusion is straightforward since globalization of the world economy, lower transportation costs, and the availability of real time market information via the internet over time have significantly facilitated the global commodity trading and integration.

Minot (2011), for example, in his work that focuses on staple food markets in eleven Sub-Saharan African countries, indicates that domestic prices of highly tradable commodities track the changes in the world prices compared to those less traded in the international markets. Minot also supports his price trend analysis using VEC model econometric analysis. Accordingly, only 13 of the 62 price series of staple foods studied show a long-run relationship in which the domestic price is influenced by the international price of the same commodity. And of the 13 domestic prices, only six have a long-term elasticity of transmission that is statistically significant. But the most relevant result of this empirical work is on rice, which most of the countries rely heavily in its imported supply, is highly integrated to the international market compared to maize on which the countries are relatively close to be self-sufficient on average. Equally, the study finding goes with this study's hypothesis, which for similar tradability reasons presumes higher integration between the Ethiopian sesame seed export market and the international oilseed markets.

Zakari *et al.*(2014) also show similar findings on wholesale grain markets' domestic prices in Niger. They used monthly data over the period 2006 to 2012 for four staple foods: maize, millet, rice and sorghum. Cointegration technique and VEC model are employed. Overall the study findings indicate the existence of market integration in which Niger domestic price is influenced by regional and international prices for the same commodity. Most importantly, the study findings show low degree of price adjustment for millet and sorghum compared to maize and rice due to the fact that the first are staple crops with high dependency on local production than import for supply compared to the latter two crops.

Moreover, Haile *et al.* (2016) provide relevant findings on the degree of vertical price transmission along the wheat-bread value chain in Ethiopia. Haile *et al.* investigate the inter-linkages in the wheat value chain and its exposure to international price shocks. They apply a VEC model using monthly price data for the period 2000-2015. The empirical findings indicate significant cointegration across prices of the different stages along the value chain. The findings also support this study's assumption of vertical integration between the Ethiopian sesame seed export market and China's sesame oil domestic market prices. Ethiopia imports a large amount of wheat, of which the imported wheat contributes a much higher share to marketed wheat than the domestically produced wheat (Haile et al., 2016; USDA, 2018). Similar to the wheat case, the sesame seed is a typical example on the export side - of which the country exports almost all of its marketable produces. On top of it, the Ethiopia supply covers the significant parts of the Chinese sesame seed import.

Nevertheless, tradability *per se* does not necessarily guarantee a prevalence of corresponding strong market integration and price transmission. Thus, findings of the empirical literatures on spatial and vertical market integration are subject to different global situations and local factors that play important role in determining respective market integration. These major factors include policy interventions, weather related domestic supply shocks, popular protests and violence, the international oil price, exchange rate, poor quality of infrastructure, and *et cetera* irrespective of their order.

On what is related to the above situations, Baquedano *et al.* (2011) provide an important case study comparison for export versus import crops in Mali and Nicaragua. Both countries obtain the bulk of their export revenue from cotton and coffee, respectively. And both import the same main staple food crop, rice. The study findings overall conclude that Nicaraguan agriculture is more integrated into the world market than that of Mali, and argue Mali's landlocked geography, poor road system , and state control over the cotton industry makes its agriculture less integrated into world markets than Nicaragua. These all factors are conspicuous variables in the study's context in Ethiopia.

Moreover, Ethiopia's sesame seed export has its own peculiar characteristics, which alert us not to straightforwardly extrapolate some connections from other related commodities. In this respect the first case is that the Ethiopian sesame seed is exported to very few markets unlike the relatively diversified destinations and hence market networks of other exports. Second, there is a difference in the commodities' quality categorization and the associated domestic and international markets demand. For instance, unlike coffee that has a robust domestic demand, the sesame seed supply is almost totally dependent on the international market. Third, the Ethiopian sesame seed price itself is among the leading references for the international sesame seed price, unlike the other way round in the other exports cases in which the domestic prices usually follow foreign market prices.

3.3 Summary on Literature

Generally speaking, the market integration concept is commonly used to describe market linkage or interdependence across space, time, and form. This particular concept is closely associated with price transmission between markets. In the context of market integration, nowadays the concept of price transmission implies a wide range of ways prices are related under the complex nature of market and its price dynamics.

There are various methods and approaches for market integration testing. Overall, the methods can be grouped into simple regression and correlation analysis, dynamic regression models, and recent regime-switching and threshold VEC models. Especially, the dynamic regression models of co-integration and VEC, also the applicable models of this study, are the dominant methods of analysis for their unique advantages over spurious regression problem cases. Moreover, these models provide an analytical tool that focus beyond the case of market integration or price transmission in testing notions such as completeness, speed, asymmetry and causality of the relationship between prices.

Nevertheless, the selected models linearity assumption on same error correction mechanism over time makes them less helpful in dealing with cases of seasonally-varying transportation costs between market places, and asymmetric price transmission along the marketing chain. Thus, the identified limitation remains the main caveat to this study.

Regarding empirical findings, results overall show that export commodities like the sesame seed case in Ethiopia are highly tending to be integrated to related international commodity markets as compared to less tradable, and domestic-supply dependent commodities. This is rightly in line with the study's general hypothesis that the Ethiopia sesame seed market is integrated to the global oilseeds market networks.

4. DATA AND METHODOLOGY

This chapter first provides a description on the data and methods of analysis. Then in the second section, the applicable econometric model specifications are outlined. Finally, a preliminary analysis of unit root test is discussed and the results are summarized.

4.1 Data and Methods of Analysis

The study uses seven-year data over the period November 2010 to January 2018. The Ethiopian export sesame seed daily price data is accessed from the ECX. The daily data is then converted to its corresponding dollar value over the study period. The publicly available, daily exchange rate data of the NBE is used for this purpose. All the rest daily prices are accessed through *Thomson Reuters Market Data*. The China National Grain and Oils Information Center (CNGOIC) is the source for sesame oil and soybean daily prices in China; the US Department of Agriculture and *Thomson Reuters* (itself) are the data sources for the US soybean and soy oil daily prices, respectively. All data series are spot (non-futures) trade prices so as to go along with the outcome variable of the analysis, the Ethiopian sesame seed export price.

I opted to convert the daily prices to monthly averages for two reasons. First, it is intuitively assumed here that the market integration dynamics may be hidden if we decrease the data frequency, and thus using the daily data may not be representative of the broader picture of the potential relationships between the markets. It is true, especially when the relatively less liquid daily trade volume of the ECX is considered. Secondly and most importantly, it is found difficult to convert daily data in real values as the available consumer price index (CPI) data are on monthly basis. In this regard, the frequent high inflation rate in Ethiopia has particularly necessitated the use of real price series. Therefore, the analysis uses the monthly frequencies, which yield a data set of 87 observations. The monthly CPIs are sourced from the OECD and CSA data.

Table 4.1: Descriptive statistics of time series variables

Variable Name	Variable [price series] description	Mean	Std. Dev.	Min	Max
Pss_Et	Ethiopia - sesame seed (ECX) export price	755.91	263.68	369.99	1,235.63
Pso_Ch	China - standard sesame oil ex-factory	4,168.30	330.28	3,099.22	4,550.88
Psyd_Ch	China- soybean domestic (Dalian) delivery	624.95	41.06	562.38	717.55
Psyi_Ch	China- soybean import (Qingdao) delivery	531.91	96.50	386.88	736.84
Psyd_US	US- soybean domestic No. 2 yellow	407.65	83.81	293.63	581.95
Psyo_US	US-soybean oil, crude FOB IL	755.08	194.74	477.45	1,103.34
Ex_Rate	Exchange rate, ETB/USD	19.89	2.51	16.47	27.22

All prices are in USD/ton, deflated by CPI=2010

I also use the aggregate ECX sesame seed export price (Pss_Et), rather than disaggregated price series by commodity quality. This is mainly because the price trends of the two major sesame types: Whitish Humera-Gondar (Pss_WHG) and Whitish Wollega (Pss_WWS) have similarity except for the marginal quality advantage the Whitish Humera-Gondar type has over the Whitish Wollega. As can be seen from Figure 4.1, the sesame types have almost the same trend and variations over the study period. It is worth reminding here that in such analyses, the series differences and variations are what matter most than the price level of the series. Thus, the aggregate average of the two commodity types – the ECX sesame seed export price is assumed the best representative of the Ethiopian export price and hence chosen for the analysis. Likewise, the other price series are chosen on the basis of which best fits the study's hypothesized reference markets among the available alternative data series.

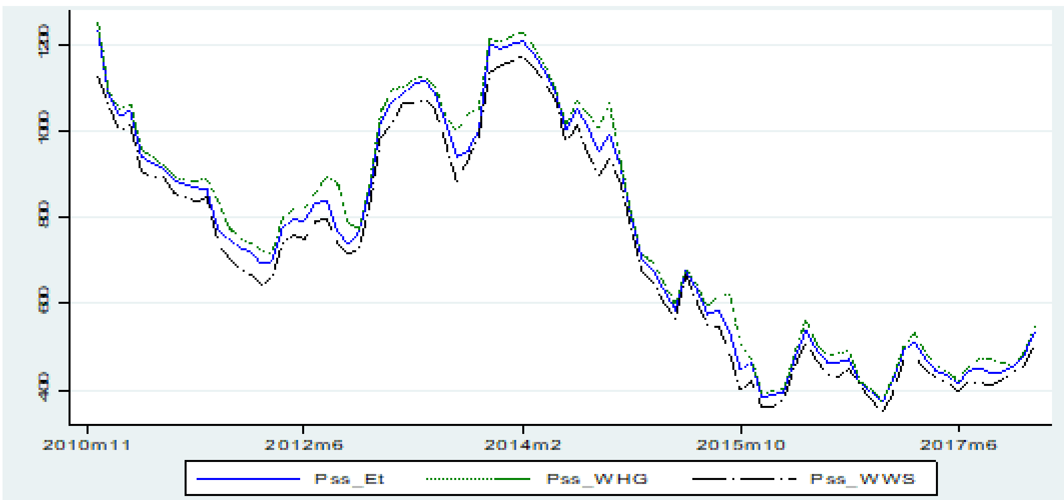


Figure 4.1: Ethiopia export sesame seed price trend by commodity type,
Monthly average in USD/ton

Regarding the serial relationship among the variables, the outcome variable - Ethiopian sesame seed export price is correlated with all other variables at 5% significance level (see Appendix 1). Overall, the Ethiopian sesame seed export price shows moderate and high correlations with the other variables in line with the study's assumption, except with the Chinese sesame oil domestic price. The two series show a statistically significant but a low correlation of 0.24 during the study period, unlike the expectations. On the other hand, the soybean and soy oil price series also show strong correlations among themselves.

From Figure 4.2, it can also be seen that the Chinese sesame oil price trend has a significant drop for a 5 month period in 2015. The possible explanation for the sharp price decrease is that China's sesame seed import price has plummeted for an extended period during late-2014 up to mid-2015, primarily due to a favorable weather condition driven, excess supply from Africa.

The import oversupply has also affected the Chinese sesame seed domestic price to drop up-to 40% within a year (Ji Xiang, 2015).[6]

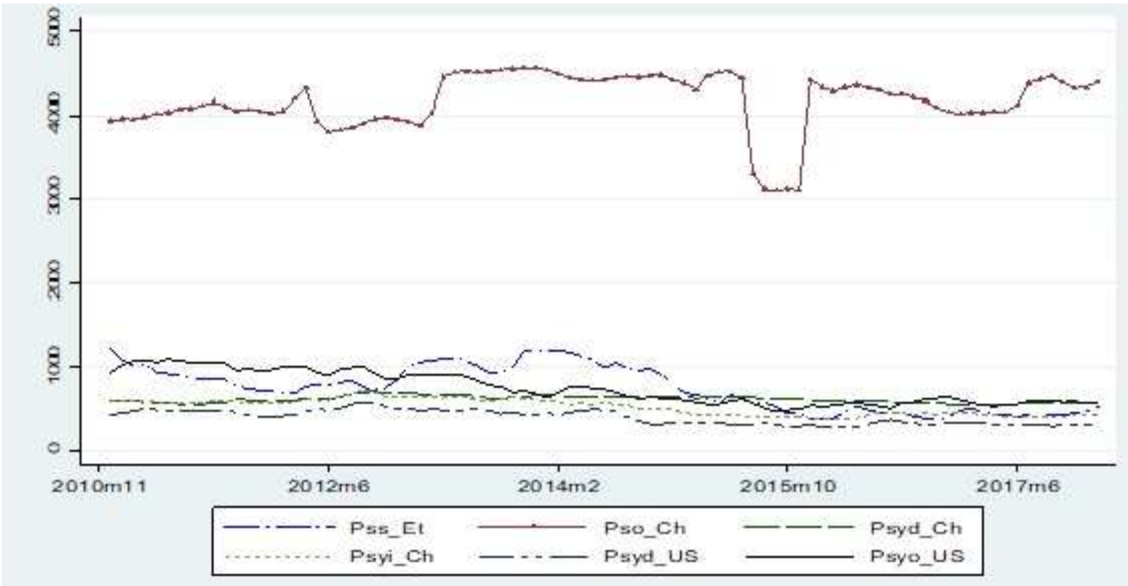


Figure 4.2: Price series trends, monthly average in USD/ton

The other relevant issue here is seasonal pattern. Both the graphical trend observation and the data inspection do not show the need to consider seasonal variability in the model analysis. For example, in Ethiopia sesame seed export case, during the major supply seasons of November to January, the price of sesame seed is expected to decrease, and increase in the slack seasons of July to October. The data trend doesn't support this hypothesis. Thus, the analysis assumes a constant seasonality across all series.

Finally, the data analysis methods and steps followed are modified from Rapsomanikis *et al.*, (2003) as outlined in Figure 4.3. The order of integration identification, i.e. the unit root test is the initial step. Then, secondly is the cointegration test procedure. If there is cointegration among the series, then follow the Granger causality test analysis and VECM estimations.

[6] *The Chinese domestic sesame oil price is a survey data by CNGOIC unlike all the other series which are real market prices. Hence, the sharp drop could also be partly related with market data collection process.*

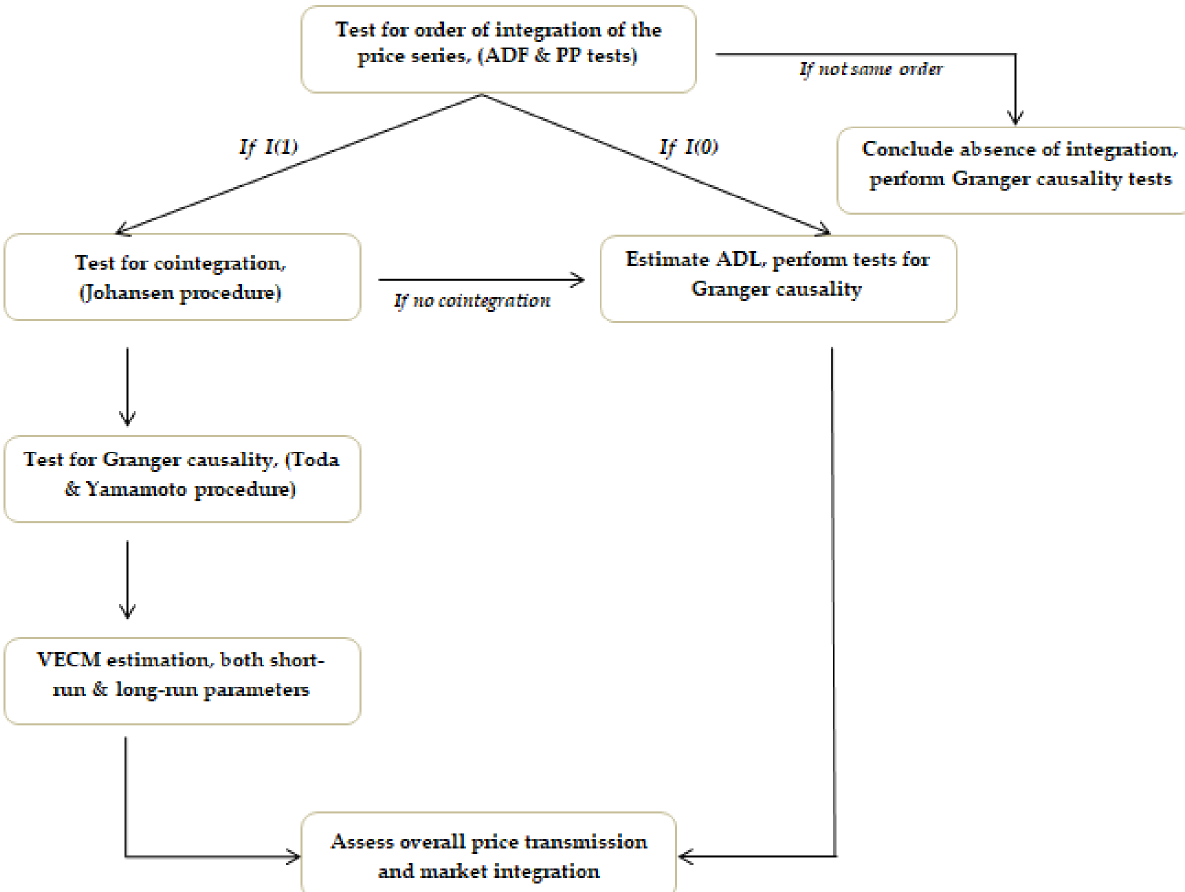


Figure 4.3: Market integration and price transmission analysis framework, Modified from Rapsomanikis *et al.*, (2003)

4.2 Model Specifications

First, a vector autoregressive model of order k - VAR (k), as a general matrix representation of the applicable model is defined as follows:

$$\mathbf{P_t = A_0 + A_1P_{t-1} + A_2P_{t-2} + \cdots + A_kP_{t-k} + V_t} \qquad (4.1)$$

Where $\mathbf{A_0}$ is constant, $\mathbf{P_t}$ is a (6x1) vector of the endogenous variables (price series). $\mathbf{A_1,\dots A_k}$ are matrices of coefficients to be estimated. $\mathbf{V_t}$ is a vector of iid disturbances with zero mean and constant finite variances.

This initial step comprises of the appropriate lag length selection process. Accordingly, the pertinent criteria of lag selection, which primarily include the Akaike information criterion (AIC), indicate that lag-two as the optimal length (see Appendix 2). Nevertheless, the VAR model of this potential lag length suffers from serial correlation. Hence, by trial and error tests on the VAR models, lag-three is selected as the optimum length of our model. Thus, a vector autoregressive model of order three, VAR(3) is set as the initial matrix representation to generate the VEC model and conduct the cointegration tests.

In the second step, the Johansen cointegration test approach is used to test for the number of cointegrating vectors among the variables. This approach provides a better test for multiple equation cases like this analysis, since it allows all possible number of cointegrating vectors and relationships to be determined empirically (Asteriou & Hall, 2011; Harris & Sollis, 2003).

According to the Johansen approach, the rank of the cointegrating matrix $\prod$ (see Equation 4.3a below) is tested using two likelihood ratio tests: the maximum eigenvalue (λ_max) and the trace test statistic (λ_trace). Both tests, as defined by Equations (4.2a) and (4.2b), are determined based on significance test on the characteristic roots or eigenvalues of the cointegrating matrix. The trace statistic has robustness and consistency advantages over the maximum eigenvalues statistic (Harris & Sollis, 2003). Hence, the study analysis primarily depends on this test. The critical values for both statistics are provided by Johansen and Juselius (1990).

$$\boldsymbol{\lambda\_trace = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right)} \qquad \mathbf{4.2a}$$

$$\boldsymbol{\lambda\_max = -T\, ln\left(1 - \hat{\lambda}_{r+1}\right)} \qquad \mathbf{4.2b}$$

Where r is the rank of the cointegrating matrix, which implies the cointegrated number of pair wise vector; λ_i is the i^{th} eigenvalue of the cointegrating matrix ordered from the largest to the smallest; and T is the number of observations.

The trace statistic follows step by step checkup on null hypotheses of utmost r cointegrating rank, in ascending order of the rank value. The process continues until the null is no longer rejected at acceptable significance level. On the other hand, the maximum eigenvalue statistic tests a null hypothesis of existence of r cointegrating vectors against the alternative r+1. In our model, a six (n) number of endogenous variables have a 6x6 cointegrating matrix ($\prod$). Hence, the maximum value r can be is 6, in which case the matrix becomes a full rank matrix with 6 linearly independent columns, which this in turn implies that the endogenous variables are already stationary series. On the other end, a zero cointegrating rank stands for an absence of linearly independent columns or no cointegrating relationships in the specific matrix. Thus, in the model, the long-run cointegrating relationship occurs if the cointegrating matrix has a reduced rank, i.e. $r < (n-1)$. Indirectly, this implies that there is $(n - r)$ common stochastic trends underlying the long-run relationship among the variables. The Johansen cointegration test result later indicates that our model has one cointegrating rank.

Thirdly, once the presence of cointegration between the price series is identified, their relationship is represented as a VECM by adjusting Equation (4.1) in first differences and error-correction components as specified by Equation (4.3a). The price series are now transformed into their logarithmic forms for ease of interpretation later on.

$$\Delta \mathbf{lnP_t} = \mathbf{\Gamma_1 \Delta lnP_{t-1}} + \mathbf{\Gamma_2 \Delta lnP_{t-2}} + \cdots + \mathbf{\Gamma_{k-1} \Delta lnP_{t-k-1}} + \prod \mathbf{lnP_{t-1}} + \mathbf{U_t} \qquad (\mathbf{4.3a})$$

Where $\mathbf{\Gamma_i} = (\mathrm{I} - \mathrm{A}_1 - \mathrm{A}_2 - \cdots - \mathrm{A}_i)$ $(\mathrm{i} = 1,2,\cdots,\mathrm{k}-1)$ and $\prod = -(\mathrm{I} - \mathrm{A}_1 - \mathrm{A}_2 - \cdots - \mathrm{A}_\mathrm{K})$. Specifically, $\mathbf{\Gamma_i}$ is a (6x6) matrix of parameters for k (i.e. three) order of lags, and measures the short-run effects as represented by $\boldsymbol{\delta}$s in Equation (4.3c). $\prod$, the cointegrating matrix, contains information regarding the long-run relationships. It can be further decomposed to $\prod = \alpha\beta'$ where α is the error-correction coefficient that represents speed of adjustment to the long-run equilibrium and β is the cointegrating vector of coefficients that represent the long-run structural relations, i.e. the long-run price elasticity between the series in the model. Both α and β are (6x1) dimensioned matrices. Thus, the rearranged form of the VECM is:

$$\Delta \mathbf{lnP_t} = \sum_{\mathbf{i=1}}^{\mathbf{k-1}} \mathbf{\Gamma_i \Delta lnP_{t-i}} + \boldsymbol{\alpha\beta'}\mathbf{lnP_{t-1}} + \mathbf{U_t} \qquad (\mathbf{4.3b})$$

This study focuses on the VECM's component, on which the Ethiopian sesame seed export price (Pss_Et) is the outcome variable. In this regards, from Equation (4.3b), the relevant equation for the particular target variable is specified as below:

$$\begin{aligned} \Delta \boldsymbol{ln}(\boldsymbol{P_{ss}Et})_t = \boldsymbol{\delta_{10}} &+ \sum_{i=1}^{k-1} \boldsymbol{\delta_{11i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{ss}Et})_{t-i} + \sum_{i=1}^{k-1} \boldsymbol{\delta_{12i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{so}Ch})_{t-i} + \sum_{i=1}^{k-1} \boldsymbol{\delta_{13i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{syd}Ch})_{t-i} \\ &+ \sum_{i=1}^{k-1} \boldsymbol{\delta_{14i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{syi}Ch})_{t-i} + \sum_{i=1}^{k-1} \boldsymbol{\delta_{15i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{syd}US})_{t-i} + \sum_{i=1}^{k-1} \boldsymbol{\delta_{16i}} \Delta \boldsymbol{ln}(\boldsymbol{P_{syo}US})_{t-i} \\ &+ \boldsymbol{\alpha_{1i}} \sum_{i=1}^{r} (\boldsymbol{ECT_i}) + \boldsymbol{U_{1t}} \qquad (\mathbf{4.3}\boldsymbol{c}) \end{aligned}$$

Where $\boldsymbol{ECT_i}$ is the error-correction term determined based on the cointegration test result (number of ranks). Given that **μ** is the constant term and **t** is a trend term, it is defined as:

$$\mathrm{ECT_i} = \beta_{i1}\ln(P_{ss}Et)_{t-1} - \beta_{i2}\ln(P_{so}Ch)_{t-1} - \beta_{i3}\ln(P_{syd}Ch)_{t-1} - \beta_{i4}\ln(P_{syi}Ch)_{t-1} - \beta_{i5}\ln(P_{syd}US)_{t-1} - \beta_{i6}\ln(P_{syo}US)_{t-1} - \gamma t_i - \mu_i$$

(4.3d)

Fourthly, the analysis performs a Granger causality test to examine the direction of price transmission between the cointegrated variables. The analysis follows the Toda and Yamamoto

(1995) procedure of testing for Granger causality, by setting a VAR (4)[7] model of the log-transformed price series. Accordingly the test statistics are assumed to be asymptotically chi-squared distributed under the null hypothesis of Granger non-causality. Thus, the Wald-tests and F-statistics are used for individual and joint causalities, respectively. This procedure has an advantage as it employs a level (non-first-differenced) data and captures relatively full information on the series. The VECM parameters, which also alternatively represent the short-run and long-run Granger causalities, are then used to cross-assess the causality results among the model variables.

The important point here is that, however, by 'causality' it is only to mean about lead-lag relationships between the variables. In other words, Granger causality test has little to say about tangible causal elements leading to dynamic adjustments. It only indicates whether a relationship among contemporaneous and lagged prices is statistically different from zero (Asteriou & Hall, 2011; Stock & Watson, 2011).

4.3 Unit Root Test

The unit root tests result indicates that all level variables are non-stationary series with first order of integration. Accordingly, the determination of cointegrating relationships between the price series, in the next step, does not suffer from a mixed order of integration.

The study employed both the Augmented-Dickey–Fuller (ADF) and the Phillips–Perron (PP) testing procedures. Equation (4.4) represents a unit roots test equation for the outcome variable where α and T represent constant and trend terms, respectively. The same standard equation is used for all remaining variables. The test is conducted with two alternatives for each procedure. One is by considering only the constant coefficient (and excluding the trend term) in the equation; and the other is by including both terms in the equation. The lag length for each test equation is primarily determined by the Akaike information criterion (AIC) and the Schwartz information criterion (SIC).

$$\Delta ln(P_{ss}Et)_t = \alpha + \gamma T + \delta ln(P_{ss}Et)_{t-1} + \sum_{i=1}^{k} \beta_i \Delta ln(P_{ss}Et)_{t-i} + U_t \qquad 4.4$$

The null hypothesis of the tests follows that the autoregressive lag term has a unit root, i.e. the series is non-stationary (H_0: $\delta = 0$) against the alternative the series is stationary (H_1: $\delta < 0$). The outcome of the test is summarized in Table 4.2. As can be seen from the table, the test result at level reveals that all variables are non-stationary series of order one with some exceptions of the Chinese sesame oil domestic price. The corresponding test for first-differenced scenario also

[7] *VAR (3+1) - three optimal lag number plus one order of integration from the unit root test.*

rightly suggests rejecting the null and accepting the stationarity alternative. One possible explanation for the Chinese sesame oil case is, however, the outlier break on the series trend. The Clemente Montanes Reyes (CMR) test for unit root detects this fact (see Appendix 3). Moreover, the PP-test for both constant and trend terms option still accepts the unit root null of the particular series, in conformity with our VEC model.

Table 4.2: Unit root test results

Price series		***Test on level variables***				***Test on first-differenced variables***			
		ADF test statistics		***PP test statistics***		***ADF test statistics***		***PP test statistics***	
Name	*lag*	*Constant*	*C-Trend*	*Constant*	*C-Trend*	*Constant*	*C-Trend*	*Constant*	*C-Trend*
ln(Pss_Et)	2	-1.34	-1.73	-1.51	-1.66	-5.70*	-5.68*	-6.94*	-6.91*
ln(Pso_Ch)	7	-3.81*	-3.80*	-3.24*	-3.24	-4.79*	-4.76*	-8.24*	-8.18*
ln(Psyd_Ch)	2	-1.56	-1.89	-1.34	-1.62	-5.47*	-5.51*	-5.92*	-5.92*
ln(Psyi_Ch)	2	-0.87	-1.77	-0.80	-1.77	-6.10*	-6.06*	-7.00*	-6.97*
ln(Psyd_US)	3	-1.07	-2.24	-1.08	-2.75	-5.87*	-5.82*	-5.97*	-5.93*
ln(Psyo_US)	4	-1.25	-1.42	-0.93	-2.27	-5.35*	-5.47*	-7.44*	-7.47*

Notes: the critical values are -2.89 and -3.45 at 5% significance for a constant equation and a constant-trend equation, respectively. (*) indicates rejection of the null hypothesis at 5% level.

5. ECONOMETRIC RESULTS AND DISCUSSION

This chapter first provides the cointegration test result summary. Empirical econometric results of the Granger causality test and the VECM estimation are discussed next. The final section discusses on model diagnostic tests result and some potential limitations of the model. Impulse response analysis is also included to reflect on the long-run interaction between markets under the study.

5.1 Cointegration Test

Both the trace and the maximum eigenvalue tests of the Johansen cointegrating procedure, as summarized in Table 5.1 show similar results, which the null hypothesis of a cointegrating matrix of rank one cannot be rejected at 5% significance level. The result implies that the price series in our model move together in the long run in conformity with the concept of market integration. However, this result by its own doesn't provide sufficient information regarding the cause and effect relationship among the variables, except that it assures at least a unidirectional causality. Therefore, the Granger causality test result (in the next section) is aimed at identifying the direction of price transmissions among these cointegrated price series. Moreover, the cointegration test result indicates that our model is fit for the VECM estimation, of which one cointegrating relationship among the price series is assumed.

Table 5.1: Johansen cointegration test result

H_0	H_1	Eigenvalue	Test value	5% critical value
λ_trace test			**λ_trace value**	
r = 0	r > 0	-	115.93	114.90
r $\leq$ 1	r > 1	0.419	**70.32***	**87.31**
r $\leq$ 2	r > 2	0.274	43.37	62.99
r $\leq$ 3	r > 3	0.202	24.42	42.44
r $\leq$ 4	r > 4	0.143	11.42	25.32
r $\leq$ 5	r >5	0.082	4.22	12.25
λ_max test			**λ_max value**	
r = 0	r = 1	-	45.61	43.97
r = 1	r = 2	0.419	**26.95**	**37.52**
r = 2	r = 3	0.274	18.95	31.46
r = 3	r = 4	0.202	13.00	25.54
r = 4	r = 5	0.143	7.20	18.96
r = 5	r = 6	0.082	4.22	12.52

5.2 Granger Causality Test

The Granger causality test result in Table 5.2 complements the above cointegration result. Overall, it is in line with some of major presumptions of the study. Particularly, it indicates that there is a strong evidence of two-way Granger causality between the Ethiopian sesame seed export price and the Chinese sesame oil domestic price. Besides, the result shows the direction of join causality running to each variable in the model, except to the US soy oil price.

Table 5.2: Granger Causality Wald test result

Equation	Excluded	chi2	df	Prob > chi2
Ethiopian sesame seed export price (ln_Pss_Et)	ln_Pso_Ch	20.432	4	0.000
	ln_Psyd_Ch	9.390	4	0.052
	ln_Psyi_Ch	1.496	4	0.827
	ln_Psyd_US	0.733	4	0.947
	ln_Psyo_US	3.849	4	0.427
	ALL	51.958	20	0.000
Chinese sesame oil domestic price (ln_Pso_Ch)	ln_Pss_Et	23.403	4	0.000
	ln_Psyd_Ch	8.592	4	0.072
	ln_Psyi_Ch	7.517	4	0.111
	ln_Psyd_US	2.172	4	0.704
	ln_Psyo_US	17.832	4	0.001
	ALL	49.723	20	0.000
Chinese soybean domestic price (ln_Psyd_Ch)	ln_Pss_Et	5.378	4	0.251
	ln_Pso_Ch	0.610	4	0.962
	ln_Psyi_Ch	11.313	4	0.023
	ln_Psyd_US	7.593	4	0.108
	ln_Psyo_US	3.604	4	0.462
	ALL	36.722	20	0.013
Chinese soybean import price (ln_Psyi_Ch)	ln_Pss_Et	14.548	4	0.006
	ln_Pso_Ch	4.635	4	0.327
	ln_Psyd_Ch	4.217	4	0.377
	ln_Psyd_US	6.072	4	0.194
	ln_Psyo_US	8.017	4	0.091
	ALL	33.215	20	0.032
US soybean domestic price (ln_Psyd_US)	ln_Pss_Et	7.911	4	0.095
	ln_Pso_Ch	9.587	4	0.048
	ln_Psyd_Ch	0.912	4	0.923
	ln_Psyi_Ch	35.387	4	0.000
	ln_Psyo_US	36.551	4	0.000
	ALL	135.430	20	0.000
US soy oil (FOB) price (ln_Psyo_US)	ln_Pss_Et	2.797	4	0.592
	ln_Pso_Ch	1.693	4	0.792
	ln_Psyd_Ch	3.810	4	0.432
	ln_Psyi_Ch	3.702	4	0.448
	ln_Psyd_US	2.229	4	0.694
	ALL	14.860	20	0.784

The result also indicates that the Chinese soybean domestic price has a causal effect on our target variable - the Ethiopian sesame seed export price at a margin of statistical significance. The causality interpretation is that the Ethiopian sesame seed export price is better predicted using the histories of its own price and of the Chinese sesame oil and the Chinese soybean domestic prices.

The above Chinese domestic prices in their side have causality linkages with other prices in the model, which in turn imply the indirect causation of other prices on the Ethiopian sesame seed export price. In this regard, the causality result shows the linkages between the Ethiopian sesame seed export price and the US soy oil price through the causation running from the later to the Chinese sesame oil price. Similarly, the Ethiopian sesame seed export price has linkages with the Chinese soybean import price and (at near-marginal significance) with the US soybean domestic prices through the causation running from the later ones to the Chinese soybean domestic price.

However, the result also shows that the Ethiopian sesame seed export price Granger causing the Chinese soybean import price and (at a certain trend towards significance level) the US soy bean domestic price. This is in contrast to the study's hypothesis, which assumes only one way causation (price transmission) to Ethiopia sesame seed export price from these dominant global soybean markets. The possible explanation for the result is the gap on the model in capturing all other exogenous factors that influence the international market dynamics.

5.3 Vector Error Correction Model

The VECM result overall indicates that the model fits well, and the estimates have correct signs of the long-run equilibrium and adjustment speeds. The results of the model are reported in Table 5.3 and 5.4, for the long-rung and short-run parameters, respectively.

To begin with the cointegrating equation result (Table 5.3)[8], the long-run equilibrium estimates reveal that three price series - Chinese sesame oil price, Chinese soybean import price and US soybean domestic price are statistically significant implying that each of the prices has a long-run equilibrium relationship with the Ethiopian sesame seed export price. In other words, this result indicates the presence of market integration between the Ethiopian sesame seed export market and the identified reference markets of the model as per the hypothesis of the study, except for the Chinese soybean domestic market and the US soybean oil market.

With regard to the long-run equilibrium (cointegarting) coefficients' signs, the Chinese soybean import price is positive implying it is above the long-run equilibrium, while the other two series

[8] *In the cointegrating (CI) equation, the outcome variable's coefficient is normalized to one and the signs of the others coefficients are reversed. The error-correction term (ECT) part of our model as specified by Equation 4.3d (pp. 28) represents this CI result.*

are negative and hence below the equilibrium. The cointegrating coefficients also represent the long-run price elasticity between the variables. Thus, it can be interpreted as, a 1% increase in the Chinese sesame oil and the US soybean domestic prices induces a 2.5% and a 3.8% increase in the Ethiopian sesame seed export price in the long run, respectively. These cross-price elasticity signs match with the complementarity and substitutability assumptions of the study on the respective prices.

However, in the Chinese soybean import price case the result is counterintuitive as its coefficient is negative despite the substitutability assumption of the analysis. There are some possible explanations for this result. First is demand side; sesame oil is highly valued product and is not as commonly consumed as soybean oil in China. This might challenge the very substitutability assumption between the Chinese soybean import price and the Ethiopian sesame seed price. There are also supply-side factors of weather, policy and regulations, global oil price and transportation cost, and *et cetera* surrounding the Chinese soybean import. The model may need to capture these intricate factors to indicate the true long-run relationship of the particular import price has with the target variable.

Table 5.3: VECM long-run parameters

Variables	CI-Equation
$\ln(Pss\_Et)_{t-1}$	1
$\ln(Pso\_Ch)_{t-1}$	-2.467***
	(0.882)
$\ln(Psyd\_Ch)_{t-1}$	-1.181
	(0.934)
$\ln(Psyi\_Ch)_{t-1}$	3.415***
	(0.775)
$\ln(Psyd\_US)_{t-1}$	-3.794***
	(0.571)
$\ln(Psyo\_US)_{t-1}$	-0.014
	(0.004)
Trend	0.006
	(0.459)
Constant	22.860

The long-run cointegrating coefficients also agree with the signs of their corresponding equilibrium adjustment parameters, the error-correction coefficients (i.e. α) as reported in Table 5.4. The error-correction signs are basically expected to have opposite sign to the long-run coefficients, as the former are assumed to balance the market disequilibrium that is implied by the latter signs. Moreover, except for the Chinese soybean domestic price and the US soy oil price, the remaining variables have statistically significant error-correction coefficients.

Table 5.4: VECM short-run parameters

Variables	Δln(Pss_Et)	Δln(Pso_Ch)	Δln(Psyd_Ch)	Δln(Psyi_Ch)	Δln(Psyd_US)	Δln(Psyo_US)
ECT₁(α)	-0.118***	0.0644***	-0.00612	-0.0394***	0.0482***	-0.00206
	(0.0356)	(0.0249)	(0.00705)	(0.0147)	(0.0152)	(0.0230)
Δln(Pss_Et)$_{t-1}$	0.293**	0.158*	0.0350	0.0221	-0.0168	0.0304
	(0.116)	(0.0810)	(0.0229)	(0.0476)	(0.0492)	(0.0748)
Δln(Pss_Et)$_{t-2}$	-0.0264	-0.305***	0.00859	0.0916*	0.0831*	-0.109
	(0.116)	(0.0810)	(0.0229)	(0.0476)	(0.0492)	(0.0748)
Δln(Pso_Ch)$_{t-1}$	-0.0464	0.330***	-0.00868	-0.0901	-0.152**	0.0380
	(0.175)	(0.123)	(0.0347)	(0.0721)	(0.0745)	(0.113)
Δln(Pso_Ch)$_{t-2}$	0.0221	-0.00548	-0.0295	-0.0856	0.187**	0.0868
	(0.174)	(0.122)	(0.0344)	(0.0716)	(0.0740)	(0.112)
Δln(Psyd_Ch)$_{t-1}$	0.266	0.266	0.353***	-0.139	-0.305	0.433
	(0.626)	(0.439)	(0.124)	(0.258)	(0.267)	(0.405)
Δln(Psyd_Ch)$_{t-2}$	-0.721	0.154	-0.113	-0.0703	0.118	-0.333
	(0.578)	(0.405)	(0.115)	(0.238)	(0.246)	(0.374)
Δln(Psyi_Ch)$_{t-1}$	0.349	0.000469	0.126**	0.312**	0.512***	-0.281
	(0.303)	(0.212)	(0.0600)	(0.125)	(0.129)	(0.196)
Δln(Psyi_Ch)$_{t-2}$	-0.0870	-0.161	0.0535	-0.154	-0.228	-0.00546
	(0.331)	(0.232)	(0.0657)	(0.137)	(0.141)	(0.215)
Δln(Psyd_US)$_{t-1}$	-0.0325	0.196	-0.0722	0.0238	0.474***	0.145
	(0.255)	(0.178)	(0.0504)	(0.105)	(0.108)	(0.165)
Δln(Psyd_US)$_{t-2}$	-0.448**	-0.00673	-0.00293	-0.115	-0.0382	-0.161
	(0.223)	(0.156)	(0.0442)	(0.0919)	(0.0949)	(0.144)
Δln(Psyo_US)$_{t-1}$	-0.0737	-0.229	0.0252	0.00557	0.398***	0.208
	(0.203)	(0.142)	(0.0402)	(0.0836)	(0.0864)	(0.131)
Δln(Psyo_US)$_{t-2}$	-0.213	0.133	-0.0473	0.0379	-0.00619	-0.141
	(0.224)	(0.157)	(0.0444)	(0.0924)	(0.0955)	(0.145)
Constant	-0.00259	-0.00465	0.00104	-0.000573	-0.000862	-0.00898
	(0.00845)	(0.00592)	(0.00167)	(0.00348)	(0.00360)	(0.00547)
R-squared	0.260	0.267	0.330	0.256	0.634	0.165
P-value	0.042	0.033	0.002	0.050	0.000	0.479

Note: standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

From Table 5.4, we also see that the Ethiopian sesame seed export price error-correction coefficient is -0.118, implying that about 12% of market disequilibrium in this particular export market is eliminated within a month. In other words, this can be interpreted that it takes less than nine months for the Ethiopian sesame seed export market to restore to the long-run equilibrium after a market shock. Here, it is calculated for assumed full restoration (i.e. 100%) having the monthly result of our model. The adjustment speed result also shows that the Ethiopian price responds fast to disequilibrium than the other prices in the model.

Regarding the short-run adjustment dynamics of the model, the results in Table 5.4 indicate that the Ethiopian sesame seed export price doesn't respond to market changes except to its own price lagged one period and the US soybean price lagged two periods. With regard to its own-price, the result shows a one month earlier, 10% change in the Ethiopian price induces a 3% increase of its own price in the next month. This is in fact in contrast to mean reverting price situation, in which a shock in one period is not persistent as price usually converges back to its equilibrium level. Whereas the latter case with the US soybean domestic price indicates a negative short-run adjustment relationship in contrast to the study's assumption that the two commodities are substitutes in the model. As it is seen earlier on Table 5.3, the long-run relationship between the two prices is positive.

The other findings are that the short-run adjustment effects of the Ethiopia sesame seed export price on the other variables. From Table 5.4, it can also be seen that a 10% increase in the Ethiopian sesame seed export price induces a 1.6% increase and a 3% decrease of the Chinese domestic sesame oil prices for lagged one period and lagged two periods, respectively. The first period implies the immediate possible market response, while the second is in line with the complementarity assumption on the two prices.

Furthermore, the short-run adjustment dynamics of the model also indicates the Chinese soybean import price and the US domestic soybean price responding to the Ethiopian sesame seed export price in lagged two periods, even though the price transmissions rate are so insignificant. These results are purely in contrast to the study's hypotheses, which assume the Ethiopian sesame seed export market price as a follower to these globally influential soybean markets. The results have no justification under the assumed model, and they seem need further investigation. The same possible explanation for similar cases of the long-run dynamics result works here, as well.

Generally, our VEC model gives strong evidence on the long-run relationship of the identified price variables. Whereas the short-run dynamics are relatively less helpful and need further examination as most of the estimates are statistically insignificant, and some lack theoretical base. However, as the definition goes, the market integration concept is essentially a long-run co-movement of price series, irrespective of the short-run dynamics. In this sense the model seems has addressed the major research question of detecting market integration between the identified price series. With regard to the short-run dynamics, however, issues such as incorporating information from the futures trading, reconsidering seasonality patterns, re-examining the sesame seed's demand structure and nature of relationship with other commodities, and *et cetera* seem good approaches of better augmenting the model.

Bearing in mind the above possibilities of further augmenting the model, the insignificant estimates of the model also hint the existence of other underlying factors that possibly hamper the market integration process. In the Ethiopian sesame seed market context, the potential major factors include: information asymmetries, transportation and transaction costs, infrastructural bottlenecks, market power (by wholesale buyers and exporters), and policy regulations (UNCTAD, 2018; Wijnands et al., 2009).

5.4 Further Topics on the Model

5.4.1 Impulse response analysis

After conducting the necessary model diagnostics tests, and checked that the model is well specified (as discussed in the next sub-section 5.4.2), the orthogonalized Impulse Response Functions (IRFs) of the model are estimated to demonstrate the long-run effects of the reference markets on the Ethiopian sesame seed export. The estimation of the IRFs are in particular aimed at identifying the magnitude of response and the time path it takes for the target Ethiopian price given a unit standard deviation shock for the significant variables in the VECM.

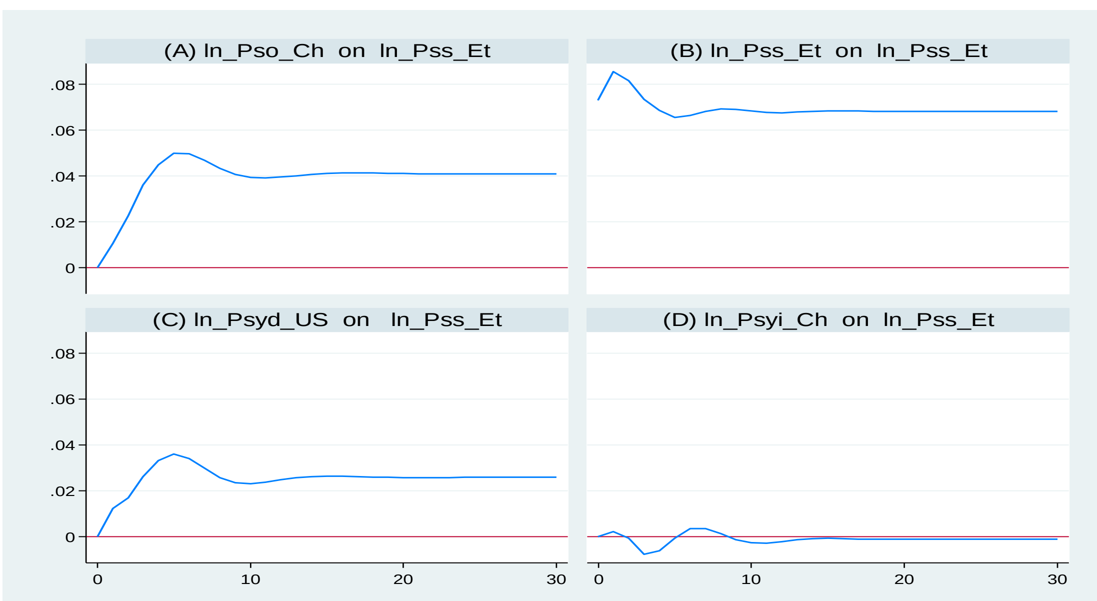


Figure 5.1: IRFs of selected series, months

As it is evident from Figure 5.1, the Ethiopia sesame seed export price (*i.e. graph B*) has a positive and permanent effect for a unit of shock in its own price. Similarly, the Chinese domestic sesame oil price and the US soybean domestic price have a positive permanent effect on the average prices of the Ethiopian sesame seed export price, while the Chinese soybean import leads to mixed positive and negative effects in the short run, which later dies out in the long run around a year after. The IRF graphs also show that the Ethiopian price responds higher to its own unit shock impulse compared to the other prices. From the graphs, we can also see that the overall impulse responses are in line with the model's earlier result on the error-correction adjustment speed of the Ethiopian price, which takes a less than nine-month period to restore to the long-run equilibrium after a market shock.

The full matrix of the IRFs graphs of the VECM is annexed on Appendix 4. There, we can also see the Chinese sesame oil market response to the Ethiopia sesame seed export impulse shock, supporting both the short-run and the long-run dynamics of the model estimates. The Chinese price first responds positively and immediately starts to shift back and show a negative response, where it remains there permanently.

Additionally, the dynamic forecast of the price series is computed to the above long-run cointegrated variables, to project their rate of price change in the long future. The graph depiction is reported on Appendix 5. Accordingly, in the coming two and more years the Ethiopia's sesame seed export price shows marginally a decreasing rate, while the Chinese sesame seed oil domestic price remains constant on average. The model overall shows a stable price trend in the long run.

5.4.2 Model robustness and limitations

The model diagnostic tests indicate that our VECM is well specified and that its results are reliable. In this regard, the first test is the stability condition, to check whether the numbers of cointegrating equations are correctly specified in the model. As illustrated in Figure 5.2, the roots of the cointegrating matrix of the model are strictly less than one, implying that the model process is stable. The LM test result for serial correlation, as summarised in Table 5.5, also shows we do not reject the null that there is no serial autocorrelation in the disturbances. On the other hand, the Jarque-Bera test rejects the joint null of normality of the distribution of disturbances. However, in the separate tests the Ethiopia sesame seed export price equation shows a normality of distribution in all aspects. This particular test result is annexed on Appendix 6.

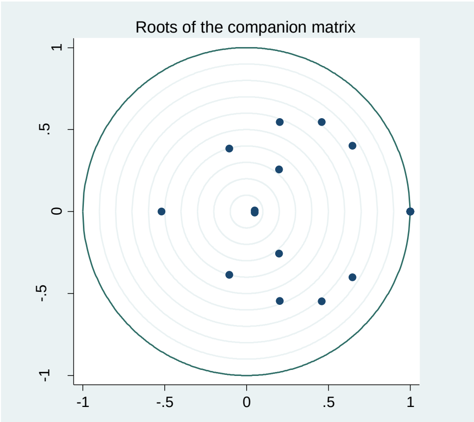


Figure 5.2: Stability of the VECM

Table 5.5: LM test for autocorrelation

Lags	Chi2	Prob > chi2
1	39.765	0.306
2	33.451	0.590
3	47.444	0.096

H_0: No autocorrelation

Nevertheless, there are still some potential limitations of the model. These limitations are mainly related with data problems. Firstly, the observation size of the study is small and thus the efficiency of the model parameters might be compromised. Secondly, the model's weakness is related to the Chinese sesame oil price data in particular. This survey data by CNIOA is not that ideal data for study, unlike the other series of real market prices. Needless to mention it adequately satisfies the analysis requirements. Thus, there might be other possibility in which the model can be further improved using better market data set of the sesame seed import prices or domestic market prices of the raw commodity in China and other countries.

Others limitations have to do with scope and model selection preferences of the analysis, which could be considered as possible topics of further analysis. These areas include price symmetry analysis on model disequilibrium, and variance decomposition analysis on price transmissions. But above all, this study can be further improved better by employing variants of dynamic models like Parity Bound and Threshold VEC models, in which cases good-sized observations are required and other relevant data on markets like transportation and transfer costs, trade regimes (arbitrage conditions) and geographical factors need to be incorporated.

6. CONCLUSION

The aim of this study is to investigate the nature of market integration between the Ethiopian sesame seed export and some selected international reference markets in China and the US. The selection of the markets is based on both the direct trade connection they have with the Ethiopian sesame seed export and their assumed dominance in the international oilseed market network. The empirical analysis is conducted using the cointegration technique and VECM.

The study findings reveal the existence of a long-run equilibrium relationship, hence market integration between the Ethiopian sesame seed export price and some of the identified international markets - namely, the Chinese oil seed domestic price, the Chinese soybean import price and the US soybean domestic price. The result indicates that a 1% increase in the Chinese sesame oil and the US soybean domestic prices induces a 2.5% and a 3.8% increase in the Ethiopian sesame seed export price, respectively. These long-run price adjustment relations match with the complementarity and substitutability assumptions of the study on the respective prices. Whereas, in the Chinese soybean import price case the result is counterintuitive as its coefficient is negative despite the substitutability assumption of the analysis.

Furthermore, the Ethiopian sesame seed export price has an adjustment speed of 12% to the long-run equilibrium. This result further implies that it takes less than nine months for the particular price to restore to the long-run equilibrium after a market shock. The impulse response analysis on the long-run relationship further reveals that the Chinese sesame oil price and the US soybean domestic price have permanent effects on the Ethiopian sesame seed export price, while the Chinese soybean import price has a transitory effect.

With regard to the short-run adjustment dynamics, however, the Ethiopian sesame seed export doesn't respond to market changes except to its own price and to the US soybean domestic price. On the other side, the Chinese sesame oil price is also influenced by the Ethiopian sesame seed price in the short-run. Especially, regarding the two prices – the Ethiopian sesame seed export price and the Chinese sesame oil domestic price, there is a strong evidence of a two-way price transmission.

In general, the global market integration process with in the context of the Ethiopian sesame seed export has two facets to the country. The first case is, in the absence of the integration the country cannot fully tap its comparative advantage of sesame in the international trade. The second case is, in the presence of the integration, the country also faces a side risk of susceptibility to the global commodity price shocks and volatility. Therefore, the relevant policy intervention on the specific commodity sector requires balancing this conundrum. To this end, the country must leverage on diversified export market strategies for the raw sesame commodity and at the same time engage on the export of value-added and processed sesame products to higher-end markets. Equally important are infrastructural developments and promotion of market institutions, among other policy priorities.

Appendices

Appendix 1: Correlation matrix

	Pss_Et	Pso_Ch	Psyd_Ch	Psyi_Ch	Psyd_US	Psyo_US
Pss_Et	1.0000					
Pso_Ch	0.2368*	1.0000				
	0.0272					
Psyd_Ch	0.5636*	0.0888	1.0000			
	0.0000	0.4136				
Psyi_Ch	0.7963*	0.0384	0.5387*	1.0000		
	0.0000	0.7240	0.0000			
Psyd_US	0.7505*	0.0044	0.4836*	0.9550*	1.0000	
	0.0000	0.9678	0.0000	0.0000		
Psyo_US	0.5963*	-0.0826	0.1286	0.8277*	0.8351*	1.0000
	0.0000	0.4472	0.2351	0.0000	0.0000	

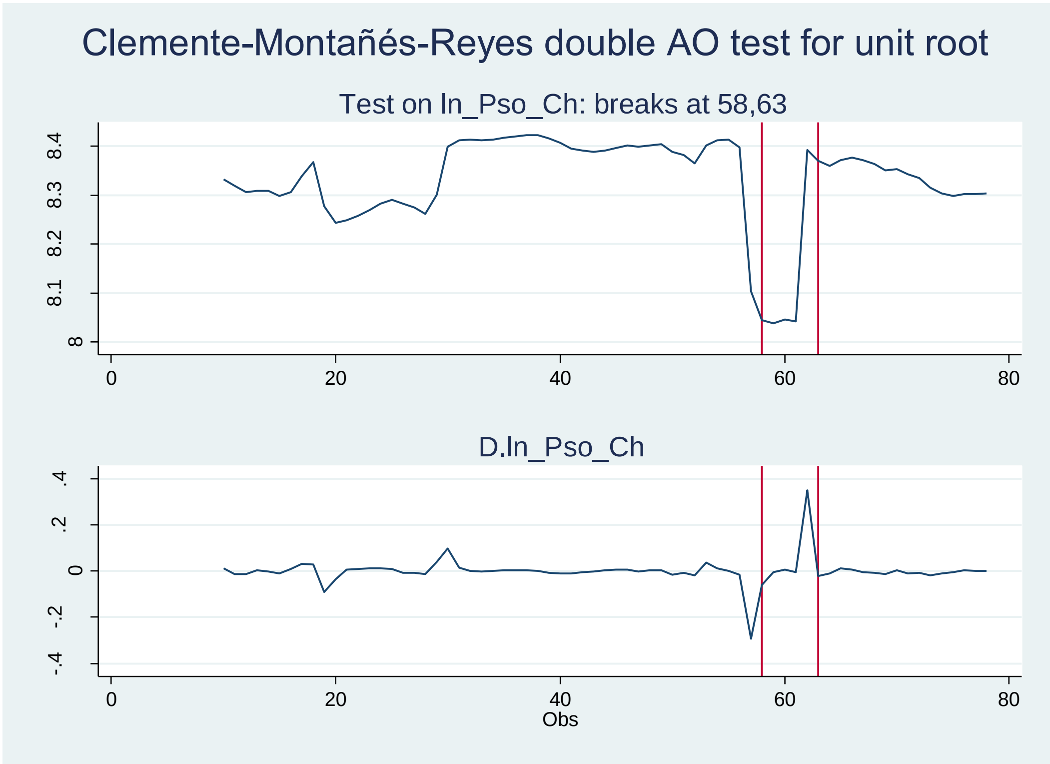
Appendix 2: **Lag selection criteria**

Selection-order criteria
Sample: 7 - 87 Number of obs = 81

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	445.501				7.8e-13	-10.8519	-10.7807	-10.6745
1	919.104	947.21	36	0.000	1.6e-17	-21.6569	-21.1588	-20.4153*
2	982.356	126.5	36	0.000	8.2e-18*	-22.3298*	-21.4047*	-20.024
3	1015.73	66.756	36	0.001	9.1e-18	-22.265	-20.9129	-18.8951
4	1043.05	54.625	36	0.024	1.2e-17	-22.0505	-20.2715	-17.6163
5	1084.42	82.753*	36	0.000	1.2e-17	-22.1833	-19.9773	-16.6849
6	1108.5	48.16	36	0.085	1.9e-17	-21.8889	-19.256	-15.3264

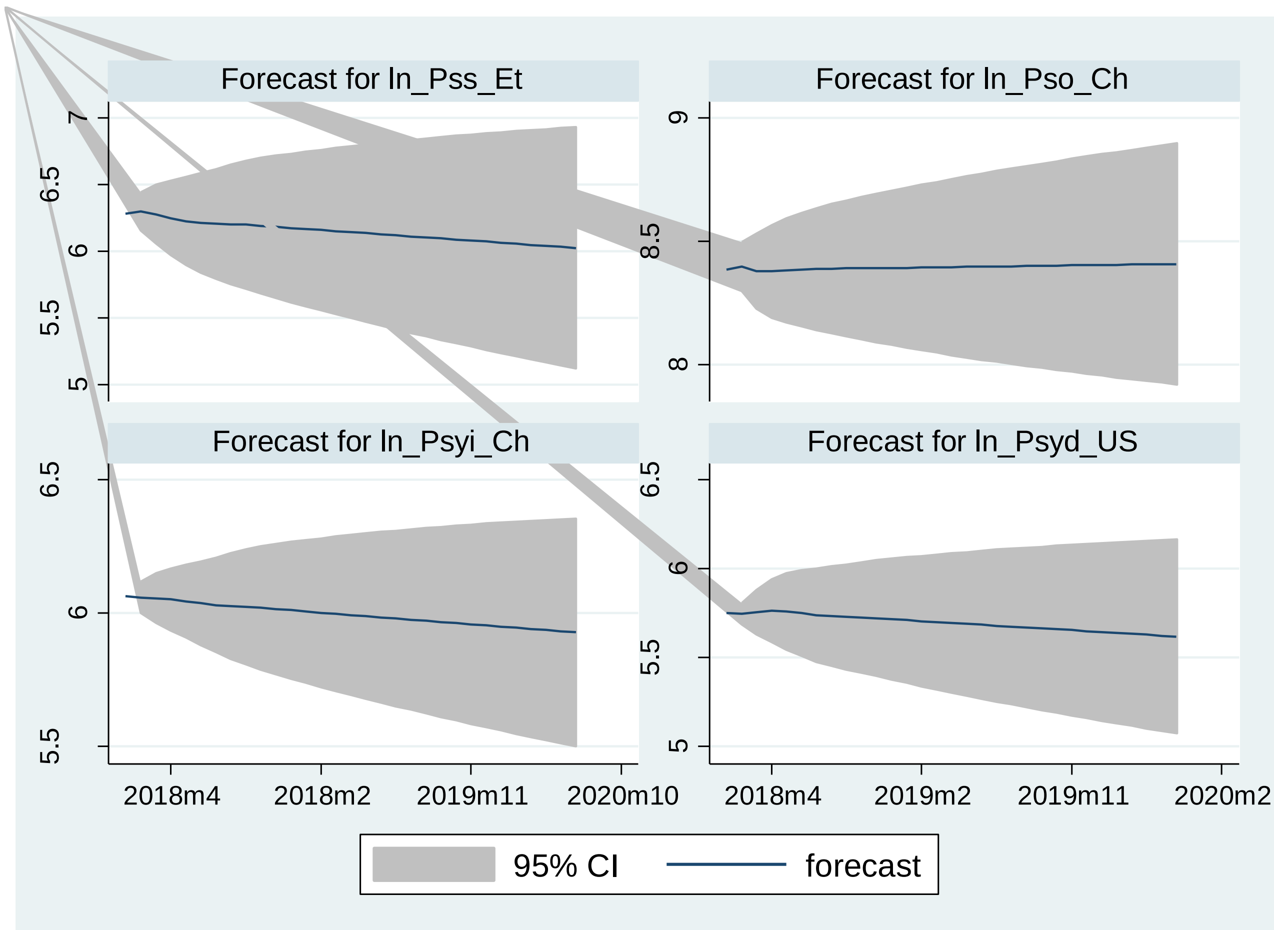
Note: *the Akaike information criterion (AIC) and the Schwartz information criterion (SBIC) are used as the major lag selection criteria for the model.*

Appendix 3: CMR unit root test with breaks



Appendix 4: Model's IRFs graphs

Appendix 5: Dynamic forecast of the price series



Appendix 6: Test for Normality distributed disturbances

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_ln_Pss_Et	1.414	2	0.49305
D_ln_Pso_Ch	515.672	2	0.00000
D_ln_Psyd_Ch	19.748	2	0.00005
D_ln_Psyi_Ch	0.349	2	0.83971
D_ln_Psyd_US	4.816	2	0.08999
D_ln_Psyo_US	21.683	2	0.00002
ALL	563.683	12	0.00000

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
D_ln_Pss_Et	.16955	0.402	1	0.52583
D_ln_Pso_Ch	.26422	0.977	1	0.32285
D_ln_Psyd_Ch	.74024	7.671	1	0.00561
D_ln_Psyi_Ch	-.15772	0.348	1	0.55511
D_ln_Psyd_US	-.27348	1.047	1	0.30619
D_ln_Psyo_US	.78244	8.571	1	0.00342
ALL		19.017	6	0.00413

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
D_ln_Pss_Et	2.4623	1.012	1	0.31447
D_ln_Pso_Ch	15.127	514.695	1	0.00000
D_ln_Psyd_Ch	4.8576	12.077	1	0.00051
D_ln_Psyi_Ch	2.9819	0.001	1	0.97296
D_ln_Psyd_US	4.0377	3.769	1	0.05221
D_ln_Psyo_US	4.9356	13.112	1	0.00029
ALL		544.666	6	0.00000

Reference

Admassie, A. (2013). *The political economy of food price: The case of Ethiopia* (Working Paper No. 2013/001).

Alemu, D., & Meijerink, G. (2010). *The Ethiopian Commodity Exchange (ECX) An overview*.

Asteriou, D., & Hall, S. G. (2011). *Applied Econometrics* (2nd ed.). New York: Palgrave Macmillan.

Balcombe, K., & Morrison, J. (2002). Commodity price transmission: A critical review of techniques and an application to selected export commodities. *A Study for the Food and Agricultural Organization (ESCR) of the United Nations, Rome, Italy*.

Baquedano, F. G., Liefert, W., & Shapouri, S. (2011). World market integration for export and food crops in developing countries: a case study for Mali and Nicaragua. *Agricultural Economics*, *42*(5), 619–630.

Barrett, C. B. (2008). *Spatial Market Integration* (SSRN Scholarly Paper No. ID 1142520). Rochester, NY: Social Science Research Network.

Barrett, C. B., & Li, J. R. (2002). Distinguishing between Equilibrium and Integration in Spatial Price Analysis. *American Journal of Agricultural Economics*, *84*(2), 292–307.

Baulch, B. (1997). Testing for food market integration revisited. *The Journal of Development Studies*, *33*(4).

Bedigian, D. (2010). *Introduction: History of the Cultivation and Use of Sesame*. (D. Bedigian, Ed.). Boca Raton, Florida: CRC Press, Taylor & Francis Group.

CSA. (2016). *Agricultural Sample Survey: Crop and Livestock Production Utilization*.

CSA. (2017). *Report on Area and Production of Major Crops* (Agricultural Sample Survey No. Volume I).

CSA. (2018). *Agricultural Sample Surveys: Report on Area and Production of Crops*.

Dercon, S. (1995). On market integration and liberalisation: Method and application to Ethiopia. *The Journal of Development Studies*, *32*(1), 112–143.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251–276.

ERCA. (2017). Annual Report. Retrieved from http://www.erca.gov.et/

Fackler, P. L., & Goodwin, B. K. (2001). Chapter 17 Spatial price analysis. In *Handbook of Agricultural Economics* (Vol. 1, pp. 971–1024). Elsevier.

FAO. (2016). FAOSTAT statistics database.

Fung, H.-G., Leung, W. K., & Xu, X. E. (2003). Information Flows Between the U.S. and China Commodity Futures Trading. *Review of Quantitative Finance and Accounting*, *21*(3), 267–285.

Granger, C., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, *2*(2), 111–120.

Granger, C. W. J. (1981). Some properties of time series data and their use in econometric model specification. *Journal of Econometrics*, *16*(1), 121–130.

Greb, F., Jamora, N., Kouyaté, C., Von Cramon-Taubadel, S., & Würriehausen, N. (2012). Price Transmission From International To Domestic Markets.

Haile, M. G., Algieri, B., Kalkuhl, M., & Gebreselassie, S. (2016). *Analysis of Price Shock Transmission: Case of the Wheat-Bread Market Value Chain in Ethiopia* (No. 246312). African Association of Agricultural Economists (AAAE).

Han, L., Liang, R., & Tang, K. (2013). *Cross-Market Soybean Futures Price Discovery: Does the Dalian Commodity Exchange Affect the Chicago Board of Trade?* (SSRN Scholarly Paper No. ID 2211880). Rochester, NY: Social Science Research Network.

Harris, R., & Sollis, R. (2003). *Applied Time Series Modelling and Forecasting* (1 edition). Chichester, West Sussex, England ; Hoboken, NJ: Wiley.

Hernandez, M. A., Rashid, S., Lemma, S., & Kuma, T. (2015). *Institutions and Market Integration: The Case of Coffee in the Ethiopian Commodity Exchange* (SSRN Scholarly Paper No. ID 2685821). Rochester, NY: Social Science Research Network.

Information Office of the State Council of the People's Republic of China. (2013). *China-Africa Economic and Trade Cooperation (2013)* (p. Beijing). Retrieved from http://www.china.org.cn/government/whitepaper/2013-08/29/content_29861254.htm

Ji Xiang. (2015, June 28). Imported cheap sesame seeds hit the domestic sesame price diving 40% [China National Radio]. Retrieved June 15, 2018, from http://country.cnr.cn/market/20150628/t20150628_518985427.shtml

Johansen, S., & Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration--With Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, *52*(2), 169–210.

Levitt, T. (2013). Ethiopia's sesame seed trade with China – a partnership of equals? *The Guardian*. Retrieved from https://www.theguardian.com/global-development/poverty-matters/2013/jul/10/ethiopia-sesame-seed-trade-china

Maddala, G. S., & Kim, I.-M. (1999). *Unit Roots, Cointegration, and Structural Change*. Cambridge University Press.

Manickam Venkataraman, & Solomon M Gofie. (2015). The dynamics of China-Ethiopia trade relations: economic capacity, balance of trade & trade regimes. *Springer*.

Mendez Parra, M. (2015, March). Seasonal Unit Roots and Structural Breaks in agricultural time series: Monthly exports and domestic supply in Argentina [MPRA Paper].

Minot, N. (2011). *Transmission of world food price changes to markets in Sub-Saharan Africa:* (IFPRI discussion papers No. 1059). International Food Policy Research Institute (IFPRI).

MoFED. (2010). Growth and Transformation Plan. FDRE.

NBE. (2017). *Annual Report 2016/17*. Addis Ababa.

Pal, A., Khanum, F., & Bawa, A. (2010). *Nutritional, Medicinal and Industrial Uses of Sesame (Sesamum indicum L.) Seeds - An Overview* (Vol. 75).

Rapsomanikis, G., Hallam, D., & Conforti, P. (2003). Market Integration and Price Transmission in Selected Food and Cash Crop Markets of Developing Countries: Review and Applications. *Commodity Market Review 2003-2004*, 51–75.

Ravallion, M. (1986). Testing Market Integration. *American Journal of Agricultural Economics*, *68*(1).

Stock, J. H., & Watson, M. W. (2011). *Introduction to Econometrics*. Pearson.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics*, *66*(1), 225–250.

UNCTAD. (2017). *The State of Commodity Dependence 2016*. New York and Geneva.

UNCTAD. (2018). *National Green Export Review of Ethiopia: Leather and Sesame Seeds*.

UNCTAD and FAO. (2017). *Commodities and Development Report 2017: Commodity Markets, Economic Growth and Development*. New York and Geneva.

UNDP. (2011). *Towards Human Resilience: Sustaining MDG Progress in an Age of Economic Uncertainty*. New York.

USDA. (2017). *China-Oilseeds and Products Annual*.

USDA. (2018). *Ethiopia: Grain and Feed Annual*.

Vercammen, J. (2011). *Agricultural Marketing: Structural Models for Price Analysis*.

von Cramon-Taubadel, S. (2017). The analysis of market integration and price transmission – results and implications in an African context. *Agrekon*, *56*(2), 83–96.

Wijnands, J., Biersteker, J., & Van Loo, E. N. (2009). *Oilseeds business opportunities in Ethiopia 2009*. The Hague.

Wioletta Nowak. (2016). China-Africa and India-Africa trade in the years 2000-2014. *Elsevier B.V.*

Zakari, S., Ying, L., & Song, B. (2014). Market Integration and Spatial Price Transmission in Niger Grain Markets. *African Development Review*, *26*(2).