Swedish University of Agricultural Sciences
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Price transmission system in Ethiopian coffee Market

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ABSTRACT

Price is the most vital element in market interaction. If there is an international free trade and the domestic market of one country is interconnected with the international market, and if there is a price shocks in one market, the impact will have the same in the other market. This is the major concept of price theory and the concept of price transmission explored here.

This paper analyses the price transmission system on the level of the producer, the auction market and the foreign (international) market in the Ethiopian coffee market in the short as well as in the long run. The study cover the periods from December 1991 to April 2009, based on 209 observations. Using the vector error correlation method and by using EVIEWS and STATA software, the study attempts to examine the three most important elements in price transmission analysis. These are causality, speed of adjustment and asymmetric response.

The finding of this study shows that, there is a long run cointegration between these three markets. The long run analysis further shows that if there is a 10% change auction market, the long run impact on the producer price is 9.56%, implies these two markets moves closely together in the long run. On the other hand, a 10% change in foreign price has only 6.5% and 5.7% impact on the auction and producer market respectively in the long run.

The result from the VEC model suggested that the adjustment coefficient for producer price is only 3% if there is a shock in the foreign coffee market by one unit in the short run. This means that only 3% of the shock is transmitted to the domestic market in each month. 3% adjustment coefficient is quite small and insignificant. This indicates that lagged producer price is insignificant in the foreign market. The result on the VECM indicates that the producer market and the foreign market are poorly dependent and have very weak relationships to one another as comparing to auction to the foreign market. Because of this, the transmission period from producer market to foreign market takes more than 12 months.

This is a clear indication for the lack of market infrastructure, information asymmetry and poor transportation system. A more organized market infrastructure may improve the supply channel and thereby raise the farmer's income.

ABBREVIATIONS

PPN = average cash received by coffee producer in Ethiopia. The price is calculated as, local currency multiplied by appropriate exchange rate to get monthly average producer price in US cents per Pound. US cent per pound is the measurement of coffee price at the international level.

APN = the national average auction price of coffee in Ethiopia.

FPN = the national average foreign price of coffee in Ethiopia. It is calculated as the auction price plus transportation to the port plus carrying cost to the ship.

ICO= international coffee organization

APT = asymmetric price transmission

VECM = vector error correction model

VAR- ECM = vector autoregressive error correlation model

LOP = The law of one price

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1 Introduction

Reducing poverty through sustained growth is the key development challenge facing sub-Saharan Africa. In order to change the relative position of Africa in the world's constellation of resource endowments, we consider primary products that constitute a major part of Africa's future export expansion. This will be the case even accounting for the fact that economic development typically involves structural transformation away from activities in the primary sectors. Like many other nations in Africa and the third world, Ethiopia relies greatly on the trade of primary goods. This paper examines the trade of coffee in Ethiopia.

Ethiopia is known as the birthplace of coffee Arabica. Coffee has been and remains the leading cash crop and export commodity of Ethiopia. According to Worako (2008), It has account for average 5% of the gross domestic product(GDP), 10% of the total agricultural production and 60% of the total export earnings for the past three or four decades. The Sub-sector affects the livelihoods of approximately one quarter of the population, providing jobs for farmers, local traders, processors, transporters, bankers and exporters. The various taxes on the crop are also an important source of government revenue. According to FAO, "*Ethiopia is Africa's leading exporter of Arabica coffee, earning over $310 million in 1997. Small private coffee plantations contribute about 90% of the country's coffee, while large state-owned plantations account for the rest. The land area under coffee cultivation is difficult to determine because plots are fragmented and interspersed with other crops. It is estimated, however, that Ethiopia has over 320,000 hectares of coffee trees. Annual production ranges from 200,000 to 250,000 metric tons, depending on weather and prices. About 35% of total production has consumed locally. The Ethiopian government is encouraging private investment in the coffee industry, which they hope will lead to the expansion of large-scale commercial plantations and improved quality and productivity*" (fao.com).

1.1 General background about coffee and Ethiopia

Ethiopia is found in east Africa. According to the world fact book (cia.gov), the total area of the country is around 1,104,300 sq km. Ethiopia's poverty-stricken economy is based on agriculture, accounting for about 45% of GDP, and 85% of total employment. The agricultural sector suffers from frequent drought and poor cultivation practices. Coffee is critical to the Ethiopian economy with exports of some $350 million in 2006. The country is bounded on the North by Eritrea, on the North East by Djibouti, on the East and South East by Somalia, on the South by Kenya, and on the West by Sudan. Ethiopia's capital city, Addis Ababa, is located near the center of the country.

Approximately 2.5 billion cup of coffee drinks every day (Dicum and Luttinger, 1999). Most of us are very familiar and we could not feel comfort without a cup of coffee in the morning. However, some of us have lack ideas about the origin of coffee. According to the ICO, the spreading of coffee globally growing and drinking begin in the horn of Africa, where according to a traditional historical tale, the province of Kaffa is the area that coffee trees originated. It is registered that slaves taken from present day Sudan into Yemen and Arabia through the great port of its day, Mocha. It is believed that coffee was cultivated in Yemen by the 15th century or earlier. In an attempt to prevent its cultivation elsewhere, the Arabs imposed a ban on the export of fertile coffee beans, a restriction that was eventually circumvented in 1616 by the Dutch, who brought live coffee plants back to the Netherlands to be grown in greenhouses (ico.org).

The most well known coffee producing region is southwestern Ethiopia (see figure 1.1). Ethiopia is a very complex coffee origin. The best Ethiopia dry-processed coffee (Harrar or Harar found in eastern highland) tends to be medium-bodied and brilliantly acidy with rough, fruity or winy tones. The best washed Ethiopian coffee (Yirgacheffe, Sidamo found in southern part) is light-bodied but explosive with complex floral and citrus notes. Djimah, Djimma, Jimma (which is found in southwestern part) can be an excellent low-acid coffee. Dry-processed Djimah is a lesser coffee often exhibiting wild or medicinal taste characteristics and is not often traded as a speciality coffee. Limu, which is Market name for a respected fragrant, floral- and fruit-toned wet-processed coffee is found in south-central Ethiopia (food-info.net).

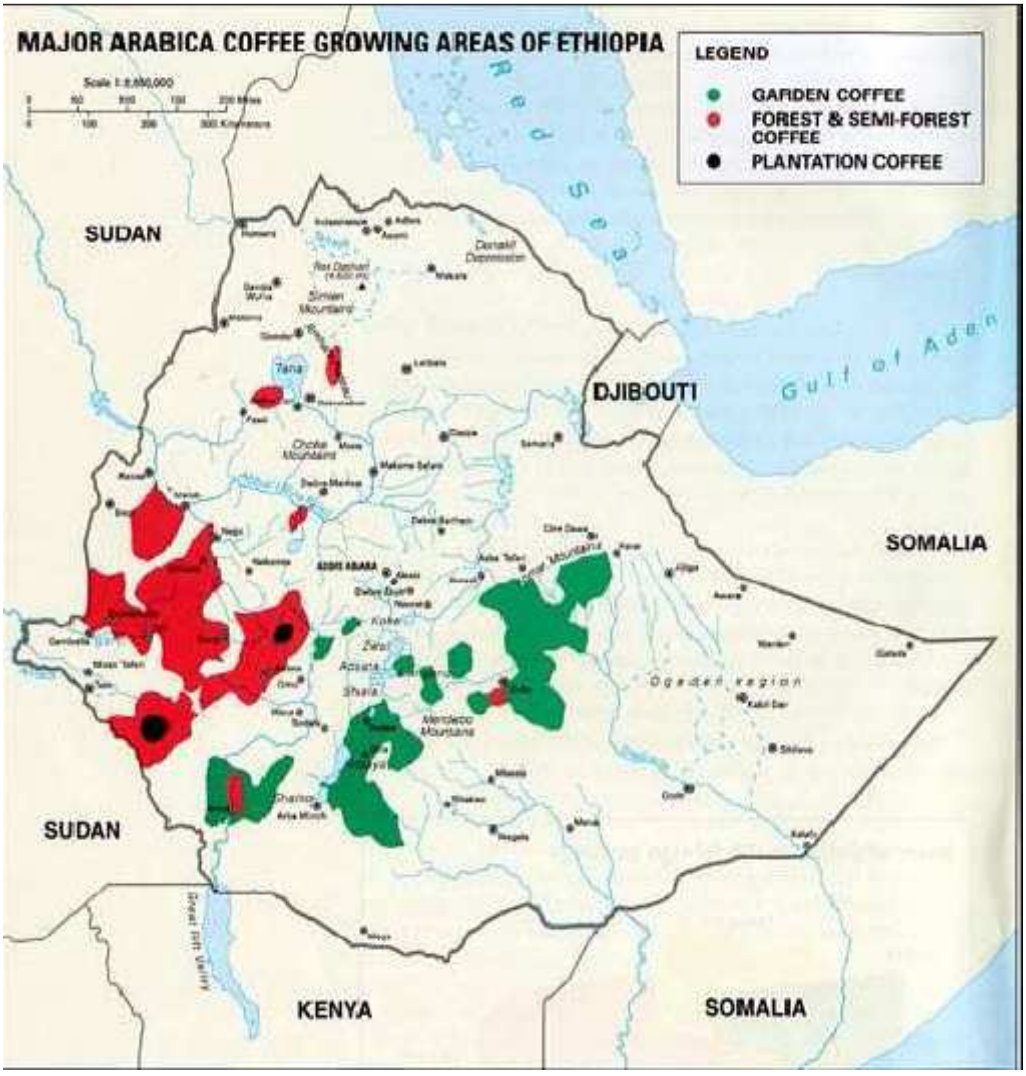


Figure 1.1 Map of Ethiopia and major coffee producing areas (Wiersum 2008)

1.2 Problem formulation

Despite its economic and social importance for the Ethiopian economy, the performance on the coffee sub-sector has remained unsatisfactory. This is because there is no significant change in the mode of production and processing for several decades. Amongst other things, problems concerning policies regulating the market and the low base of market infrastructure were cited as major causes of weak performance.

Coffee is almost entirely produced in developing countries and mostly consumed in the developed world. A key feature of the world coffee market has been the substantial short-term fluctuations in coffee prices, both at the level of international markets as well as markets relevant for coffee producers. Analysis of the world coffee market usually make references in the "coffee paradox" (tutor2u.net). This is to explain that coffee price in producing countries has a trend towards lower price that has a negative impact on living standards of millions of people in developing nations. On the other hand, there is a coffee 'boom' in consuming countries (in developed nations) with increasing retail sales and profits for coffee retailers. A widening gap has observed between producer and consumer prices. Moreover, the sales of coffee each year exceed $70 billion (tutor2u.net) but coffee producing countries only share $5 billion of the total value. The fundamental economic questions arises here in the sense that how the local and national market of coffee is integrated with the foreign market, and how prices signal to be transmitted from the international to the national as well as the local level.

Poor price signals in different markets shows that how the agricultural commodity markets are poorly integrated. According to FAO working paper (fao.com), this poor market infrastructure arises due to high transfer costs. Especially in developing countries, poor infrastructure, transport and communication services can give rise to large marketing margins due to high costs of delivering the locally produced commodity to the export port, hindering the transmission of price signals, and thus preventing arbitrage. Oxfam (2002) also mentioned that a lower degree of price transmission results from lack of available information, infrastructural gap, together with remoteness and limited market size, these could be a major problems to get the right signals for coffee producer (farmers) in Ethiopia (Oxfam, 2002).

The situation is extremely difficult when coffee prices in the international market become very low especially from 2000 to 2002. It is more problematic for coffee farmers in Ethiopia whose lives depend on subsistence agriculture. Mohammed Ali Indris, Ethiopian coffee farmers in the province of Kaffa told Oxfam researchers:

"Five to seven years ago, I was producing seven sacks of red cherry [unprocessed coffee] and this was enough to buy clothes, medicines, services and to solve so many problems. But now even if I sell four times as much, it is impossible to cover all my expenses . . . Three of my children can't go to school because I can't afford the uniform. We have stopped buying teff [staple starch] and edible oil. The children's skin is getting dry and they are showing signs of malnutrition." (Quoted in Gresser and Tickell 2002:10)

According to the BBC (2002), nearly 15 million households have affected by the situation. This was how a farmer interviewed by the BBC correspondent described the situation: "In the past we had coffee, now the price of coffee has fallen and we have no food. I don't know what to do. I just sit in my home and weep". (bbc.co.uk)

At this response indicates, suppliers and growers were discouraged by coffee prices in the world market, some suppliers resorted to selling their coffee in the domestic market where the premium was higher, and others engaged in illicit trade such as smuggling to neighbouring countries to avoid paying tax to the government. The effect on the growers became increasingly worse at this time.

The International Coffee Organization (ICO) has revealed that in Ethiopia many people in the coffee sector are now living on less than US$1 per day. Farmers are now selling coffee at prices well below the cost of production. Since coffee on average constitutes over 50% of export earnings, the government is suffering severe fiscal constraints. There has been a considerable reduction in employment. Coffee farmers are now unable to pay for their children's education and for basic medicines. They have also had to cut back on food consumption, living on one meager meal a day, with frequent cases of malnutrition. There has been increased migration to urban centers, which itself has lead to swelling urban unemployment (dev.ico.org).

1.3 Aim

This study looks at the spreads between international and domestic coffee prices and explains why these spreads have increased or decreased over time. In other words, it measures the price transmission mechanisms after 1992 in the Ethiopian coffee market by considering the three most important markets; these are a producer, auction and foreign markets. Two questions are asked about the relationship between domestic prices and world prices of coffee:

1. Are variations in world prices transmitted to auction and domestic prices in the short as well as in the long run?

2. Do these variations in world prices constitute an important component of variations in auction and domestic prices?

The extent of which price signals are transmitted from one market to another is an ambiguous concept and difficult to answer the above two questions, analysis should be made on the following points as the concept of price transmission is based on the following notations (fao.org)

A. Coefficient of variation (Volatility) – This part give the reader a broad highlight how coffee price vary (fluctuate) over time.

B. The quantitative relationship between the three markets – This gives the readers how the three markets are quantitatively related. This also helps to show mathematically how two or more spatially separated markets attain in equilibrium by considering transportation costs.

C. Test for co - movement in the long run – This is to confirm whether it exits a long run relation between the three markets. Note that complete price transmission can be ascertained when prices co-move being in a form of long run equilibrium.

D. Causality test – This help to answer questions like which market is a follower and which one is the leader of coffee market in Ethiopia.

E. The speed of adjustment – This adjustment coefficient could be utilized for analyzing the time period to show how much time does it take if there is a change in the leading markets to transmit to the flower market in the short run as well as the full transmission in the long run. Prices adjustment to their equilibrium is essential in understanding the extent to which markets are integrated.

1.4 The Significance of the study

In this paper, the main question is; to what extent are world price of coffee transmitted to auction and domestic price in Ethiopia? Answering this question is vital for understanding the relationship between domestic and world markets. In order to do this ideally, we would like to have data's on the price of the same commodity in three markets. The implication of Commodity market integration is that these prices should be converges over time. All things being equal in the market, such a good convergence will speed up the volume of trade (read more explanation in the literature part of this paper).

The most important contribution of this paper is to identify the domestic, auction and foreign coffee market integration in the Ethiopian coffee market in the short as well as in the long run after 1991. Besides this, it measures speed of adjustment (how many months that it takes if, there is a shock in one market to transmit to other market), causality, nature of adjustment and historical volatility (coefficient of variation). According to FAO working paper, these elements have important implications for the efficient functioning of the commodity market, as it ensures that the stakeholders have adequate information to decide on the quantities to be produced, exported or consumed domestically (fao.org). In order to do these, I used different modeling system and extensive literature reviews.

As far as my knowledge is concerned, two available research papers were written regarding to price transmission system in Ethiopian coffee market. The first one is the impact of coffee market reforms on Producer Prices and Price Transmission, scientific research paper (Krivonous, 2004). He focused on the coffee sector reform period during the 1980s and early 1990s on the main coffee producing countries and he took Ethiopia as one of the producing countries. The second studies is in title price transmission and adjustment in the Ethiopian coffee market, contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference (Zerhun and Taddesse, 2009). Both papers focused on

the market policy reform (the introduction of market economy) in Ethiopia and its impact on the price transmission. Both researchers conclude that producers are better off after the introduction of market economy. My questions raised here in the sense that it has been more than eighteen years since the introduction of market economy and still we have observed a widening gap between producer and foreign prices (see section 1.2 of this thesis).

1.5 Methods

In order to reach the objectives of this study, a quantitative approach is used followed by the vector error correlation model (ECM) which is a well-established methodology in price transmission analysis (Ihle and von Cramon-Taubadel, 2008).

Figure 3.1 gives us a highlight how to use this model. First, we have to run a unit root test to know whether our data's are stationary or non-stationary. If the data's are non-stationary, we have to stick on the rights side of the diagram otherwise; we have to test elements on the left side. In doing time series economic analysis, it is common to find out the impact on the change in one variable to the other variables. The granger causality gives us more information to do such types of analysis. The idea is that if X is the cause of y, then change in X is happened first followed by Y. The cointegration test used to measure the unit root. The vector error correction specifies and forecast the short run and the long run equilibrium relationships between variables (Note that all these econometric variables are intensively discussed in chapter three of this paper).

1.6 Delimitation

The type and grade of coffee is highly diverse from region to region with regard to the quality of coffee. Ethiopia is the producer for several renowned varieties of coffee including Harar, Yirgacheffe (in Sidamo),Limmu, Bebeka. Apart from these, there are several other famous varieties that are grown in Ethiopia. In this particular paper, the study consider the four highly exported coffee type, these are Sidamo, wollega, jimma and Harar, it means excluding other less exported coffee type. Besides this, each coffee type has its own grades. (for example Jimma grade 1, Jimma grade 2 etc) to make relatively simple the average price of each coffee type is taken.

1.7 Structure of the research

Figure 1.2 explains the outline of the thesis in a simple way to give the reader a broad image. *Chapter 1* will give the reader information about the problem, background and motives for study. This chapter is also included the methods for analyzing the data. *Chapter 2* summarizes literatures that have studied about price transmission in the past and the present. *Chapter3* explain methods for measuring price transmission. *Chapter 4* models the mathematical relationships between the producer (PPN), auction (APN) and Foreign market (FON). By using the appropriate methods that I mentioned, results are discussed in Chapter 5. Summary, conclusions and recommendations are included in chapter 6 by stressing the thesis statement, and to leave some final ideas to the reader.

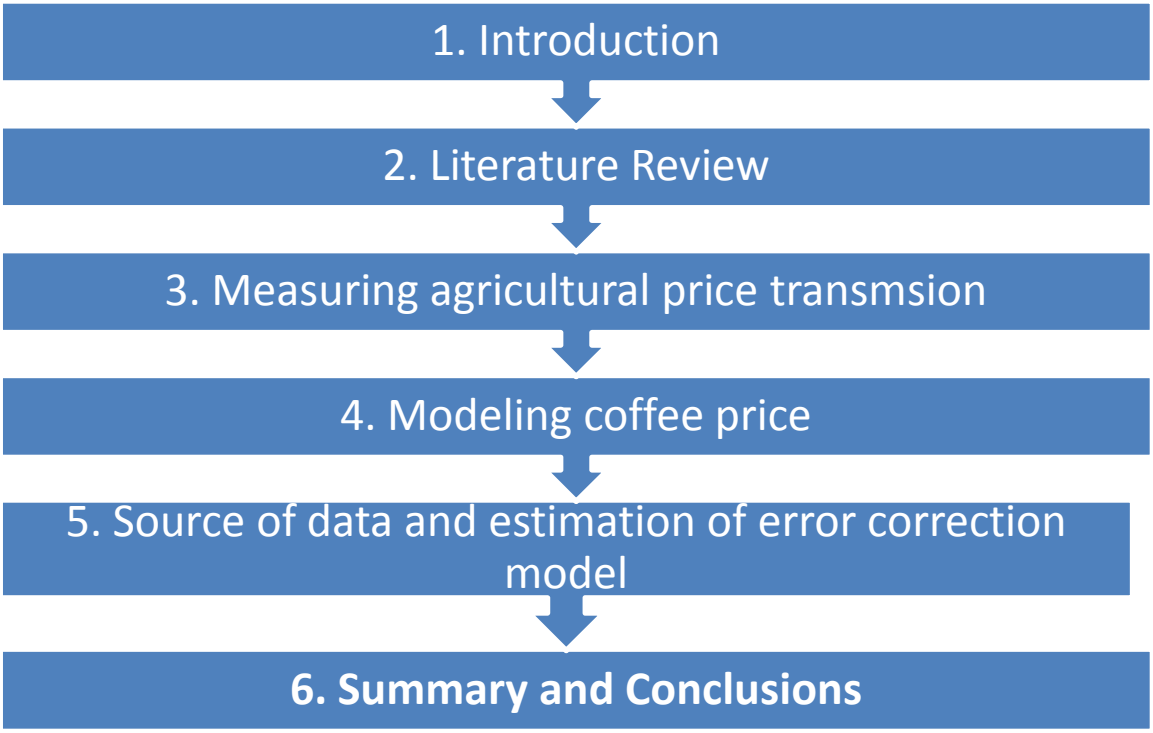


Figure 1.2 outline of the study

2 Literature review

The literature review part of this study mainly dividing into three parts. The first part (section 2.1) of this chapter focuses on the idea of market integration and price transmission systems. The basic matter of discussion when we talk about international agricultural commodity trading is how the local and the national markets respond when there is a change in the international price. The issue of price transmission and market integration is the keys for understanding how the coffee market in Ethiopia integrated with the foreign markets. This section also includes key determinants of price transmission.

The other main part of this chapter (section 2.2) discuss about asymmetric price transmission. The implication of asymmetric price transmission is that the reduction or increase in the world price might not be fully transmitted to the producer market. Besides this, asymmetric response of one market to another implies the upward or downward movement in the price of one market is symmetrically or asymmetrically transmitted to the other market. This issue is also help to understand the reason for price asymmetry that might be important for understanding why coffee price in Ethiopia is symmetric or asymmetric.

The last section of this chapter (section 2.3) provides a basic high lights about factors that affects agricultural commodity prices. The general price level of agricultural commodity whether at international or local market influenced by different market forces that could make differences in the present and future balance between supply and demand. This could give the reader a broad perspective why commodity prices fluctuate on the national and international level. This section also gives emphasis to the International Coffee organization (ICO) agreement. The International Coffee Organization enhances cooperation and issues laws between nations that consume, distribute and produces coffee that have a direct or indirect impact on the supply and quality of coffee in different mechanisms.

2.1 Price transmission and market integration

Agricultural economist authors have written many literatures about price transmission. As far as my knowledge is concerned, almost all the literature that I read relates price transmission with the law of one price or market integration. Therefore, it is prudent to state that price transmission; the law of one price and market integration is rather related ideas.

2.1.1 Price transmission and the law of one price

Different disciplines have different laws. Physics, for example, has a very good law, the law of gravity. Economics, as a disciple has different laws. The major basic law of economics is the law of demand and supply. Another law of economics is the law of one price. According to Protopapadakis and Stol (1983) the law of one price (LOP) states that for a given commodity a representative price adjusted by exchange rates and allowance for transportation costs will prevail across all countries. The LOP plays an important role in models of international trade and exchange rate determination. Furthermore, Persson (eh.net) relate the law of one price with the impact of market arbitrage and trade on the prices of identical commodities that have exchanged in two or more markets. In an efficient market there must be, in effect, only one price of such commodities regardless of where they have traded. The intellectual history of the concept traces back to economists active in France in the 1760-70's, that applied the "law" to markets involved in international trade. Most of the modern literature also tends to discuss the "law" in that context. However, since transport and transaction costs are positive the law of one price must be re-formulated when applied to spatial trade (eh.net).

Suppose two markets which are traded, say, wheat but with wheat going in one direction only, from Chicago to Liverpool, as has been the case since the 1850's.In this case the price difference between Liverpool and Chicago markets of wheat of a particular quality, say, Red Winter no. 2, should be equal to the transport and transaction cost of shipping grain from Chicago to Liverpool. This is to say that the ratio of the Liverpool price to the price in Chicago plus transport and transaction costs should be equal to one. Tariffs are not explicitly discussed here but can easily be introduced as a specific transaction cost at par with commissions and other trading costs. If the price differential exceeds the transport and transaction costs, this means that the price ratio is greater than one. In this case

"*Self-interested and well-informed traders take the opportunity to make a profit by shipping wheat from Chicago to Liverpool. Such arbitrage closes the price gap because it increases supply and hence decreases price in Liverpool, while it increases demand, and hence price in Chicago. To be sure, the operation of the law of one price is not only based on trade flows but inventory adjustments as well. In the example above, traders in Liverpool might choose to release wheat from warehouses in Liverpool immediately since they anticipate shipments to*

Liverpool. This inventory release works to depress prices immediately. Therefore, the expectation of future shipments will have an impact on price immediately because of inventory adjustments. If the price differential does not exceed the transport and transaction cost, this means that the price ratio is less than one, then self-interested and well informed traders take the opportunity to restrict the release of wheat from the warehouses in Liverpool and decrease the demand for shipments of wheat from Chicago. These reactions will trigger off an immediate price increase in Liverpool since supply falls in Liverpool and a price decrease in Chicago because demand falls" (EH.net).

This is a good example how price in one market is transmitted to another market in the sense of "law of one price".

On the other hand, Ravallion (1986) wrote about price transmission in the context of market integration. Under the regularly assumed restriction on the country, slop, curvature, and domain of utility and production function, a competitive equilibrium for a complete set of markets will exist and be efficient in the paretian (Pareto optimality) sense. In general, this will also hold for the spatial competitive equilibrium in an economy consisting of a set of N regions among which a trade occurs at a fixed transport costs (See also Takayama and Judge, 1971). Such equilibrium have the property such that, if trade takes place between any two regions, then the price in the importing region equals price in the exporting regions plus the unit transport cost incurred by moving between the two markets. If this holds, then the market may be defined as spatially integrated. Stigler and Sherwin (1985) also investigate the relationship that exists between different series of prices. They consider a number of items like silver, flour, wheat, gasoline. This study discusses about major issues related to market integrations and conclude that spatial price correlation as a method for describing the geographical boundaries of the markets.

The basic idea behind market integration is the interaction between two or more markets in spatially separated markets. Goletti and Babu (1994) explain that in the extreme case where the two markets A and B completely separated from each other; the prices of the same commodity should not be related to each other. If the areas where the market A is located experience a bad harvest, prices will suddenly increase. In market B, there is no reason to assume that a bad harvest has also occurred. In the absence of communication flows

between the two markets, prices in B would not show any movement. On the other hand, if A and B were integrated, the price in B would also increase. This is because some food would flow from B to A decreasing the available supply in B. At the same time, the price in A would be lower because of increased supply. Therefore, the co-movement of prices gives an indication of the degree of market integration. The first, which is related to the segmentation of markets, would occur if a price movement in market B is completely irrelevant to forecast price movements in market A. However, markets for the same commodity are rarely segmented. That may occur under situations of natural calamities or civil strife. Within the analysis of one commodity that is undertaken in any market, a more relevant issue is to understand if there is a stable relation between prices in different localities. Prices move from time to time, and their margins are subject to various shocks, that may drive them apart or not. If in the long run they exhibit a linear constant relation then we say that they are cointegrated (Goletti and Babu , 1994).

If two markets, A and B, are cointegrated, then there must be some sort of 'causality' running from one market to the other. The concept of causality here has to be interpreted in the limited meaning of contribution to predictability. This is the case when only the past movements of prices in one market are considered, then the issue of Granger causality becomes relevant (Granger, 1969). The issue is whether lagged values of prices in market B can be used to forecast values in market A. If this is the case, then market B prices are said to Granger cause market A prices. If market B causes (in the Granger sense) market A, and market A causes market B, then there is feedback relation between the two markets. Only when the causation is unidirectional, then can we use the past prices of one market to forecast the prices in the other market. If we are able to identify one market that causes other markets (in the Granger sense specified above), without being caused by them, that market can be interpreted as a central market. If there is only one central market, then there is a situation that is best described by a radial model. In a radial model of price transmission, prices in each market are dependent on their own past values and on current and past values of the central market price (Ravallion, 1987).

2.1.2 Key determinants of price transmission

Perfect transmission of movement in the agricultural commodity markets simply implies that price in one market is fully transmitted to price in the other market assuming that the two markets are integrated. It is very difficult to find complete price transmission in the short run in the real world. Different literatures have identified the key factors that play a role in the degree of price transmission (FAO, 2004). The main factors are

- Perfect information*:* If traders do not have up-to-date information about prices in other markets, they cannot respond quickly to profitable opportunities. This will impede the process of spatial arbitrage that transmits price changes from one market to another.

- Transportation or transaction costs: These are the main factors for trades in national as well as in the international level; sometimes transportation costs are large relative to cost of production especially for bulk products. Transaction costs include negotiating, monitoring and enforcement costs. The law of one price assumes that if transportation costs are zero, then changes in the world market should be fully transmitted to the domestic markets (Brooks and Melyukhina, 2003, McNew, 1996).

- Market power: The ability of the firm to set price rather than to take price. If market power increases, competition decrease and the speed of price transmission decrease. That is, a common concern of policy makers relates to the assertion that, due to imperfect price transmission (perceived to be caused by market power and oligopolistic behavior), a price reduction at the farm level is only slowly, and possibly not fully, transmitted through the supply chain. In contrast, price increases at the farm level are thought to be passed more quickly on to the final consumer (Paval and Barry, 2005).

2.2 Price asymmetry and market integration

Many literatures have examined price transmission mechanisms with a long-standing history. In 1970s and 1980s agricultural economist like Tweeten and Quance, 1969; Wolffram, 1971; Houck, 1977 focused on the issue of price asymmetry. Tweeten and Quance developed a simple price asymmetry model, which was later improved by Wolfram (1971). On the other

hand, Boyd and Brorsen, (1988) used a dynamic model in order to test for both price asymmetry, and the speed of price adjustment. Tests for asymmetry have been used to determine if the changes in the base or leading market (such as the U.S. Gulf) are transmitted to other regions or levels in the marketing channel in an identical fashion for both price increases and price decreases. Keynesian economic thought also justify the process of wage and price adjustment over time. The macroeconomics literatures provide empirical research on asymmetric price transmission and price adjustment over time (cf., Mankiw and Romer, 1991). The studies of these researches contribute the development of theoretical price transmission asymmetries. On the one hand, asymmetric price transmission (APT) is examined as the consequence of interaction in price setting at the microeconomic level like staggered timing of price changes and the cost of price adjustment. Besides this, in general, asymmetric price transmission is considered as the result of imperfect competitions that also include coordination failure and demand externalities.

In 1930s great economic depression, economists were attempting to address the failure of the market that was characterized by high level of unemployment. Earlier studies noted that firms in industries characterized by oligopolies tended to change prices less frequently than theory might predict. This is known as the "administered price hypothesis". Gardiner C. Means (1972) work led to analyses of the relationship between structure and pricing, in particular to analyses of structure, the speed and extent of changes in cost and demand on prices.

Another agricultural economist, Ward (1982) examined price transmission for a number fresh produce items is U.S. market. For those products where significant asymmetry was discovered, he found that price rises were not passed on to the same extent as were price falls. He suggested a number of possible reasons for this, including the perishability of produce, which implied that retailers would be unlikely to raise prices and risk stock moving more slowly and deteriorating. Samuel Peltzman also added

"*Output price tend to respond faster to input increases than to decreases (…) it is found as frequently in producer goods as in consumer goods market. (…) This suggested a gap in the essential part of economic theory*." (Peltzman 2000,pp 466)

According to Peltzman, this tendency is found two of every three markets examined. It is found as frequently in producer goods markets as in consumer goods markets. In both kinds of markets, the asymmetric response to cost shocks is sustainable and durable. On average the immediate responses to a positive cost shock are at least twice the response to a negative shock, and the difference is sustained for at least five to eight months. Unlike past studies (agricultural, gasoline, etc...) This one uses a large sample of diverse products: 77 consumers and 165 producer goods. According to the result, suggest a gap is an essential part of economics theory. As a start of filling this gap the study finds no asymmetry in the response to an individual decision making (a supermarket chain) to its costs, but it finds above average asymmetry where a cost shock is filtered through a fragmented wholesale distribution system. It also finds a negative correlation between the degree of asymmetry and its input price volatility and no correlation with proxies for inventory costs, asymmetric menu costs of price changes and imperfect competition (Peltzman, 2000). On the other hand, authors like Guathier and Zapata (2001) suggested caution due to methodological problems associated with empirical tests for asymmetry. The conclusions generated from some previous applications of asymmetric price-transmission models may be fragile. It is possible to find asymmetry even in its absence or to not detect asymmetry when it exists. This study underscores the admonition to exercise care and caution in the choice of tools used to create facts about economic phenomena. The Monte Carlo findings suggest that previous findings with the use of price segmentation techniques to study asymmetry should be revisited and compared to findings generated from more general asymmetric process such as momentum threshold autoregressive (M-TAR) process. They point out the standard test (such as the test applied by Peltzman) can lead to excessive rejection of the null hypothesis of symmetry under common conditions.

Although market power has been identified as, the main cause of imperfect price transmission in some cases, and is widely suspected as a cause in others, recent research shows that this does not always have to be the case. Wang, Tadesse and Rayner (2006) explored the impact of market power on the degree of price transmission allowing for the interaction between oligopoly power in the food retail sector and oligopsony power in the farm sector when industry technology is characterized by non-constant returns to scale. The major conclusion is that the impact of the interaction between market power and industry

technology is ambiguous. Consequently, the outcomes for the degree of price transmission are inconclusive. Firstly, increasing returns to scale technology and market power can either complement each other to enhance the degree of price transmission relative to the perfectly competitive and constant returns to scale benchmark or counter each other's impact. Secondly, decreasing returns to scale technology and market power can either complement each other to weaken the degree of price transmission relative to the perfectly competitive and constant returns to scale benchmark or counter each other's impact. The key to these inconclusive outcomes lies in the functional forms of retail demand and farm input supply on the one hand and in the relative magnitudes of changes in the mark-up and in the mark-down on the other. The policy implications seem to be that without prior knowledge of changes in the markup and in the mark-down no conclusions can be drawn regarding the interaction between market power and industry technology. Therefore, caution needs to be applied when making inferences regarding industry structure based on empirical estimates of the price transmission elasticity alone.

2.2.1 Types of asymmetry

Asymmetric price adjustments have been widely documented in gasoline and agricultural markets in a number of countries. A consumer goes to the gasoline station or the grocery store and ask, Why do retail prices always seem to go up so fast when the price of crude oil or farm products goes up, but they are so slow to come down when oil or farm prices go down? This supposed phenomenon is referred to alternatively as asymmetric price adjustment, asymmetric price transmission, and price transmission asymmetry (APT). The question to consider is as follows: Do firms raise prices faster when their costs go up than they cut prices when their costs go down? The macroeconomic version of this question is the following: Are prices more sticky (slow to change) downward than upward? An assumption of downward price stickiness has been central to Keynesian macroeconomics. Certifications of this assumption, and thus support for the ideas of a convex aggregate supply curve and the Phillips curve, have important implications for monetary and fiscal policy. The clear route to examining downward price stickiness is microeconomic price theory. However, price theory from textbook economics cannot easily answer our questions. Profit maximization based upon the optimization criteria that the marginal benefits should be equal to marginal cost

implies that marginal revenue should adjust to marginal cost immediately, so that price should symmetrically adjust in response to increases or decreases in cost (www.entrepreneur) but this situation is fail to apply in some other industries. According to Meyer and Taubadel (2004), Asymmetry can be divided into three criteria in the context of price asymmetry.

2.2.1.1 Asymmetry with reference to speed and magnitude

Here we can analysis whether the speed or the magnitude of price is asymmetric. The difference between the speed and magnitude of asymmetric price transmission is represent in figure 2.1 where a price (p^{out}) is assumed to depend on another price (P^{in}) that either decreases or increases at a specific point in time. In figure 2.1A, the magnitude of the response to a change in p^{in} depends on the direction of this change, in figure 2.1B; it is the speed of the response that depends. Clearly, combinations of these two fundamental types of asymmetry are conceivable. In figure 2.1C, price transmission is asymmetric with respect to both speed and magnitude because an increase in p^{in} takes two periods (t_1 and t_2) to be

A, magnitude

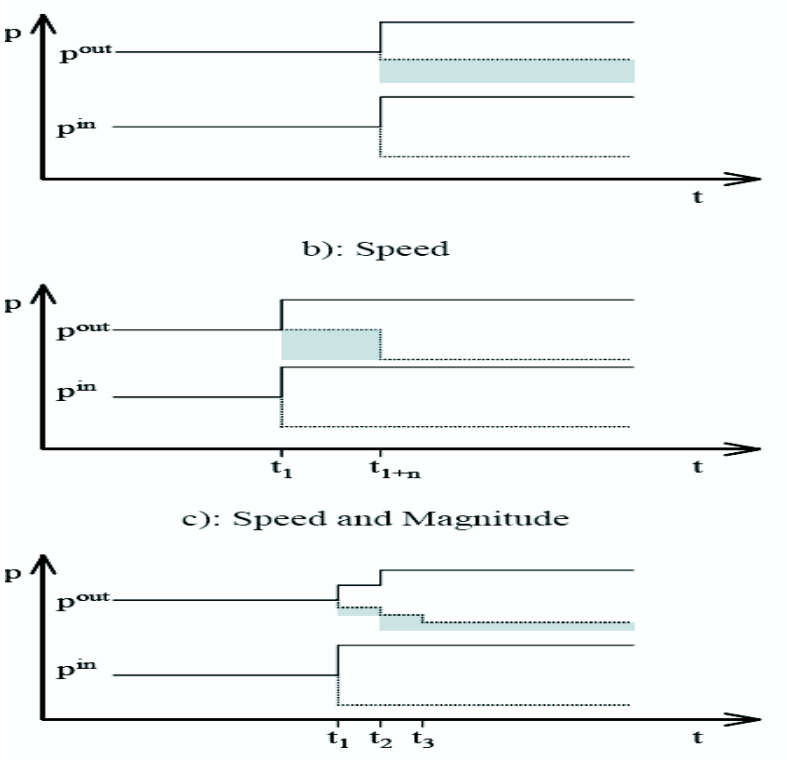


Fig 2.1, asymmetric price transmission (source: Von Cramon-Taubadel , 1998)

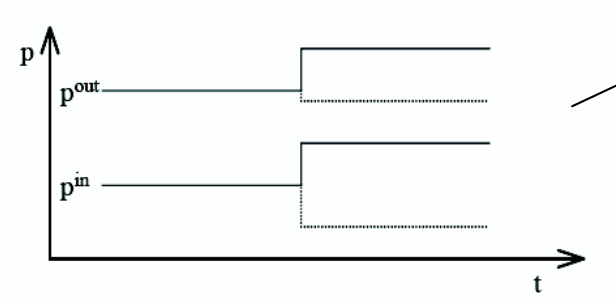
fully transmitted to p^{out} , while a decrease in p^{in} requires three periods (t_1, t_2 and t_3) and is not fully transmitted.

The shaded area in figure 2.1 represents the welfare effects associated with the speed and magnitude of asymmetric price transmission. Interpretation is confronted by assuming a constant, the volume of transactions over time, i.e. price inelastic demand for the output good is complete. Asymmetry with respect to the speed of price transmission leads to a temporary transfer of welfare – in this case from buyers of the output good to sellers – the size of which depends on the length of the time interval between t_1 and t_{1+n} as well as the price changes and transaction volumes involved (figure 2.1B). Asymmetry with respect to the magnitude of price transmission leads to a permanent transfer of welfare (Figure 2.1A), the size of which depends solely on the price changes and transaction volumes involved. Figure 2.1C shows that asymmetry with respect to speed and magnitude leads to a combination of temporary and permanent welfare transfers. Which type of welfare transfer is of greater concern cannot be determined *a priori*; depending on the numbers involved, a large temporary transfer could outweigh the present value of smaller permanent transfer. If the asymmetric price transmission (APT) in question results from the exercise of market power, then asymmetry with respect to magnitude, perhaps accumulated over a number of episodes, could be used as a way of surreptitiously imposing or 'easing in' oligopoly or monopoly pricing. In this case, as noted above, asymmetric price transmission will imply not only welfare transfers but also net welfare losses.

2.2.1.2 Negative Vs. positive APT

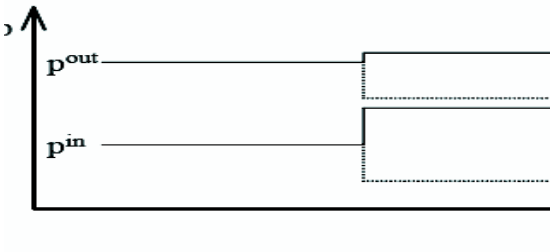
Following an observation provided by Peltzman, asymmetric price transmission has classified as positive or negative. If p^{out} reacts more fully or rapidly to an increase in p^{in} than to a decrease, the asymmetry is termed 'positive' (figure 2.2A). Correspondingly, 'negative' asymmetry denotes a situation in which p^{out} reacts more fully or rapidly to a decrease in p^{in} than to an increase (figure 2.2B). This convention can be misleading if interpreted in a normative fashion; if p^{in} and p^{out} represent farm gate and retail prices for a commodity, respectively, 'negative' asymmetry is 'good' for the consumer, while 'positive' asymmetry is 'bad' in the sense that the former (latter) is associated with welfare gains (losses). At the same time, however, this highlights the importance of the distinction between positive and

negative asymmetry, as it determines the direction of welfare transfers due to APT (See figure 2.2).



Positive APT be defined as a set of reactions according to which any price movement that squeezes the margin (i.e. an increase in p_{in} or a fall in p_{out}) is transmitted more rapidly and/or completely (to p_{out} or p_{in}, respectively) than the equivalent movement that stretches the margin.

Figure 2.2a, Positive asymmetric price transmission



APT is negative when price movements that stretch the margin are transmitted more rapidly and/or completely than movements that compress it.

Figure 2.2b, Negative asymmetric price transmission

Figure 2.2, positive and negative asymmetric price transmission

2.2.1.3 Vertical Vs. spatial APT

This classifies whether asymmetric price transmission affects vertical or spatial price transmission system. A very good example of vertical APT, given by Von Cramon and Meyer is

"*Farmers and consumers often complain that increases in farm prices are more fully and rapidly transmitted to the wholesale and retail levels than equivalent decreases in farm prices. An example of spatial APT would be a rise in the US export price for wheat causing a more pronounced reaction in the Canadian export price than a corresponding reduction of the same magnitude. Spatial APT, like vertical APT, can be classified according to speed and*

magnitude, and according to whether it is positive or negative" (Meyer and Cramon-Taubadel, 2004, pp 5)

2.2.2 Causes of asymmetry price transmission

There are a numbers of factors that believed to be the cause of price asymmetric according to different literatures but for this particular analysis it is better to divide in to three parts by considering the first two big factors and categorizing another factors as miscellaneous.

2.2.2.1 Adjustment costs

According to economics dictionary, adjustment cost is the cost to a firm of altering its level of output. For example, it may be desirable for a firm to cut down on its output, but doing this will create adjustment costs such as redundancy payments and lower staff morale. On reflection of its adjustment costs, it may be more desirable to keep producing at a suboptimal level. Similarly, a rapid expansion in output may create problems such as difficulties in negotiating a bigger plant to rent and the difficulties in hiring more workers (economicshelp.org).

Firms may face different adjustment costs depending on whether prices are rising or falling (Bailey and Brorsen, 1989). Competition between meat packers faced with high fixed costs and excess capacity, for example, might result in farm prices that are bid up rapidly in response to increased demand for meat products, but fall more slowly as demand weakens. In the short run, margins may thus be reduced in an attempt to keep a plant operating at or near capacity. Therefore, because of competition between different packers, farm prices may be bid up more quickly than they are bid down (negative APT).

Similarly, Ball and Mankiw (1994) posit a model in which firms face menu costs (the costs involved in changing nominal prices, such as the cost of reprinting catalogues, etc.) and inflation. In this environment, shocks that increase a firm's desired price will trigger larger responses than shocks that reduce it, because firms will take advantage of positive shocks to correct also for accumulated and anticipated inflation, while inflation will already have affected some of the adjustment made necessary by negative shocks. This asymmetry, however, disappears under price stability. Moreover, during periods of sustained deflation, the asymmetry is reversed: relative prices are adjusted downward more quickly than they are

adjusted upward. Thus, the model may prove useful for understanding differences in price adjustment under different monetary regime. Contrary to this, Peltzman (2000) indicates that asymmetric adjustment is prevalent with retail prices rising faster, as compared to falling, while this asymmetry is not related to inventory costs, menu costs and imperfect competition. Such findings not only suggest that asymmetry is the rule rather than the exception in market price adjustment but raise a number of questions related to the suitability of empirical price-based tests and the conventional theory of prices.

Ward (1982) suggests that retailers may be hesitant to raise prices of perishable goods for fear that they could end up holding spoiled stocks. Wholesale prices are shown to lead both retail and shipping point prices. Asymmetry in the retail-wholesale response indicates that wholesale price decreases are reflected at the retail more so than are wholesale price increases. Wholesale price decreases are more fully passed through to the shipping point relative to wholesale increases. In all these cases, the speed of price transmission is asymmetric, but there is no reason to expect that long-run elasticity of price transmission will be asymmetric as well. Heien (1980) on the other hand argue that increases in wholesale prices are transmitted to the retail level via mark-up-type pricing behavior. This behavior is shown to be consistent with firm optimization under the assumption of constant returns to scale and Leontief production technology at the retail level. He concludes that changing price is not a problem for perishables, but for items with a long shelf life, price changes are costly both in terms of time to put on new labels and in goodwill lost.

2.2.2.2 Market power

Market power is defined as the ability of the firm to raise prices above its marginal cost. Lands and Posner (1981) further define market power as the ability of the firm (or a group of firms, acting jointly) to raise price above the competitive level without losing many sales so rapidly that the price increases are rendered, unprofitable and must be rescinded. Along production chains, some agents may behave as price makers while some other as price takers, depending on the degree of concentration of each industry. It may be the case that, for example input price increased in an industry may be passed over to consumers, while input price decreases can be captured in the markup of the industry (Wohlgenant, 1999; Azzam, 1999; Goodwin and Holt, 1999).

Different articles on asymmetric price transmission explain that non-competitive market as a source of APT. Meyer and Taubadel (2004) explain that this is more common in agricultural commodities. Farmers at the begging of the marketing chain and consumer at the end of the marketing chain frequently imagine that imperfect computation in processing and selling allows intermediaries to use market power. This could be resulted from a positive asymmetric price transmission. Therefore, it has expected that margin-squeezing increases in input prices (or decreases in output prices) will be transmitted faster and/or more completely than the corresponding margin-stretching price changes. On the other hand, McCorriston and Rayner (1998) show how a price change in the farm level is transmitted to the retailer sector. A price transmission elasticity is derived which is shown to depend on the degree of market power in the food industry and the nature of the food industry's processing technology. They further develop a model to show the impact of market power on the intermediate stage on price transmission on the food sector can lead to imperfect price transmission without considering asymmetry. In their findings the offsetting role of processing technology and market power in determining the extent of price transmission is highlighted.

Von Cramon et al. (1997) argue that marketing chains for food products are often much less concentrated at the farm level than at higher levels. He explains that

"*Oligopolistic processors, for example, might react collusively more quickly to shocks that squeeze their margins than to shocks that stretch it, resulting in asymmetric short-run transmission. In an attempt to hide the exercise of market power behind the 'confusion' created by major shocks, processors could also react less completely to shocks that stretch their margins, leading to asymmetric long-run transmission* " (Van Cramon 1997, pp 10).

R. Ward and Kinnucan and Forker (1987) suggest market power might explain the findings of asymmetric price adjustments. Scherer (1980) argues price inflexibility may exist in industries characterized by non price competition, high market concentration ratios, and large advertising expenditures. This idea was further supported by Bailey and Brorsen (1989:247) by considering some examples. According to them asymmetry could result if firms perceive kinked demand curve. The kink in the demand curve can result when individual firms believe that no competitor will match a price increase, whereas all firms would match a price cut. The opposite is also possible when the individual firm believes that all its competitors would

match a price increase. Here there is no clear a priori how price transmission will be skewed. Furthermore, concentration is perhaps a necessary but certainly not a sufficient condition for the exercise of market power and the theoretical and empirical evidence on the relationship between these two phenomena is inconclusive (Van Cramon 1997, Weaver, 1989; Goodwin, 1994).

Luoma (2004) studied the transmission of producer price changes to consumer prices in Finnish beef and pork markets. According to the previous studies price transmission has asymmetric because of market power and adjustment costs. Here they argued that market power is the most likely explanation for asymmetric price transmission in the long run. In imperfectly competitive markets, retailers may keep price levels relatively fixed for long periods, or oligopolies may react quicker to declining margins by utilizing their market power. The reason they do this is to maintain market shares, keeping long-run rather than short-run profits in mind. Hence, market power can affect price transmission in opposite ways.

Several economists have been studying price asymmetry in the oil industry and the causes of it. Borenstein (1997) study vertical price transmission from crude oil to gasoline prices, and conclude that:

"Downward stickiness of retail prices for gasoline in an oligopolistic environment will lead to positive asymmetry. They assume that in the presence of imperfect information about the prices charged by other firms, the old output price offers a natural focal point following changes in the input price. While increases in the price of crude oil will lead to an immediate increase in gasoline prices, because margins are squeezed, cost decreases won't lead to immediate output price decreases because firms will maintain prices above the competitive level as long as their sales remain above a threshold level" (Borenstein et al. 1997 pp. 324).

He further argues that "*lags in the adjustment of price to input cost changes are not consistent with simple models of either competitive markets or monopoly*" (pp 301). The price set by a profit maximizing monopolist depends on marginal costs. The profit maximizing monopolist thus wants to change his price every time marginal costs change. Therefore, in the case of transparency and perfect flexibility, there is no ground for either upstream or downstream time lags. By the same token, Balke, Brown and Yucel (1998) explain that in the retail gasoline market, consumer search costs could lead to temporary market power for gas

stations and an asymmetric response to changes in the wholesale price of gasoline (See BCG, Norman and Shin 1991, Borenstein 1991, and Deltas 1997). Each gas station has a locational monopoly that is limited only by consumer search. After consumers have searched, the profit margins at each gas station are pushed down to a roughly competitive level. When wholesale prices rise, each station acts to maintain its profit margins and quickly passes the increase on to customers. When wholesale prices fall, however, each station temporarily boosts its profit margins by slowly passing the decrease on to customers. Only after the customers engage in a costly and time-consuming search to find the lowest prices are the stations forced to lower prices to a competitive level.

Many paper's emphasis the idea that market power that consider APT caused not by input price change, but by shifting the output demand. In a paper on imperfect information in a competitive duopoly, Damania & Yang (1998) stress the main causes of asymmetric price transmission is potential punishment. This model stress that the demand of the product is expected to fluctuate between high and low states randomly. Punishment occurs if a firm believes that its competitor is undermining a collusive price. Given the possibility of punishment, firms facing low demand dislike a price reduction, while prices can be increased without fear of punishment following a switch to the high demand situation. Kovenock and Widdows (1998) also present a simple price leadership model in which equilibrium behaviour exhibits price rigidity following downward demand shocks and price flexibility after an increase in demand. The source of this asymmetric rigidity lies in the fact that leader-follower equilibrium prices are lower than their collusive levels and that any firm leading a round of price adjustment must anticipate the optimal price response of the follower. In addition, they found that there is a range of shocks, both positive and negative, in which the identity of the price leader is endogenous.

To sum up, many authors agree that market power leads to asymmetric price transmission. Most writers on these issues believe that the cause of positive APT is market power. Meyer and Cramon-Taubadel (2004) explain that the situation is differing in the case of pure monopoly and common oligopoly context. In a pure monopoly context, this would appear to be reasonable. However, in the more common oligopoly context, both positive and negative APT is conceivable, depending on market structure and conduct.

2.2.2.3 Miscellaneous causes

There are other miscellaneous causes, in addition to transfer costs and market power that causes price asymmetry. In spatial markets, for example, asymmetries may result from inventory holding behavior in domestic markets as stock accumulation may result from high international price expectation (Maccini, 1978; Blinder, 1982). Different reaction to increase and decrease of input costs is the other reason for asymmetric price adjustment, as competition between wholesalers with high fixed costs and excess capacity may result in producer prices that increase rapidly when demand for processed product is high, but decrease at a slower rate when demand is low (Bailey and Brorsen, 1989; Kovenock and Widows, 1998). Besides these Search costs associated with asymmetric information may lead to asymmetric price adjustment (Bénabou and Gertner, 1993).

Table 2.1 Literatures summary of price transmission

Researchers	Major Findings
Stigler and Sherwin, (1985)	- The study includes different markets like future and commodity markets and mainly discuss about the major issue related market integration and came to the conclusion that spatial price correlation as a method for describing the geographical bounders of the markets.
Ravallion(1986), Takayama and Judge, (1971)	- A competitive equilibrium for a complete set of market will exit and be efficient in Pareto optimality sense. This equilibrium has the property that price in the importing region equals price in the exporting regions plus the unit transport cost incurred by moving between the two markets. Then the markets are called spatial integrated markets. - In his model of market integration, the price series for each local market have their own autoregressive structure and a dynamic relationship with market prices in a central region. His approach permits to distinguish between short and long run market integration.
Brooks and Melyukhina,(2003), McNew, (1996)	- The lower the transportation and transaction costs, the higher the speed of price transmission. The law of one price assumes that the price of a commodity in one market is the same with another spatially integrated market assuming that the transportation cost is zero.
Paval and Barry, (2005)	- Due to imperfect price transmission (perceived to be caused by market power and oligopolistic behavior), a price reduction at the farm level is only slowly, and possibly not fully, transmitted through the supply chain. In contrast, price increases at the farm level are thought to be passed more quickly on to the final consumer.

Table 2.2 Literatures summary on price asymmetry

Researchers	Major findings
Von Cramon-Taubadel (1998)	- He analyzed German pork market with an earlier non-symmetric error correction model and found evidence of asymmetric price transmission in the form that wholesale prices react more strongly to compress than stretched margins
Wang, Tadesse and Rayner (2006)	- explored the impact of market power on the degree of price transmission allowing for the interaction between oligopoly power in the food retail sector and oligopsony power in the farm sector when industry technology is characterized by non-constant returns to scale
Luoma (2004)	- Market power is the most likely explanation for asymmetric price transmission in the long run. In imperfectly competitive markets, retailers may keep price levels relatively fixed for long periods, or oligopolies may react quicker to declining margins by utilizing their market power.
Meyer and Taubadel (2004)	- Farmers at the beginning and consumers at the end of the marketing chain often suspect that imperfect competition in processing and retailing allows intermediaries to use market power.
Ward (1982)	- Examined price transmission for a number fresh produce items is U.S. market and found that price rises were not passed on to the same extent as were price falls, he mentioned many reason including the perishability of produce, which implied that retailers would be unlikely to raise prices and risk stock moving more slowly and deteriorating
Maccini, 1978; Blinder, 1982	- In spatial markets, asymmetries may result from inventory holding behavior in domestic markets as stock accumulation may result from high international price expectation.
Brorsen, 1989; Kovenock and Widows, 1998	- Different reaction to increase and decrease of input costs is the other reason for asymmetric price adjustment
(Bénabou and Gertner, 1993	- Search costs associated with asymmetric information may lead to asymmetric price adjustment

2.3 Factors that affects agricultural commodity prices

The general price level of an agricultural commodity, whether at a major terminal, port, or commodity futures exchange, is influenced by a variety of market forces that can alter the current or expected balance between supply and demand. Accoording to Randy (2006) many of these forces emanate from domestic food, feed, and industrial-use markets and include consumer preferences and the changing needs of end users; factors affecting the production processes (e.g., weather, input costs, pests, diseases, etc.); relative prices of crops that can substitute in either production or consumption; government policies; and factors affecting storage and transportation. International market conditions are also important depending on the "openness" of a country's domestic market to international competition, and the degree to which a country engages in international trade.

Besides these factors in analyzing the coffee prices, we have to keep in mind factors that could influence the price of coffee. The International Coffee Agreement is one of these factors.

According to the Kravis, the international coffee agreement (ICO) is defined as

"*The International Coffee Agreement (ICA) is an agreement between the principal coffee exporting and importing countries that imposed export quotas in order to raise the price at which member country exporters sold coffee to member country importers. Member importing countries have accepted the higher prices paid by their consumers in order to benefit governments and farmers in less developed coffee exporting countries*." (Kravis, 1968, pp 1)

The international coffee agreement was introduced in 1963 when the first agreement entered into force in 1962. The agreement was for the period of five years since then there has a successive agreement negotiation for each five year period. After 1963 agreement, there was 1968 ICO agreement (two expansion), the agreement in 1976 (one expansion), the agreement in 1983 (four expansion), 1994 agreement (one expansion) and the agreement in 2001 (three expansion). The recent agreement is in 2007. The agreement is entered into force if a two third of exporting and importing members accepts or approved (ico.org). I only consider the agreements that includes between the periods from 1992 to 2009 as the main data's in this paper are from December 1991 to April 2009.

INTERNATIONAL COFFEE AGREEMENT 1983

- It is important to exert export quotas when necessary to assure price stability at international coffee council meeting of exporting and importing countries;

- There are no quota systems if price increases above certain level and quota may reintroduce if the price fell again; (ico.org)

INTERNATIONAL COFFEE AGREEMENT 1994

This agreement mainly focuses on

- Arranging discussion forum in the international level that have a positive impact in the world coffee market;

- Increasing market transparency by gathering and spreading market information widely in the world coffee market; (ico.org)

INTERNATIONAL COFFEE AGREEMENT 2001

This agreement contains a number of new objectives, this includes "encouraging *members to develop a sustainable coffee economy; promoting coffee consumption; promoting quality; providing a forum for the private sector; promoting training and information programs designed to assist the transfer of technology relevant to member countries; and analyzing and advising on the preparation of projects to the benefit of the world coffee economy*" (thefreelibrary.com)

INTERNATIONAL COFFEE AGREEMENT 2007

The new overall objective of the 2007 Agreement is to strengthen the global coffee sector and promote its sustainable expansion in a market-based environment for the betterment of all participants in the sector. Other new objectives include facilitating information on financial tools and services, and encouraging members to develop and implement strategies to enhance the capacity of local communities and small-scale farmers, and develop appropriate food safety procedures in the coffee sector. This agreement also includes Millennium Development Goals (MDGs) that focus on poverty reduction in the sense that the coffee sector should be sustainable (ico.org).

3 Methods for measuring agricultural price transmission

Price transmission occurs when the change in one price causes to another price to change. Economists have long been concerned with the measurement of price transmission in different markets. In this chapter, I revised different types of measuring price transmission system. As usually, each system has its own merit and demerit.

3.1 How do we measure price transmission?

There are four major types of mechanisms system, that measure Price transmission. These are

A. Ratio of percentage changes between two time periods
B. Correlation analysis
C. Regression analysis
D. Co-integration analysis (N. Minot, 2010).

3.1.1 Ratio of percentage changes between two time periods

What does the "percentage change" element of our elasticity formula mean? We simply want to examine how much the price changes, and then express this as a percentage. As an example, consider at the following table.

Table 3.1 Ratio of percentage change between two prices

	Price of maize in Dar in US/ton	Price of US No. 2 yellow maize in US/ ton
June 2007	120	165
June 2008	239	286
Percentage change	99%	75%

(Source: Measuring food price transmission, Presented at the Comesa training course)

The elasticity of transmission = 0.99/0.75 = 1.32. This figure explain that if there is a 99% increase in the price of maize causes a 75% increases in the price of US no. 2 yellow maize,

then price transmission elasticity is 1.32 (a 1.32% increase in price of maize for each 1% increase in price of US No. 2 yellow maize)

This method is highly criticized because it only uses two points in time, does not take trends into account (Minot et al. 2010).

3.1.2 Correlation analysis

In non-technical language, correlation exists when two variables display linear relationship beyond what is expected by chance alone (Stockwell, 2008). When examining data in statistical analysis, correlation reveals itself by the relationship between two variables. The most common measure of correlation is called the "Pearson Product-Moment Correlation Coefficient". It is important to note that while more than two variables can be analyzed when looking for correlation, the correlation measure only applies to two variables at a time (Stockwel et al, 2008). Correlation is defined by most statisticians as

"A *measure of the strength of relationship between random variables. The population correlation between two variables X and Y is defined as:*

$$\rho (X, Y) = \text{Covariance } (X, Y) / \{\text{Variance } (X) * \text{Variance } (Y)\}^{½} \quad (3.1)$$

ρ is called the Product Moment Correlation Coefficient or simply the Correlation Coefficient. It is a number that summarizes the direction and closeness of linear relations between two variables. The sample value is called r, and the population value is called ρ (rho). The correlation coefficient can take values between -1 through 0 to +1. The sign (+ or -) of the correlation defines the direction of the relationship. When the correlation is positive (r > 0), it means that as he value of one variable increases, so does the other. If a correlation is negative (r < 0), it indicates that when one variable increases, the other variable decreases. This means there is an inverse relationship between the two variables" (sas.com).

According to Stockwell, It is important to note that a correlation measure of zero does not necessarily imply that there is no relationship between the two variables, just that there is no linear relationship present in the data that is being analyzed (as the sample data is drawn from the population). It is also sometimes difficult to judge whether a correlation measure is "high" or "low". There are certain situations where a correlation measure of 0.3, for example, may be considered negligible. In other circumstances, such as in the social sciences, a 0.3

correlation measure may suggest that further examination is needed. As with all data analysis, the context of the data must be understood in order to evaluate any results (Stockwell et al, 2008).

In order to determine whether two events happen at the same time or by chance, we use the concept of statistical significant. Statistical significance is a mathematical tool used to determine whether the outcome of an experiment is the result of a relationship between specific factors or due to chance (wisegeek.com). Typically, in many sciences, results that yield $P \leq 0.05$ are considered borderline statistically significant, but remember that this level of significance still involves a pretty high probability of error (5%). Results that are significant at the $P \leq 0.05$ level are commonly considered statistically significant, and $P \leq 0.005$ or $P \leq 0.001$ levels are often called "highly" significant. Remember that these classifications represent nothing else but arbitrary conventions that are only informally based on general research experience (statsroft.com)

Like any quantitative measurement, correlation has its advantages and disadvantages. The Advantage is easy to calculate and understand but is it only considers the relationship between two variables at the same time and it does not take lags in to accounts (Minot, 2010).

3.1.3 Regression analysis

Regression analysis is a statistical tool for examination of relationships between variables. Usually, the investigator seeks to ascertain the causal effect of one variable upon another—the effect of a price increase upon demand, for example, or the effect of changes in the money supply upon the inflation rate. To explore such issues, the investigator assembles data on the underlying variables of interest and employs regression to estimate the quantitative effect of the causal variables upon the variable that they influence. The investigator also typically assesses the “statistical significance” of the estimated relationships that is, the degree of confidence that the true relationship is close to the estimated relationship (O. Sykes, 2000).

There are two major types of regression analysis that are well known in statistics. These are simple linear regression and multiple linear regression analysis. In simple linear analysis we only consider two main basic variables, one as dependent and the other one as an

independent. One simple example created by Sykes is the relationship between education and earrings. At the outset of any regression study, one formulates some hypothesis about the relationship between the variables of interest, here, education and earnings. Common experience suggests that better educated people tend to make more money. It further suggests that the causal relation likely runs from education to earnings rather than the other way around. Thus, the tentative hypothesis is that higher levels of education cause higher levels of earnings, other things being equal (O. Sykes, 2000). A simple linear regression model is given by the equation

$$y = \beta_0 + \beta_1 x + \varepsilon \qquad 3.2$$

Where β_0 and β_1 are unknown parameters and ε is a random variable, usually considered normally distributed. The model equation (3.2) states that a value of *y* is equal to a linear function of *x* plus a random quantity *ε*. The parameters β_0 and β_1 are the intercept and slope of the regression line (stat.ufl.edu). In applications, the model is fitted to data using the method of least squares, giving the "prediction" equation

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x + \varepsilon \qquad 3.3$$

Where $\hat{\beta}_0$ and **βrror! Bookmark not defined.**$\hat{}_1$ are estimates of β_0 and β_1 and $\hat{y}$ is a "predicted value" of y obtained by inserting a value of x into the prediction equation (stat.ufl.edu).

In multiple regression analysis, the general purpose (the term was first used by Pearson, 1908) is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable (statsoft.com). In the above Sykes example, earnings are affected by a variety of factors in addition to years of schooling; consider the introduction into the earnings analysis of a second independent variable called "experience". Holding constant the level of education, we would expect someone who has been working for a longer time to earn more (O. Sykes, 2000).

A multiple linear regression model with k independent variables has the equation

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + \varepsilon \qquad 3.4$$

ε is a random variable with mean 0 and variance σ^2. A prediction equation for this model fitted to data is

$$\hat{y} = b_0 + b_1 x_1 + ... + b_k x_k + \varepsilon \qquad 3.5$$

Where $\hat{y}$ denotes the "predicted" value computed from the equation, and b_i denotes an estimate of β_i (stat.ufl.edu).

Concerning price transmission, most of the previous study uses simple correlation coefficient (Minot, 2010). A high correlation coefficient is evidence of co-movement and often interpreted as a sign of an efficient market. Another early approach was to use regression analysis on contemporaneous prices, with the regression coefficient being a measure of the co-movement of prices. For example, Mundlak and Larson (1992) estimate the transmission of world food prices to domestic prices in 58 countries using annual price data from the FAO. They find very high rates of price transmission: the median elasticity of transmission was 0.95, implying that 95% of any change in world markets was transmitted to domestic markets.

The static regression approach has been criticized for assuming instantaneous response in each market to changes in other markets. In fact, there is generally a lag between the price change in one market and the impact on another market due to the time it takes traders to notice the change and respond to it. A change in world prices may take more than a month to be reflected in domestic prices. These dynamic effects can be captured by including lagged world prices as explanatory variables in the regression analysis (Ravallion, 1986; Timmer, 1987).

The advantages and the disadvantage of using multiple linear regression analysis in price transmissions are

Advantage

- Gives information to calculate transmission elasticity
-Can test relationships statistically
-Can take into account lagged effects, inflation, and seasonality;
- Can analyze the relationship of greater than two prices,

Disadvantages

- Awkward to do in Excel (easier with STATA or Statistical Package for the Social Sciences (SPSS))
- Misleading results if data are non-stationary regression analysis. (Minot 2010),

3.1.4 Co-integration analysis

Cointegration theory is definitely the innovation in theoretical econometrics that has created the most interest among economists in the last decade. The definition in the simple case of 2 time series X_t and Y_t, that are both integrated of order one (this is abbreviated I(1), and means that the process contains a unit root),

Definition:

A vector of I(1) variables y_t is said to be cointegrated if there exist at vector β_i such that $\hat{\beta}_i y_t$ is trend stationary. If there exist r such linearly independent vectors β_i , i= 1,...,r, then y_t is said to be cointegrated with cointegrating rank r. The matrix $\beta = (\beta 1, \ldots \beta r)$ is called a cointegration matrix (Bent, 2005). The main concept of Cointegration (Granger, 1981) and the estimation of Cointegration give us a framework for estimating and testing for long run equilibrium relationships between non-stationary variables (inter alia Engle and Granger, 1987; Johansen, 1988, 1991, 1995).

A time series is said to be stationary if there is no systematic change in mean (no trend), if there is no systematic change in variance and if strictly periodic variation have been removed (Chatfield, 2004). On the other hand, a non-stationary series has statistical property which is time dependent. Non-stationary series may contain stochastic or deterministic trends.

Consider two prices, p_{1t} and p_{2t} contain stochastic trends and are integrated of the same order, say I(*d*), and the two prices are in spatially separated market, then the price are said to be cointegrated if

$$P_{1t} - \beta P_{2t} = \mu_t \qquad 3.6$$

Where β is referred to as the cointegrating vector, whilst equation (3.6) is said to be the cointegrating regression. The above equation can be estimated by utilizing *inter alia* Ordinary Least Squares (OLS) (Granger, 1987) or a Full Information Maximum Likelihood method developed by Johansen (1988, 1991). The main concept of Cointegration is that, in the long run these prices are closely moving together, even if there may be a drift apart in the short run, and this is consistent with the idea of market integration. Engle and Granger test the null of no Cointegration by applying unit root tests on $\hat{u}_t$. Johansen derived the distribution of two test statistics for the null of no cointegration referred to as the Trace and the Eigenvalue tests (FAO, 2003).

As μ_t is stationary, these prices have a trend in the long run proportionality; β measures the long run relationships between the two prices. According to Balcombe and Morrison (2002), this measurement has sometimes referred to as the elasticity of price transmission; this is when the prices are converted to logarithms. On the other hand, this cointegrating parameter does not identify this elasticity, or in other words, the completeness of transmission.

Besides testing market integration, the general idea of Cointegration has an important implication, alleged by the Granger Representation Theorem (Engle and Granger, 1987). According to this theorem, if two trending, say I(1), variables are cointegrated, their relationship may be validly by an Error Correction Model (ECM), and vice verse. In the case that prices from two spatially separated markets, p_{1t} and p_{2t}, are cointegrated, the Vector Error Correction (or VECM) representation is as follows:

$$\begin{pmatrix} \Delta P_{1t} \\ \Delta p_{2t} \end{pmatrix} = \begin{pmatrix} \mu_1 \\ \mu_2 \end{pmatrix} + \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} (p_{1t-1} - \beta p_{2t-1}) + A_2 \begin{pmatrix} \Delta p_{1t-1} \\ \Delta p_{2t-1} \end{pmatrix} + \ldots + A_k \begin{pmatrix} \Delta p_{1t-k} \\ \Delta p_{2t-k} \end{pmatrix} + \begin{pmatrix} v_{1t} \\ v_{2t} \end{pmatrix} \qquad 3.7$$

In equation 3.7, p_{1t} and p_{2t} along the respected changes, ΔP_{1t} and Δp_{2t} are the central variables for the explanation of error correlation model. Matrix's that contains A_2 to A_k measures the short run effect of the model, β is the cointegrating parameter that characterizes the long run equilibrium relationship between the two prices. The levels of the variables enter the ECM combined as the single entity ($p_{1t-1} - \beta p_{2t-1}$) which reflects the errors or any divergence from this equilibrium, and correspond to the lagged error term of equation (3.7), the vector α_1 and α_2 contains the parameters that explains the error correction

coefficient and usual between 0 < /α/ <1, i= 1,2, and it measures the extent of corrections of the errors that the market initiates by adjusting p_{1t} and p_{2t} towards restoring the long run equilibrium relationship. We can see the speed of α_i(it is near to one or not) to judge whether the market returns to its equilibrium, according to this statement short run adjustments are directed by, and consistent with, the long run equilibrium relationship. This give a chance to the observer to determine the speed of adjustment that shapes the relation between the two prices (fao.org). Another important point about Cointegration is the concept of causality. Granger (1987) explains that if there is a Cointegration between two time series, causality will exist at least in one direction. The idea of causality testing has been used by economic historians interested in the industrial revolution, for instance Hatton and Lyons (1983) consider export-led growth, and Tsoulouhas (1992) the link between population and technology. However without cointegration causality tests may yield spurious results. Engle and Granger (1987), prove that;

"*If two series are individually I(1), and cointegrated, a causal relationship will exist in at least one direction. Furthermore, the Granger representation theorem demonstrates how to model cointegrated I(1) series in the form of a vector autoregressive model (VAR) model. In particular, the VAR can be constructed either in terms of the levels of the data, the I(1) variables; or in terms of their first difference, the I(0) variables, with the addition of an error correction term (ECM) to capture the short-run dynamics. If the data are I(1) but not cointegrated, causality tests cannot validly be derived unless the data are transformed to induce stationary which will typically involve tests of hypotheses relating to the growth of variables*" (Les and Greasley, pp 1389)

The above definition has results significant dispute in the literature (Pagan, 1989) as it really shows precedence, rather than instantaneous causality that the majority of economists profess. However, if there is an integration between the two markets, the price in one market, p_1, would commonly be found to Granger-cause the price in the other market, p_2 and/or vice versa. Thus, Granger Causality gives us additional evidence weather or in which direction price transmission is occurring between two series. We here seriously note the following.

"*Granger causality may exist, indicating that, although the two price series drift apart due to other factors such as non-stationary transaction costs, some price signals are passing through from one market to another. On the other hand, lack of Granger causality may not imply an absence of transmission, as price signals may be transmitted instantaneously under special circumstances*" (fao.org).

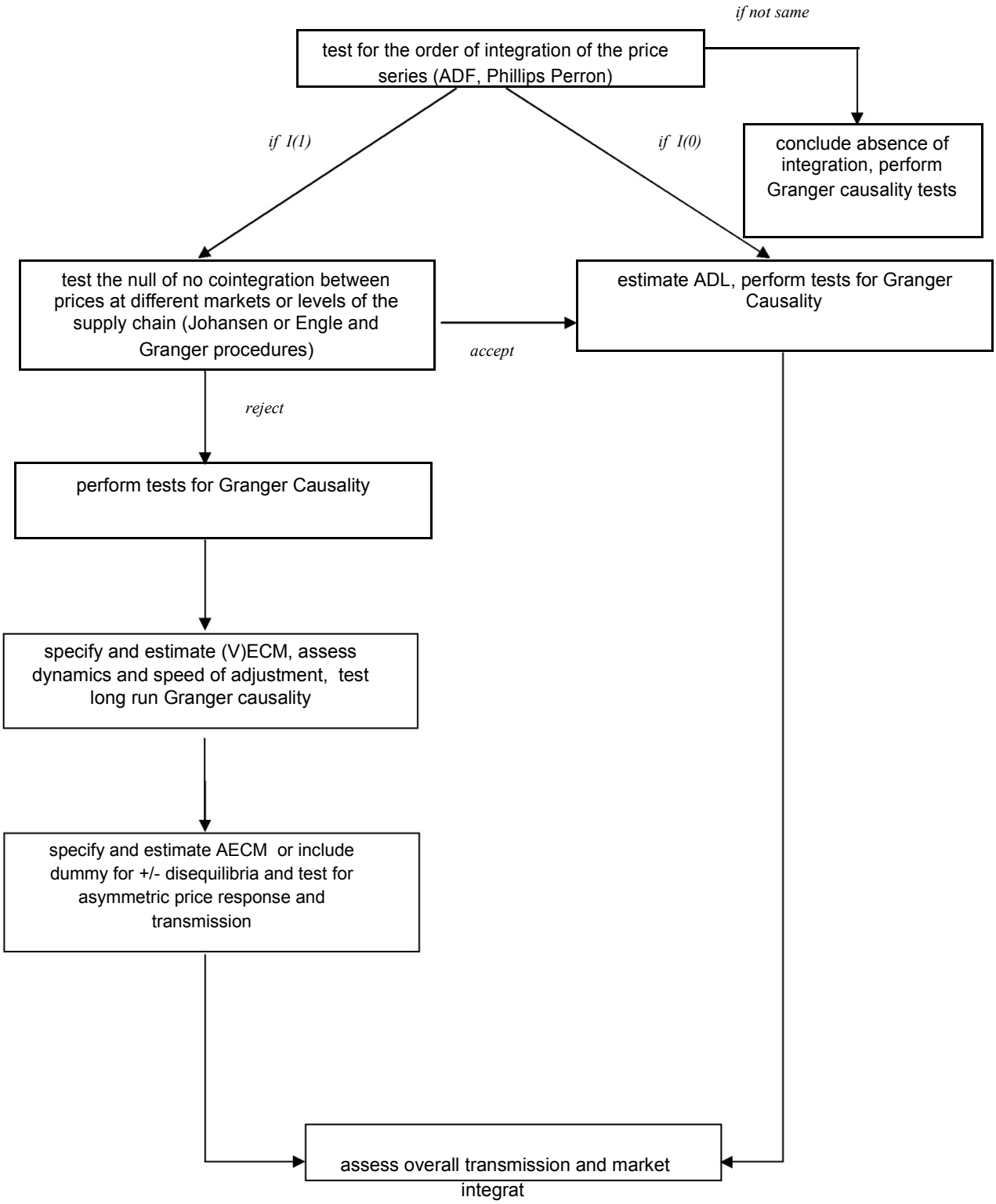
The Error Correction Model (ECM) is an additional source for testing for non-linear adjustment to the long run equilibrium and asymmetric price transmission. Lee and Granger (1989) suggested an Asymmetric Error Correction Model (AECM) where the endogenous variable speed of adjustment depends on whether the deviation from the long run equilibrium is positive or negative. The single asymmetric ECM is specified as follows:

$$\Delta p_{1t} = \mu_1 + \alpha_1^{+} (p_{1t-1} - \beta p_{2t-1})^{+} + \alpha^{-}_1 (p_{1t-1} - \beta p_{2t-1})^{-} + \sum_{i=1}^{k} \delta_i \Delta p_{2t-i} + \sum_{i=1}^{n} \delta_i \Delta p_{1t-i} + v_{1t} \qquad 3.8$$

From the above equation, the divergence equilibrium equation has two parts, $(p_{1t-1} - \beta p_{2t-1})^{+}$ and $(p_{1t-1} - \beta p_{2t-1})^{-}$ expressing positive and negative disequilibrium respectively. According to FAO working paper "asymmetry occurs in the event when positive and negative divergences from the long run equilibrium between p_{1t} and p_{2t} result in changes in p_{1t} that have different magnitude. Therefore, asymmetric transmission implies that α^{+}_1 is not equal to α^{-}_1. The null of symmetry against the alternative hypothesis that adjustment is asymmetric is tested by imposing the equality restriction, $\alpha^{+}_1 = \alpha^{-}_1$" (FAO, 2003 p 58).

Consider the above empirical tools that can be used to assess the nature of market integration and price transmission, the next discussion is to show how to apply the basic time series techniques (FAO, 2003), (See also figure 3.1). The sequence of the test is

Figure 3.1 cointegration and vector error correction model.



Source: FAO working paper 2003

1. Start by testing the Augmented Dickey-Fuller (Dickey and Fuller, 1979) or the Phillips and Perron tests (Phillips and Perron, 1988). Dickey and Fuller developed a procedure for testing whether a variable has a unit root or equivalent that the variable follows a random walk.

2. After testing the Augmented Dickey-Fuller, we can see that the series are integrated with the same order (say I(1)), or not. If the series are integrated (say I(1)), we can test the null of non Cointegration against one cointegrating vector using the Johansen procedure (Johansen 1988, 1991).

3. If the prices are cointegrated then we focus on error correction representation, in the form of a vector error correction model (VECM) and observing carefully the speed of adjustment, the short run dynamics and the direction of granger causality in the short or the long run following Granger (1969, 1988) causality test.

4. The next task is to specify asymmetric error correction model (AECM) based on the results on the direction of causality and test for the null of symmetry following Granger and Lee (1989).

5. Discuss on the result and comments on the nature of price transmission and market integration.

Note that, for this particular thesis I used the method of Cointegration analysis because

- It consider lags
- It does not give misleading results if the data are non-stationary, moreover
- It help to build an error-correction model (ECM), the dynamic co-movement among variables and the adjustment process towards long-term equilibrium (Koh and Ramin, 1995),which I am particularly interested.

4 Mathematical formulation of coffee price in Ethiopia

In the literature review section, the law of one price is discussed, which states that when one price is converted to a common currency, the same good should sell for the same price in different markets. Samuelson also defines the Spatial Equilibrium Model, as the models solving the simultaneous equilibrium of plural regional markets under the assumption of the existence of transportation costs between two regions (Samuelson, 1951). The same model is discussed by Enke (1951) and Takayama and Judge (1971).

In our case of the Ethiopian coffee, we have three different market prices of coffee, let's further assume that

ppn_t= producer price of coffee at national level in a given time period (t).

apn_t = auction price of coffee at the national level in a given time period (t).

fpn_t = foreign price of coffee at national level in a given time period (t).

T_{pa} = transportation cost from the producer to the auction market.

T_{pf} = transportation cost from producer to foreign market.

T_{af} = transportation cost from auction to foreign market.

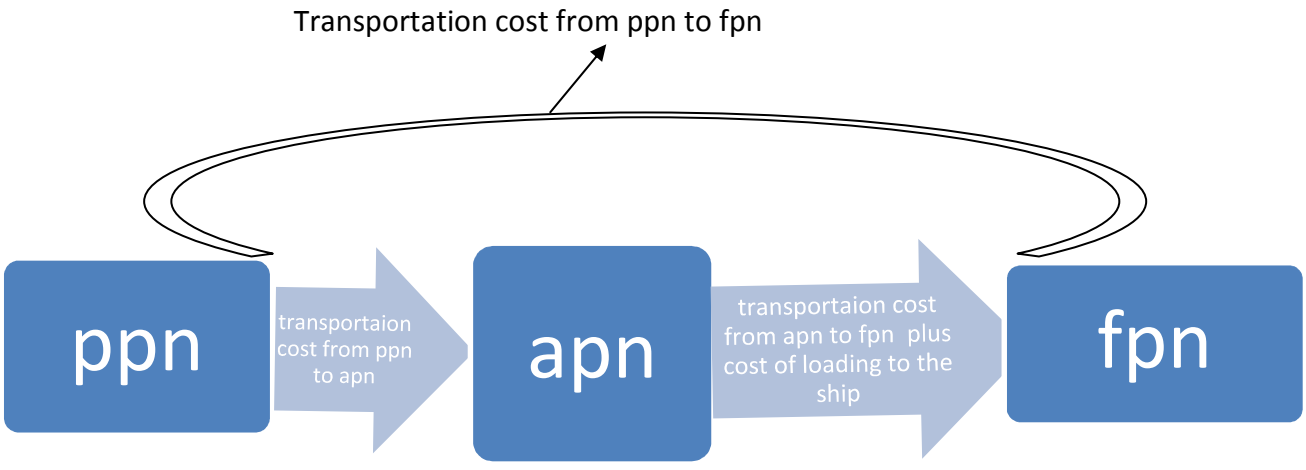


Figure 4.1 outline of the three major coffee prices

According to the model, "*given prices for a commodity in two spatially separated markets p_{1t} and p_{2t}, the Law of One Price and the Enke-Samuelson-Takayama-Judge model postulate that at all points of time, allowing for transfer costs c, for transporting the commodity from market 1 to market 2, the relationship between the prices is $p_{1t} = p_{2t} + c$.*" (Robert 2006, pp 10)

In our case, the coffee price in auction market is equal to the producer price plus transportation costs (see also Rapsomanikas et al. (2004), Fortenbery and Zapta (2004), Krivonos (2004)).

$$apn_t = ppn_t + T_{pa} \quad 4.1$$

Similarly, the equilibrium in coffee price between auction market and foreign market is

$$fpn_t = apn_t + T_{af} \quad 4.2$$

The equilibrium in coffee price between foreign and producer price is

$$fpn_t = ppn_t + T_{pf} \quad 4.3$$

Assume that R_{pa}, R_{af} and R_{pf} are constant ratios that coffee price in two markets is attain in equilibrium in producer – auction, auction –foreign, and producer – foreign market respectively. (i. e. ppn/apn=R_{pa}, apn/fpn= R_{af}, ppn/fpn= R_{pf}) then

$$apn_t = ppn_t * R_{pa} \quad 4.4$$

$$fpn_t = apn_t * R_{af} \quad 4.5$$

$$fpn_t = ppn_t * R_{pf} \quad 4.6$$

In the above equations, Q(4.4) to Q(4.6), R_{pa}, R_{af} and R_{pf} are hypothesized to be greater than one. This is because the price in the three markets should be related as fpn > apn > ppn. Hence, we can measure the transportation costs in the following ways from Q(4.1) to Q(4.3).

$$T_{pa} = apn_t - ppn_t \quad 4.7$$

$$T_{af} = fpn_t - apn_t \quad 4.8$$

$$T_{pf} = fpn_t - ppn_t \quad 4.9$$

In the short run, the equilibrium relationships in equation (4.2) to (4.6) need not to exist due to the incomplete transfer of information. However, they will be equilibrium relationships in the long run.

The transfer cost in the equilibrium is the fixed ratio of the two locational prices. From our equations (4.7), (4.8) and (4.9) , dividing these equations by apn_t, fpn_t and again fpn_t then we get

$$Tp_a/apn_t = (apn_t - ppn_t)/apn_t = 1 - ppn_t/apn_t = 1 - R_{pa} \quad 4.10$$

$$T_{af}/fpn_t = (fpn_t - apn_t)/fpn_t = 1 - apn_t/fpn_t = 1 - R_{af} \quad 4.11$$

$$T_{pf}/fpn_t = (fpn_t - ppn_t)/fpn_t = 1 - ppn_t/fpn_t = 1 - R_{pf} \quad 4.12$$

In the literature of this paper, the equilibrium price of coffee has time series patters in relation to Cointegration analysis (see also Fortenbery and Zapta (2004), Krivonos (2004)). We can write equation (4.4) to (4.6) as

$$apn_t = ppn_t + R_{pa} \quad 4.13$$

$$fpn_t = apn_t + R_{af} \quad 4.14$$

$$fpn_t = ppn_t + R_{pf} \quad 4.15$$

Assume further that in equations (4.13) to (4.15), if auction price is cointegrated with producer price, foreign price is also cointegrated with auction price and producer price with same variable β, then

$$apn_t - \beta_1 ppn_t = \omega_{1t} \quad 4.16$$

$$fpn_t - \beta_2 apn_t = \omega_{2t} \quad 4.17$$

$$fpn_t - \beta_3 ppn_t = \omega_{3t} \quad 4.18$$

Here ω_{1t}, ω_{2t} and ω_{3t} represent a stationary process with a constant mean that the two prices are cointegrated.

According to Engle and Granger (1987), certain economic series are such that they should not drift too far apart from each other. This means that the variables may depart from each other in the short run, but there are certain mechanisms that force them back to a common path after some periods. Examples of such series are, the price of a certain commodity sold at two different locations, wages and expenditure, etc., this means that we are able to hypothesis a long run relationships between the two coffee markets in Ethiopia. Besides this, there exist linear combinations of the random variables that are stationary in our equation (4.4) to (4.6) (Johansen, 1988).

We can express equations (4.13) to (4.15) in the long run to fit together by using the vector error correction model (VAR-ECM), starting by defining the basic framework and then considering an n – dimensional vector autoregressive error correction model. The model has the following general form (Minot, 2010)

$$\Delta P_t = \alpha + \prod p_{t-1} + \sum_{k=1}^{q} \Gamma_k \Delta p_{t-k} + \varepsilon_t \qquad 4.19$$

Where

p_t is an nx1 vector of n price variables,

$\Delta$is the difference operator, so $p_t = p_t - p_{t-1,}$

ε_t is an nx1 vector of error terms, and

α is an nx1 vector of estimated parameters that describe the trend component

Π is an nxn matrix of estimated parameters that describe the long-term relationship and the error correction adjustment, and

Γ_k is a set of nxn matrices of estimated parameters that describe the short-run relationship between prices, one for each of q lags included in the model.

The vector error correction model tests for the effects of one variable on each other variables. In our study, it measures the effect of world price to domestic price and auction price. For our particular purpose the above equation is being simplified as

a, the relation between domestic and auction price

$$ppn_t = \alpha + Q(ppn_{t-1} - \beta apn_{t-1}) + \partial \Delta apn_{t-1} + þ \Delta ppn_{t-1} + \varepsilon_t \quad 4.20$$

b, the relation between domestic and foreign price

$$ppn_t = \alpha + Q(ppn_{t-1} - \beta fpn_{t-1}) + \partial \Delta fpn_{t-1} + þ \Delta ppn_{t-1} + \varepsilon_t \quad 4.21$$

c, the relation between auction and foreign price

$$apn_t = \alpha + Q(apn_{t-1} - \beta fpn_{t-1}) + \partial \Delta fpn_{t-1} + þ \Delta apn_{t-1} + \varepsilon_t \quad 4.22$$

Where ppn_t is producer price at time t

apn_t is auction price at time t

fpn_t is domestic price

Δ is the difference operator, so $\Delta p_t = p_t - p_{t-1}$

α, Q, β, , and þ are estimated parameters, and

ε_t is the error term

As describe in chapter three of this paper (figure 3.1) if the original price series are I(1), then the first differences (Δp) will be stationary, or I(0). The coefficients in the error-correction model can be interpreted as follows:

1. β is the long-run elasticity of price transmission, if for example β=0.4 in equation (4.21), this means that 40% of the foreign price will be transmitted to the producer price in the long run.

2. Q is the speed of adjustment. The term in parentheses represents the deviation or "error" between the prices in the previous period and the long-run relationship between the two prices.

3. The coefficient on change (∂) is the short run elasticity of one price relative to the other price. If for example in equation (4.21) it represents the percentage adjustment of producer price one period after 1% shock in the foreign price.

4. þ represents the effect of each change in the price on the change in the same price in the next period.

By using the VAR –ECM Model, we can do the following analyses.

1. We have to test the presence of Cointegration, and if it is, we have to identify the number of Cointegration. Once the number of Cointegration Vectors has been determined, we can return to the model formulation, re - estimating the model under the restriction that there are say, r cointegrating vectors. We will then estimate R VECM with only stationary variables. At this point, we only know that there are stationary relations among the data series. We don't know what they represent yet (Bo Sjö, 2008).

Many economic time series are cointegrated and require specialized statistical methods to analyze them. Economic variables, such as consumption, investment, and income, tend to grow over time, while the differences between any two of those variables never deviate too far from a constant equilibrium value. VECMs are used to model such relationships.

2. Test for long run homogeneity is a valid restriction
3. Estimating the speed and adjustment in the long run relationships
4. If prices are away from the long run cointegrating relationships, then which prices adjust, (is that producer price, FOB price, auction price or all price)

5 Source of data and estimation of error correlation model

This chapter mainly focuses on three main sub topics. The first subtopic summarizes the sources of data; the second sub topic of this chapter examine historical price of coffee and its volatility for two decade by considering the international coffee agreement. This gives a broad understanding to the reader how the price looks like. Besides this, the sub topic also includes graphical analysis of price convergence. The last part details the explanation of the model by using econometric tools for estimating equation (4.16) to equation (4.22) that formulated in chapter four of this study.

5.1 Source of data

The main source of data is the Central Statistical Agency of Ethiopia (CSA). The activities and the mandate of the Central Statistical Agency (CSA) of Ethiopia are aimed at the production of statistical data required for development planning, monitoring and evaluation of all sectors of the economy. To achieve this, the Agency conducts several surveys to collect and compile economic statistics in various sectors, as one of the main objectives of the CSA to steadily develop and improve the system of economic statistics in order to extend and intensify data collection and improve the quality of the statistical data in the country (csa.gov.et). The producer price of coffee (ppn) was collected from a monthly survey report by CSA. The other two price types called, auction price (apn) and foreign price (fpn) are from the Ministry of Agriculture and Rural Development (MOARD). This government ministry oversees the agricultural and rural development policies of Ethiopia on a Federal level. Foreign price refers to the price of each coffee type, which includes the value of coffee plus cost of transportation to port including cost of loading onto ship.

Data was collected from December 1991 to April 2009 on monthly basis (around 209 observations). Four major exported coffee types have taken into consideration; these are Sidama, Harar, Wollega and Jimma for Producer, auction and foreign price lists. (See delimitation of the study how coffee types are selected).

5.2 Coffee price after 1991 in Ethiopia

The world coffee market has adramaticy change for the last twodecaded. The situation is the same for Ethiopian coffee market, as Ethiopia is active in the world market and generates 60% of the total export earnings (Worako al el, 2008). This is because of many factorial changes including weather, international policy environment and technological changes.

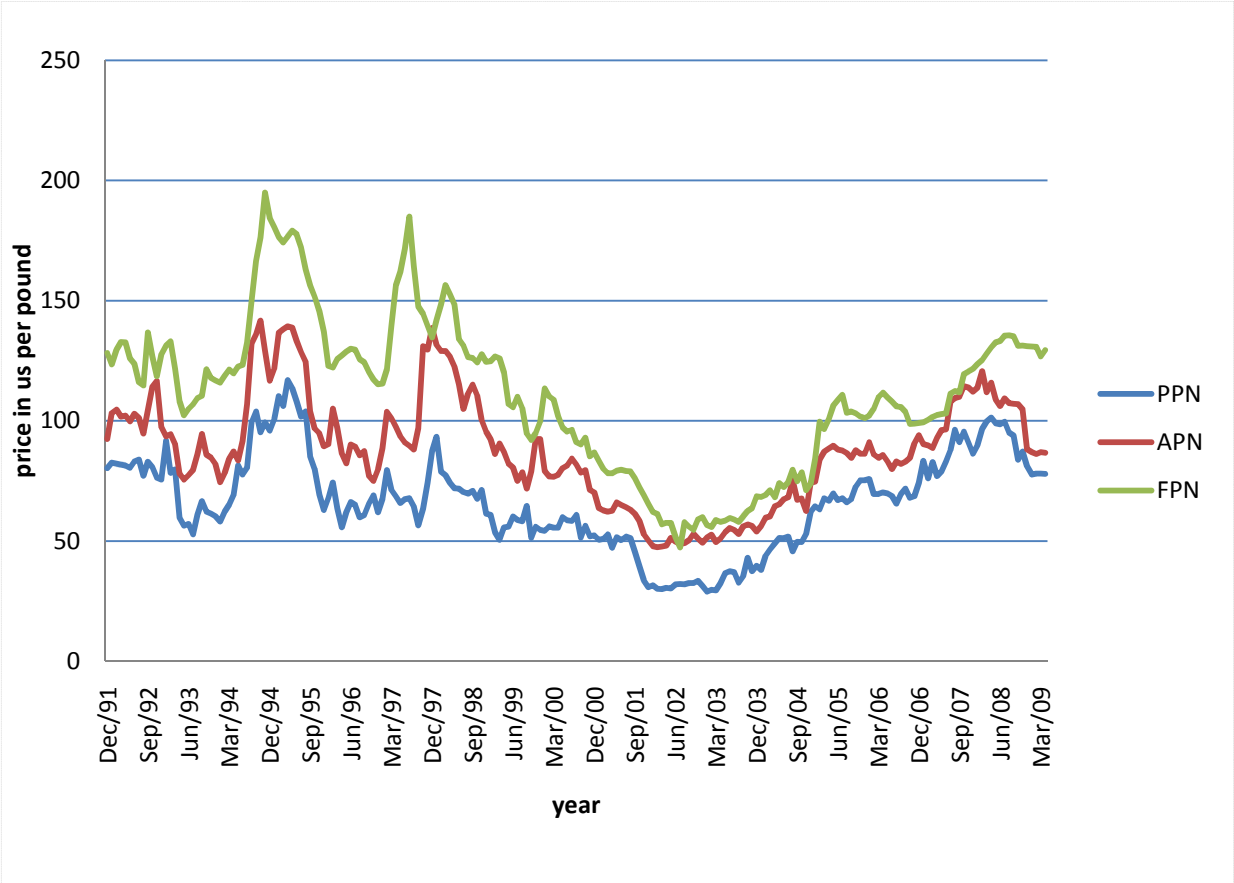


Figure 5.1 producer, auction and foreign price in Ethiopia (source: own source)

In 1993/94 and 1997, the price of coffee rises up (see figure 5.1). This is the direct impact of the international coffee market that the supply of coffee in the world market decreases. The shortage in the supply of coffee was the extreme weather events called “El Nino “.The most severe effects from any El Nino system are found close to the equator, coffee growing regions around the world were experiencing major weather upheavals. While El Nino rains were bringing mudslides and disaster to Peru, Colombia was suffering from a lack of rain so severe that its coffee harvest was at risk. Nonstop, torrential rains brought an outbreak of epidemic in East Africa (allbusness.com). In 2000, the price of coffee was falling in the world

market and reaches to its lowest real value in 100 years of history. This is because of overproduction of coffee in the international market. In 2003, for example, 112 million to 114 million 60 kg bags of coffee were produced, compared to the 85 million bags currently consumed (Suri, 2004). According to Oxfam (2001), more than five billion pounds of coffee go to waste each year. Given that demand for coffee is growing very slowly while global production continues to expand, most analysts predict that coffee's price recovery will be slow (Varangis et al. 2003).

From the above graph, we can see that there is a high price fluctuation in the market. In the next sub chapter, I summarize the volatility of coffee because it helps to understand the price fluctuates in the short as well as in the long run.

5.2.1 Coffee Price Volatility

In agricultural commodity markets, volatility is a historical word always mentioned by economists and market makers. According to international coffee council paper 94-5,

"*Volatility is a statistical measure of price fluctuations over a given period. It measures the size of the increase or decrease in prices in a short period. It does not measure price levels but their degree of variation from one period to the next. Marked volatility indicates a rapid swing from low to high or high to low prices. In the case of coffee prices, volatility is strongly influenced by supply and demand conditions. For coffee producers, volatility becomes a matter of concern when there is a fall in prices or a price correction. When there is a significant upturn in prices, it merits little attention. A highly volatile market has a higher standard deviation, i.e. a high historical volatility. A market without pronounced price fluctuations would be characterized by a low standard deviation and low historical volatility*" (International Coffee Council, 2005, pp 2).

There are different types of volatility, but the two most common are historical volatility, which is the most commonly used measure. This is the simple standard deviation of previous daily, weekly, or monthly percentage change in price. The other one is implied volatility, which is derived from options, and aim to predicate actual volatility (Gilbert and Brunetti, 1995).

	Volatility			
Year	PPN	APN	FPN	No. Of Obs.
1991 - 1993	11,15 %	11.14 %	9.86 %	25
1994 - 2000	16.82 %	21.09 %	27.18 %	84
2001 - 2006	15.68 %	14.91 %	19.32 %	72
2007 - 2009	8.36 %	10.99 %	12.47 %	28

Table 5.1, volatility according to the ICO agreement

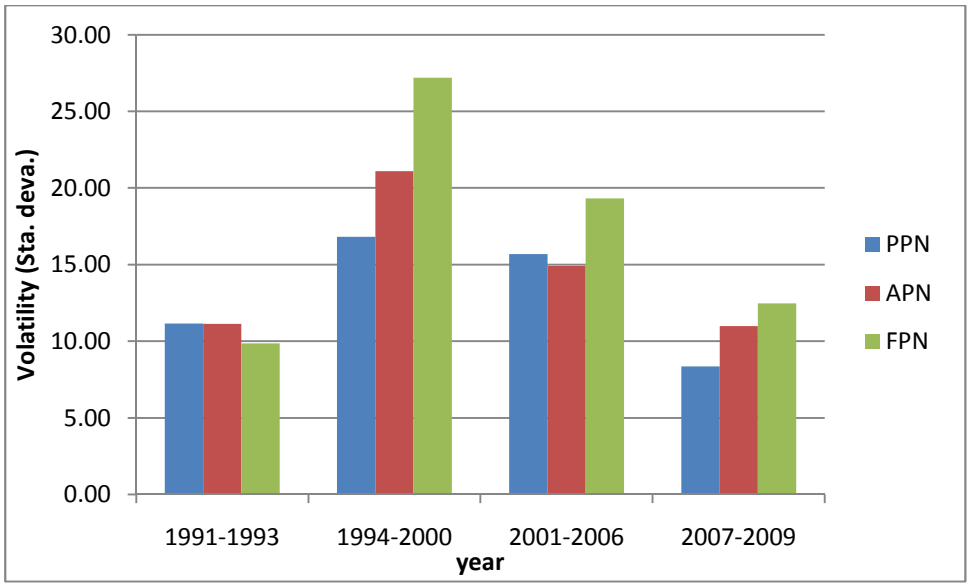


Figure 5.2, coffee price volatility

Source: own sources

From the table and the graph above, during the period of 1991 – 1993 volatility was relatively weak comparing from the period 1994 -2000. This period was the period that the quota system introduced in the international coffee agreement. This system introduced in 1980 and then suspended in 1986, after the suspension of the quota system, coffee volatility was relatively stable.

From the period 1994 to 2000, coffee price was highly volatile. In 1997, the price reaches the maximum level (see figure 5.1). At the end of 1997 coffee price, start declining in all markets. The fall in the price from 1997 to 2000 was very dramatic and the lowest in real terms for 100 years. According to the ICO, the reason for this is the current imbalance between supply and demand for coffee. Total production in coffee year 2001/02 (October-September) is estimated at around 113 million bags (60-kg bags) while world consumption is just over 106 million bags. On top of that, world stocks amount to some 40 million bags. Coffee production has been rising at an average annual rate of 3.6%, but demand has been increasing by only 1.5%. At the origin of this coffee glut lies the rapid expansion of production in Vietnam and new plantations in Brazil, which is harvesting a record crop in the current season (ico.org). Due to the above reason the ICO come up with a new agreement in 2001, one of whose objectives is to encourage its members to develop a sustainable coffee economy. The ICO recognizes that sustainable development has an economic and social as well as environmental dimension. There is little doubt that the exodus from rural areas and increased poverty in coffee producing areas caused by the current price crisis poses a very real and wide-ranging threat to sustainable development.

Coffee price remained relatively stable from the period 2001 to 2007 comparing to 1994 to 2000 period. Finally, my test results indicate that volatility, measured based on monthly price variations, is relatively weak from the period 2007 to 2009 (see table 5.1).

From this analysis, we can see that coffee price volatility mainly influenced by supply and demand. The supply situation was influenced by some exogenous factors like climatic conditions in supplying countries. (El Nino, drought, floods). On the demand side, as all the demand comes from the developed world, the economic and industrial situations in developed countries looks the main factors. The ICO is also playing a vital role in stabilizing the volatility by introducing and suspending quota system, by using sustainable coffee economy ideas, using intergovernmental consultations, increasing transparency and the access to information.

5.2.2 Graphical analysis of price convergence

In the literature on market integration and the Law of One Price, the term “price convergence” is often discussed. However, there is a potential risk of confusion concerning

what is actually meant by “price convergence”, since there is a lack of terminology consistency in the literature. Generally, two forms of price convergence may be distinguished: short run price convergence and long run price convergence. In brief, the difference between the two is whether two regional markets are integrated (in the sense that if transaction costs decrease over time and/or there is a better signal for optimal decision) or whether they are moving towards market integration (Gluschenko, 2005).

Short run convergence

The first of the two forms of price convergence concerns the case where two regionally separated areas, e.g. A and B, are part of the same market, i.e. the two markets are integrated. If this is the case, the price of a certain good in region A cannot diverge limitlessly from the price of the same good in the region B. If the price difference should ever increase to more than the cost of transporting the good between the regions, arbitrage mechanisms will cause this difference to disappear.

Long run price convergence

Long run price convergence is the process towards the integration of two separated markets. Long-run convergence entails a gradually narrowing gap between the prices in different regions. Studies of long run price convergence have its methodological origins in development economics and studies of economic growth (Durlauf & Quah, 1999). In these cases, whether or not incomes in different regions are converging has been the key research question. However, the methodology and the concepts are well suited for the studies of long- run convergence of prices as well and have been used for this purpose in a number of studies (Ramírez, 1999; Gluschenko, 2005; Robinson, 2007). The econometric techniques for determining whether variables have converged over time have mainly applied to cross-country studies in real income convergence (Sala-I-Martin, 1995; Baumol and Wolff, 1986).

To get an initial idea on whether coffee prices have converged in our three different markets, I consider the concept, which was developed by Constantin (2005). If for example we consider producer (PPN) and auction (APN) markets, the short run convergence can be expressed as $apn_t - ppn_t = 0$ where t=0…T and the long run convergence also illustrated as $\lim_{n\to\infty}(apn_t - ppn_t) = 0$ (see also Constantin, 2005).

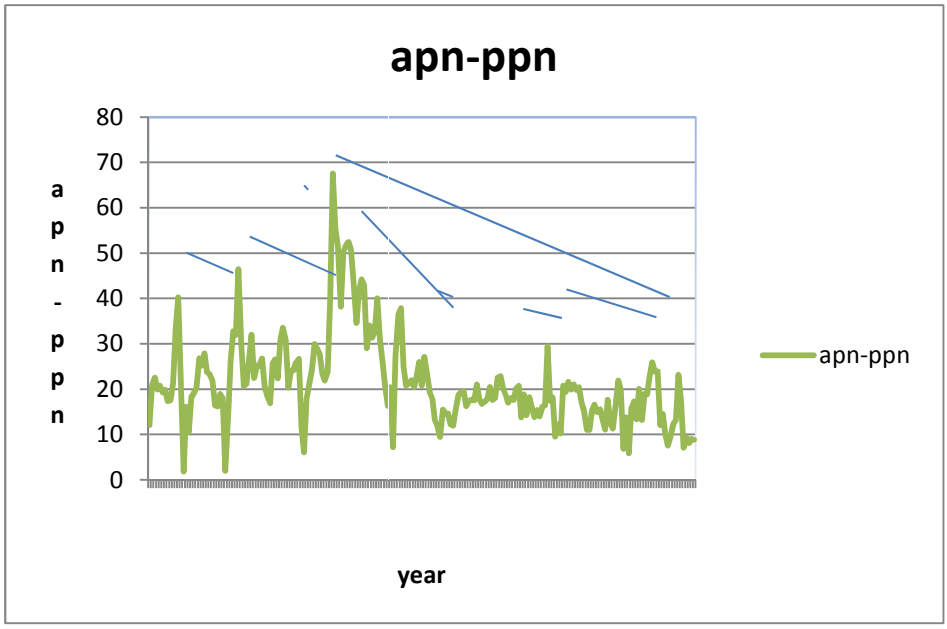


Figure 5.3 price differences between APN and PPN

In Figure 5.3, the small negatively sloped lines show as a short run convergence while the long negatively sloped line represents the long run price convergence between the two markets. We can clearly see from the graph that the difference between the two markets become converged over time in the long run since 1998. This year was the turning point in the Ethiopian coffee industry because, the government proposes a law (Pro.No.99/1998) that consolidation of all the taxes and duties levied on the coffee exporters into a single tax family, abolishing of the quota system at auction, allowing private traders to trade washed coffee, suppliers and exporters to sell coffee domestically at market-determined prices.

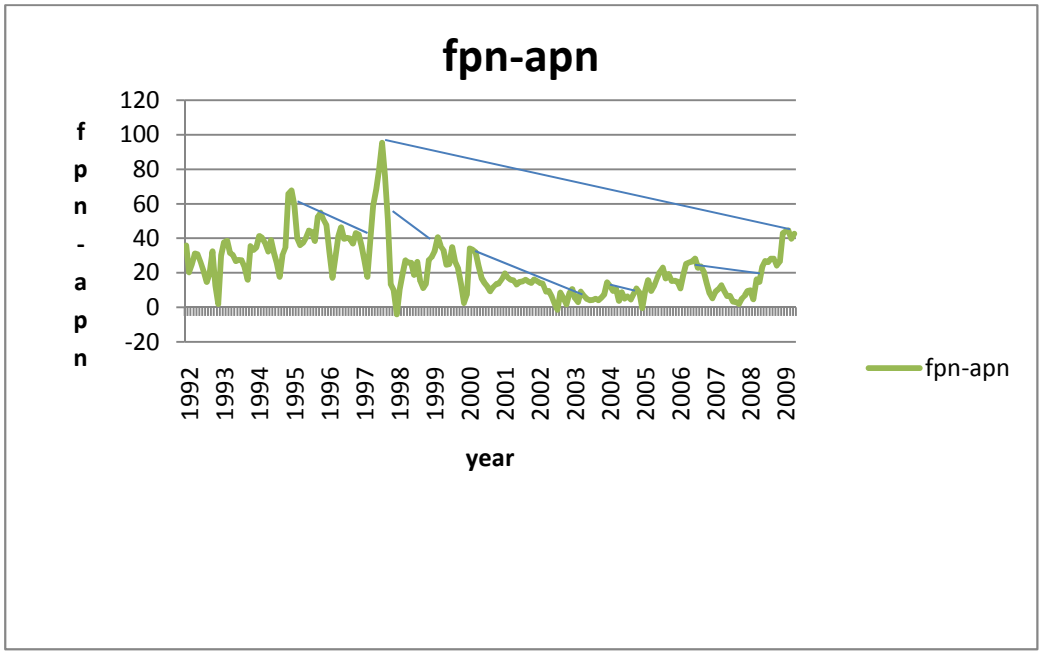


Figure 5.4-the price difference between FPN and APN

A comparison of the price difference between foreign market and auction market, (FPN – APN) is display in Figure 5.4. The Figure indicate that even if there is an indication for price convergence in the long run, the speed of convergence is not as fast as in the case of APN-PPN market (compare the slope of the two graphs). According to the economics theory, international trade in the coffee market should lead to gradual price convergence across the international and the auction market. Remember here that what the law of one price says. According to this law, the price of coffee in the auction market is the same as the price in the international market allowing for the difference in the transportation costs. It is clear that the FPN – APN market is less to converge relative to the APN-PPN market.

When we examine the price difference between foreign market and local market, we get the following graph.

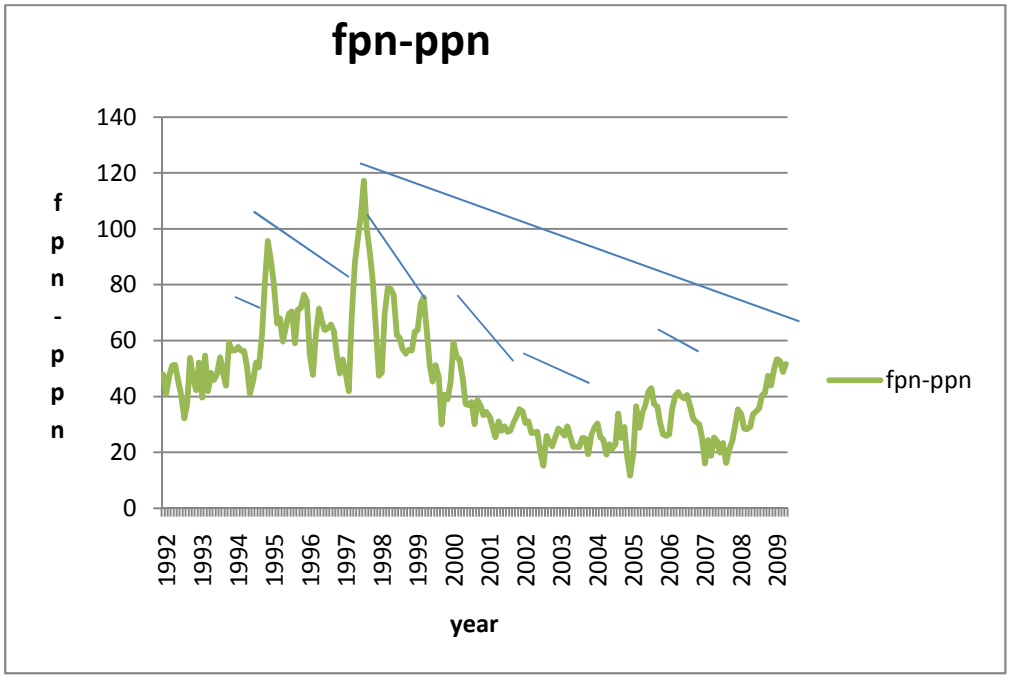


Figure 5.5-Price difference between FPN and PPN

Figure 5.5 above is similar to Figure 5.3 (APN – PPN), which means that there is relatively slow convergence in the two markets but the speed of convergence is low comparing to the other two markets. This is because of the gap between foreign and producer market.

The above three graphs are simply to give the reader a broad highlight how price in two different markets are converging over time.

5.3 Interpretation of the models

For analyzing and interpreting the model, I used basic econometric tools that simplify to estimate the error correction model. The sequences of the tests are followed from figure (3.1) of this paper.

5.3.1 Augmented Dickey Fuller (ADF) unit root test

I begin the analysis by examining the stationary properties of the variables using the Augmented Dickey-Fuller (ADF) Test (Dickey and Fuller, 1981). The following equation is estimated for each of the time series:

$$\Delta x_t = \alpha_0 + \alpha_{1t} + \beta_0 x_{t-1} + \sum_{i=1}^{k} \beta_i \Delta x_{t-1} + \varepsilon_t \qquad 5.1$$

Where Δ is the first difference operator; t is the time trend; k denotes the number of lags used and ε is the error term; α_s and β_s are parameters. The purpose of the unit root test is to determine whether the series is consistent with I (1) (integrated of order one) process with a stochastic trend, (Nelson and Plosser, 1982) or if it is consistent with an I(0) process. That is stationary, with deterministic trend, and still others to be integrated of order two (e.g., price indices in some countries) (Juselius, 1993).

Variable name	Test on	test statistics	Probability	decision	Order of Integration
PPN	Level	-2.012030	0.2816	No rejection	**I(1)**
	First difference	-15.06238	0.0000	Rejection	
APN	Level	-2.543525	0.1068	No rejection	**I(1)**
	First difference	-11.71673	0.0000	Rejection	
FPN	Level	-1.863115	0.3493	No rejection	**I(1)**
	First difference	-10.28081	0.0000	Rejection	

Table 5.2, Augmented Dickey-Fuller Test of Unit Root (Period: 1991 to 2009)

Table 5.2, above reports the results of the Augmented Dickey-Fuller (ADF) unit root test for PPN APN and FPN. The fact that level of the null hypothesis of the unit root cannot be rejected when the series are in level but can be rejected when the series are in first difference indicate that the series are integrated of order one. In all the above cases the time series are found to be non stationary and integrated by order I(1). This means that each variable is a random walk and integrated of the same order (I(1)). This is a necessary but not sufficient condition for cointegration (see Granger, 1986). The next step is to carry out co-integration analyses of the variables.

5.3.2 Testing the number of co-integration

Cointegration test is only valid the empirical data that we have is a non-stationary series. The main purpose of the Cointegration analysis is to test whether several non stationary time

series data are cointegrated or not, this test will help as to determine whether a long run relationship exists between the variables. Knowing the degree of Cointegration gives as a basis for VEC specification (Katarzyna, 2007).

I mathematically formulate an equation (4.16, 4.17 and 4.18) by assuming that the auction price is cointegrated with producer price, foreign price is also cointegrated with auction price and producer price with some variable β. The estimation of these equations held here. The software gives the Johansen test of Cointegration. Johansen proposes two different likelihood ratio tests: the trace test (table 5.3A) and maximum eigenvalue test (table 5.3B).

Table 5.3, Cointegration test (Series: PPN APN FPN)

A. Unrestricted Cointegration Rank Test (Trace)

Hypothesized No of CE (s)	Eigenvalue	Trace Statistic	0.05 critical value for trace statistics
None *	0.115910	37.50846	29.79707
At most 1	0.041643	12.37630	15.49471
At most 2	0.017969	3.699083	3.841466

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

B. Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No of CE (s)	Eigen value	Trace Statistic	0.05 critical value for trace statistics
None *	0.115910	25.13216	21.13162
At most 1	0.041643	8.677215	14.26460
At most 2	0.017969	3.699083	3.841466

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The trace test indicates that there is 1% significance Cointegration equation (table 5.3A), as the same time, the maximum eigenvalue test indicate also that there is one Cointegration

equation between the three variables (table 5.3B). Here we notices that both trace test and Max –eigenvalue test agree. Due to the result of these two tests, we can conclude that there is a long-term relationship between producer, auction and foreign prices; hence, the three prices are conjugated in the long run.

Since the long-run cointegrating relation found among the three variables, the estimation of cointegrating vectors is executed at the same time (equations 4.16, 4.17 and 4.18 of chapter 4). The value of the cointegrating vectors (β) for auction and producer market is as follows.

Table 5.4, Cointegration vector of APN- PPN (equation 4.16 in chapter 4)

One Cointegrating Equation	**Log likelihood**	-1254.61
Normalized cointegrating Coefficients (standard error in parentheses)		
APN	PPN	W_1
1.000	0.956 (0.16)	-24.41

According to table 9, we can derive a cointegrating equation between the auction price and producer price as follows,

$$apn = 0.956ppn - 24.41 \qquad 5.2$$

The Cointegration equation above suggests that a 10% permanent increase in the level of producer price results from an increase in the auction price by 9.56%. This indicates that the auction market is strongly co-integrated with the producer market in the long run. The value of the cointegrating vector (β) for foreign price and auction price in the long-run is also estimated as,

Table 5.5, Cointegration vector of FPN-APN (equation 4.17 in chapter 4)

One Cointegrating Equation	**Log likelihood**	-1273.64
Normalized cointegrating Coefficients (standard error in parentheses)		
FPN	APN	W_2
1.000	1.523 (0.14)	23.16

According to table 10, the Cointegration between foreign price and auction price is

$$fpn = 1.53apn + 23.16 \qquad 5.3$$

According to equation 5.3, it is clear that a 10% permanent increase in the level of auction price will result from a 15.3% change increase in the level of foreign price. This equation

indicates that even if there is a long run cointegration between foreign and auction market, the integration is relatively weaker than the producer auction market. (the above equation can also written as, $apn = 0.65fpn + 15.13$, which means that if FPN increase by 10%, APN will only increase by 6.5% in the long run.)

Similarly, the value of cointegration vectors (β) between foreign price and producer price in the long run is estimated as,

Table 5.6, Cointegration vector of FPN-PPN (equation 4.17 in chapter 4)

One Cointegrating Equation	**Log likelihood**	1279.01
Normalized cointegrating Coefficients (standard error in parentheses)		
FPN	PPN	W_3
1.000	1.739 (0.329)	4.486

From table 5.6, by using the estimator of Cointegration vector we can drive the Cointegration equation between the foreign and producer price as,

$$fpn = 1.739ppn + 4.486 \qquad 5.4$$

The equation above suggests that 10% permanent increase in the level of producer price will results from a 17.39% change increase in the level of foreign price. This Cointegration equation prove that the long run Cointegration between foreign and producer market is the weakest of all the three cases (The above equation can also written as $ppn = 0.57fpn + 2.58$, a 10% permanent increase in foreign market has only 5.7% impact on producer market in the long run).

5.3.3 The Granger Causality test

Granger causality implies there exist a relation between the current value of one variable and the past values of others (Granger, 1986). If past X contains useful information (in addition to the information in past Y) to predict future Y, we say X "Granger causes" Y. It does not mean changes in one variable cause changes in another. By using n-test jointly, test for the significance of the lags on the explanatory variables, this in effect 'Granger causality' test between these variables. It is possible that causality exists from variable X to Y, but not Y to X; from Y to X, but not X to Y and from both Y to X and X to Y. Although in the interpretation of the relationship is difficult. The 'Granger causality' test can also be used as

a test for whether a variable is exogenous. I.e. if variable in the model affect a particular variable; it can be viewed as exogenous.

Table 5.7, the granger causality test of PPN, APN and FPN

Null Hypothesis	F-Statistic	Probability
PPN does not Granger Cause APN	1.66526	0.14480
APN does not Granger Cause PPN	5.24274	0.00015
FPN does not Granger Cause APN	1.93670	0.08999
APN does not Granger Cause FPN	7.90805	8.5E-07
FPN does not Granger Cause PPN	0.72394	0.60622
PPN does not Granger Cause FPN	4.89141	0.00031

When we test Granger causality of producer and auction market, we cannot reject the hypothesis that the producer price does not Granger causes the auction price, but we do reject the hypothesis that auction price does not Granger cause producer price. Therefore, it appears that Granger causality runs one way here from auction to producer, and not on the other way. This evidence suggested that, in order to predict the price of future auction market, we need to depend on the producer price but not visa verse. Note the following that, if two variables have a common trend, Granger causality must exist in at least one direction, unidirectional or bidirectional (Granger, 1986, 1988). Even if Cointegration indicates the absence or present of Granger causality, it does not indicate the direction of causality between variables. This direction of the Granger (or temporal) causality can be detected through the VECM derived from the long run cointegrating vectors (Mansur & Masih, 2002) (see section 5.2.4 and 5.2.5 below).

Furthermore, we cannot reject the hypothesis that foreign price does not Granger Causes auction price (0.08 is too small to reject especially when we use lag 4) and as the same time we do not reject the hypothesis that auction price does not Granger cause foreign price.

Therefore, it appears that Granger causality runs from auction to foreign and from foreign to auction. This indicates that it is possible to predict the auction market by analyzing price in foreign national market or, to predicate the foreign national market by depending on the auction market.

When we compare the Granger causality between the foreign market and producer market, we reject the null hypothesis that foreign market does not granger causes producer price, but we cannot reject the null hypothesis that producer price does not granger causes foreign price. Therefore, granger causality runs from producer market to foreign market but not vice versa. Note that the term "granger causality "is something of a misnomer since a finding of causality does not mean that movement in one variable physically causes movement in another (Chris, 2002). In the above analysis if, for example, movements in the domestic market (PPN) found to Granger cause movement in the foreign market (FPN), this would not imply that the foreign market change as a direct result of, or because of movement in the domestic market (PPN). Rather causality simply implies that a chronological order of movement in the series.

5.3.4 Estimation of vector error correction model (VEC)

Short run integration test can be incorporated in the model by specifying a Vector Error Correction Model (VECM) when long–run integration is observed. A vector error correction (VEC) model is a restricted vector autoregressive (VAR) designed for use with non-stationary series known to be cointegrated. The VEC has Cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge to their Cointegration relationships while allowing for short-run adjustment dynamics (Krishna, 2010). The Cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

In chapter four of this study (equation 4.20 to 4.22) estimation has done about the vector error correction model that helps to test the effect of each variable on each other variables. In these equations, I specify the short-run dynamics of producer, auction and foreign variables in the system and in a framework, which anchors the dynamics to long-run

equilibrium relationships. For instance, economic theory suggests that economic activity across regions should converge. If this convergence hypothesis is true, we might observe long-run relationships between producer, auction and foreign price.

Table 5.8. Vector error correction estimation of APN-PPN

Standard errors & t-statistics in parentheses		
Cointegrating Eq:	CointEq1	
APN(-1)	1.000000	
PPN(-1)	-1.068778 (0.10952) (-9.75865)	
C	-17.00206	
Error Correction:	D(APN)	D(PPN)
CointEq1	-0.140259 (0.04744) (-2.95628)	0.059697 (0.04130) (1.44554)

The first part of the above table presents the estimates of the cointegrating equation, which has already estimated in section 5.3.2 of this study. We cannot reject the hypothesis that the Cointegration coefficient is 1, as $\frac{1.06-1}{0.1} = 0.6$

The second part of the table shows the rest of the Error Correction Model (ECM). The first row in the second part presents the estimates of the speed of adjustment coefficient for each variable, their standard errors and the t-statistics. The adjustment coefficient of Cointegration (CointEq1) is equal to 14% each month for auction price and significant where as it is only 5% for producer price and insignificant. This means that about 5% the disequilibrium in producer market is corrected and insignificant while 14% of the disequilibrium is corrected each month by the change in the auction market and significant. Lagged producer price is insignificant in the auction price equation, but lagged auction price is significant in the producer price equation.

Table 5.9. Vector error correction estimation of FPN-APN

Standard errors & t-statistics in parentheses		
Cointegrating Eq:	CointEq1	
FPN(-1)	1.000000	
APN(-1)	-1.477168 (0.11770) (-12.5505)	
C	19.01057	
Error Correction:	D(FPN)	D(APN)
CointEq1	-0.094056 (0.02705) (-3.47734)	0.106350 (0.03013) (3.52934)

The finding suggested that about 10.6 of disequilibrium in auction price is correct each month while 9.4% of the disequilibrium corrected each month by the change in foreign market and both are significant. Here we see that Lagged auction price is significant in the foreign price equation, and lagged foreign price is significant in auction price equation. This looks confusing but remembers that, foreign price here refer to the national foreign price of coffee in Ethiopia, which was calculated as auction price plus transportation cost to the port, plus caring cost to the ship.

Table 5.10 Vector error correction estimation of PPN-FPN

Standard errors & t-statistics in parentheses		
Cointegrating Eq:	CointEq1	
FPN(-1)	1.000000	
PPN(-1)	-1.680921 (0.26709) (-6.29348)	
C	0.670216	
Error Correction:	D(FPN)	D(PPN)
CointEq1	-0.061671 (0.02129) (-2.89621)	0.032465 (0.02137) (1.51924)

The above result also suggests that that about 6% of disequilibrium in foreign price is correct each month and significant while 3% of the disequilibrium corrected each month by the change in the auction market and insignificant. Lagged producer price is insignificant in the

foreign price equation, but lagged foreign price is slightly significant in producer price equation.

5.3.5 Impulses response

According to Potter (1995), interpretation of the dynamic interrelationships among prices at alternative market levels is best pursued through a consideration of impulse response functions. In contrast to other linear models, the response of the shock is dependent upon the history of the series. Potter also added that the possible asymmetric nature of the response implies that the size and sign of the shock will influence the nature of the response. The impulse responses generally represent percentage changes in prices to a certain percentage shock in one of the prices. There are many types of impulse response function (Daniel and Barry, 1999) but for this particular study I used Potter (1995) that define response (denoted I_{t+k}), on the basis of observed data, Z_t, Z_{t-1}, ….,(in our case it is APN and PPN) and the shock u (in our case it is FPN)

I_{t+k}= (u, Zt, Zt-1,…)= $E(Z\text{t+k}\ /Z\text{t}+u, Z\text{t-1}= Z\text{t-1}---) - E(Z\text{t+k}\ /Z\text{t}= Z\text{t}, Z\text{t-1}= Z\text{t-1},\ldots.)$ 5.5

In the context of this study, the impulse response function answers questions with regard to the response of the auction and producer market to a one standard error unit shock in foreign market. In this analysis, the sign, magnitude and persistence of responses of one market to shocks in another coffee market are captured. I estimate the producer and auction price response with respect to foreign price by considering historical volatility summarized in section 5.1.1.2 of this study. In this subsection, volatility is relatively low before 1993 but reached a maximum in the period of 1994 in 2000, after that volatility has been decreasing. This is to test the response when foreign price increase and decrease as volatility is low and high.

I estimate the auction and producer price responses using the entire sample and using two Subsamples:

(i) December 1991 to December 2000 (109 observations) and

(ii) January 2001 to April 2009 (100 observations)

From figure 5.4 below, the upper dashed line in the center is estimation of the impulse response function while the line in the center and dashed line (down) shows the price response of auction and producer price to foreign price increase (up) and decrease (down).

Figure 5.6 Auction and producer price response to change in foreign price.

A. The first subsample, December 1991 to December 2000

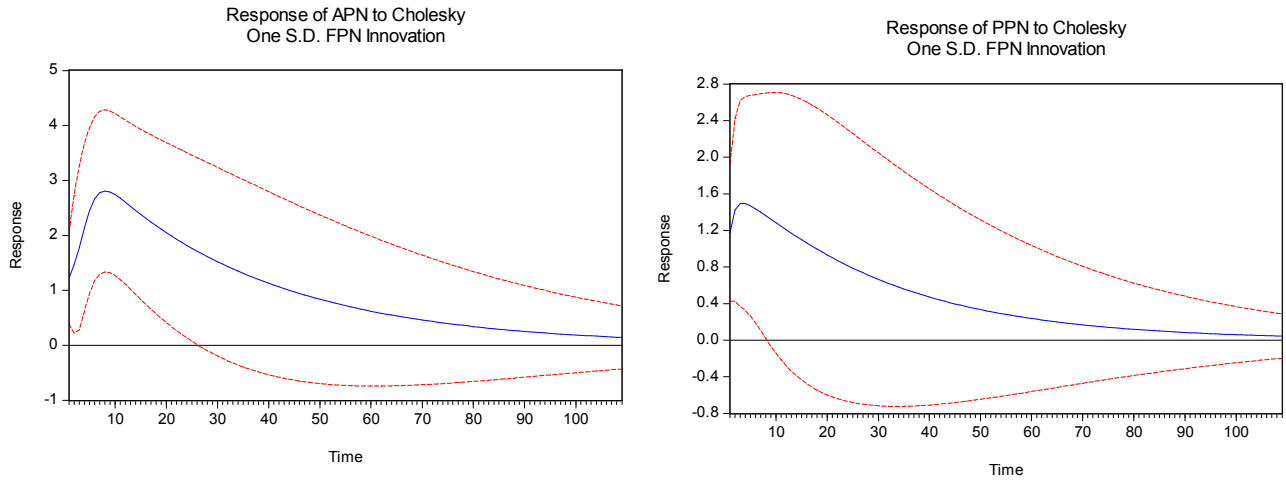


Figure 5.6A shows that the shock of FPN with respect to APN and PPN from month one to month 109 (This is from year 1991 to year 2000). From the figure, it is clear that the positive shock is not the same as the negative shock until a certain point, (P^+ is not equal to P^-, meaning the magnitude is different). This indicates that the response is asymmetric in both cases. Asymmetric may exist in the form of speed and magnitude and could vary whether the shock is positive, negative, or transmitted to upward or down word along the chain (see also section 2.3.1 and 2.3.2 of this study). The impulse response for producer and auction price shows different reactions to negative shocks than to positive shocks. In the case of negative shocks, the auction and producer price shows little reaction; in contrast, positive shocks initiate more reactions. This means that positive price transmission from the foreign to the auction and producer price transmit faster than the negative once in the short run in this period.

It appears to take around 50 -55 months (4 ¾ years) for APN and 55 – 60 months (around 5 years) for PPN for the response to shocks to settle to new long run equilibrium value. Note that if the graph is not flat, then the market is not perfectly efficient (Leigh, 2009).

Figure 5.6B. The second subsample, January 2001 to April 2009

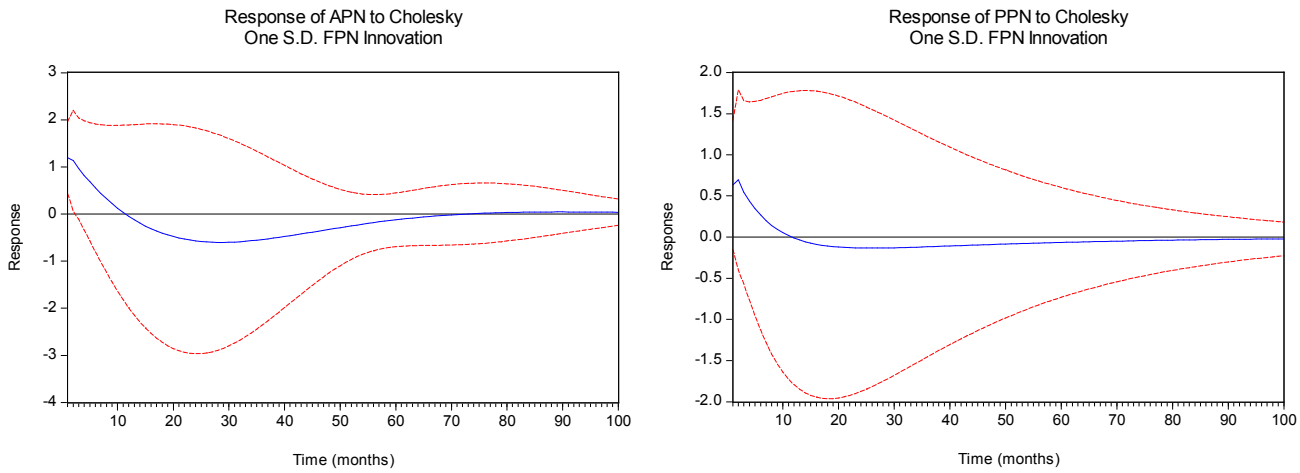


Figure 5.6B shows the impulse response function from the period 2001 to 2009. It is clear that the auction and producer market shows different reactions for both positive and negative shocks (the magnitude is different). In the case of positive shocks, producer and auction prices show slow reaction. In contrast, negative shocks trigger much more reaction. This means that negative price transmission from the foreign to the auction and producer price transmit faster than the positive once in the short run. In this case, the full adjustment takes around two years for auction price and around three years for producer price. The producer and auction price fully adjust in the short period to foreign price for the year 2001 - 2009 comparing to the year 1991 – 2000. This evidence suggests that markets are relatively efficient from the year 2001 – 2009. From the above graphs we could also, analysis that the auction price is fast to respond to the foreign price comparing to the producer price.

The literature review part of this paper reveals that (section 2.4), adjustment costs and market power are the main causes of asymmetric price transmission; other possible causes of asymmetric price transmission are the presence of government interventions, stock accumulation, and search costs associate with asymmetric information may also lead to asymmetric price transmission. It is difficult to particularly analysis the main sources of asymmetric price transmission in the case Ethiopian coffee market, it needs further research and investigation.

6 Summary, conclusions and recommendations

Here I have attempted to give an overview of this study by summarizing the main results and give basic conclusions and recommendations.

6.1 Summary

The nature of price transmission from the foreign market to the auction and then to the producer markets was assessed by testing co movement, Granger causality test, the speed of adjustment and asymmetric response to the foreign market. The tests conducted on the bases of average monthly producer price, auction and foreign price. Each price has calculated by taking the four major exported coffee types in Ethiopia. These are Sidamo, Wellega, Jimma and Harar.

Test types	PPN	APN	FPN
Co–movement Q(5.3) to Q(5.5)	Price co-move with APN and FPN in the long run	Price co-move with FPN in the long run.	-
Causality Equations (4.20) to (4.22)	Foreign price causes domestic price but not vice versa	Foreign price causes APN, and APN price causes FPN	-
Speed of adjustment with respect to FPN Equations (4.20) to (4.22)	only 3% of the disequilibrium is corrected each month by change in foreign price	10.6% of the disequilibrium is corrected by change in foreign price	-
Adjustment months to foreign price (Calculated from the above disequilibrium result)	More than 20 months	9 months	-
Impulse response (Adjustment type) Equation (5.5)	Asymmetry to FPN,	Asymmetry to FPN	-
Volatility (Standard deviation) for the whole period.	19,74	22,87	31,92

Table 6.1 Summery of price transmission

The producer and the auction price follow a similar trend as that of the foreign price in the long run (See figure 5.1). There are some confusions in the result of Granger causality tests, some writers explain that Granger causality test show the cause of one variable to another, but finding causality does not necessarily mean that movements in one variable causes

movement in another. Rather it means that one variable can help in predicting the other variables. The granger causality test results show that in order to predict future producer prices we have to depend on the auction price, but Granger causality is found in two ways when I examine the relationship between foreign price and auction price.

Vector error correction model is used for determining the direction of the long-term and short-term relationship between the series. In other words, it is an effective method of determining the direction of the causality relationship between series (Özen, Bozdoğan, Zügül, 2009). According to the result, auction price causes domestic price but not vice versa, causality also runs from auction price to foreign price and from foreign price to auction price. This is because the study considers the national foreign price of coffee in Ethiopia.

The short run adjustment coefficient for producer price is only 3%. This means that if there is a shock in the foreign coffee market in one unit, only 3% of the share is transferred to the producer price per month and this is insignificant and it takes more than 20 months for the full transmission. In general, the test suggested that, the producer market is weekly integrated with foreign market and the adjustment in the long run is very slow.

The adjustment coefficient for auction price is 10.6% for any one unit shock in the foreign market and the adjustment periods takes around 9 months for full transmission to the auction market. This implies that the auction and foreign market are fairly integrated and the adjustment in the long run (9 months) is relatively fast, with the auction price adjust fully to change in foreign price after approximately 9 months comparing to the producer price.

Asymmetric price transmission (The impulse response function) was tested to examine whether price increases was passed through auction and producer market as fast as price decreases. The result suggested that producer price react slower to change to foreign price but auction price react relatively faster to changes in foreign markets. It is also noted that, the impulse response to producer and auction price shows different reactions to negative shocks and positive shocks. For the first 109 months (from the year 1991-2000), negative price transmission is faster than positive price transmission but for the last 100 months (2001-2009) positive price transmission is faster than negative price transmission for both APN and PPN market. The result also shows that full adjustment asymmetric price

transmission takes relatively shorter period for the year 2001 – 2009 comparing to the year 1991-2000. This is an indication of market improvement in the recent periods.

6.2 Conclusions

The analyses of price transmission in this thesis suggest that the price of producer and auction move together with foreign price in the long run (Figure 5.1). This information is vital for making decisions in the domestic market to know how much should produce for the international as well as domestic market. It was also found that the price of producer-foreign, producer-auction, and auction-foreign is dynamically stable, meaning that when there is a shock in the price, the disequilibrium error will be corrected within a specific period even if the adjustment period is long and relatively fast for producer and auction price respectively.

The empirical finding of this study focus on methods that established for measuring price transmission. Cointegration method is used to formulate the quantitative relationships between the three prices followed by the estimation of error correction models.

The result from the VEC model suggested that the adjustment coefficient for producer price is only 3% if there is a shock in the international coffee market in one unit. 3% coefficient is quite small and insignificant. The research conclude that the producer market and the foreign market are poorly dependent and have very weak relationships to one another as comparing to auction to the foreign market. The policy implications of this result suggested that more agricultural policies should be designed and implemented in the marketing infrastructure of the two markets. Organized and efficient market infrastructural facilities bring a better market cointegration and help the transmission of right price signals. The result of poor infrastructure, especially in the transportation and communication services causes marketing margins as costs of delivering the commodity increases.

On the other hand, 10.6% monthly adjustment coefficient is found in the analysis of auction price with respect to foreign price. Even if this is favorable comparing to producer price, still it is also far from strong market integration. If two markets are strongly integrated, the adjustment coefficient should be near to one that is 100% (Heman and Fateh, 2006)

It is noted that, the symmetry of response in price transmission is an important concept here. Asymmetric response of one price to another implies that upward and downward movements in the price in one market are symmetrically or asymmetrically transmitted to the other. It is found that asymmetric price transmission could occur when the producer and auction price adjusted in the short run. Asymmetric price transmission is strong in the short run and could decline in the long run. As literature reviewed in this study, the main causes of asymmetric price transmission is market power. The other most important explanation for asymmetric price transmission is adjustment and menu costs. Government intervention also mention as a possible cause of asymmetric price transmission. Meyer and Taubadel (2004) explain non-competitive market as a source of Asymmetric price transmission and this is more common in agricultural commodities.

6.3 Recommendations

This thesis considers the price transmission system in the Ethiopian coffee market from the period 1991 to 2009. 1991 is the period that the present government came to power. Even if success has been registered in the Ethiopian coffee trade, the impact on the producer is insignificant. This indicates that coffee farmers are not well integrated in the foreign market.

For the benefit of coffee farmers in Ethiopia, and what extensively studied in the literature part of this thesis, it is recommended the following points.

1. The result of vector error correction model reveals low speed of price adjustment for producer (3%) and auction market (10.6%) on average respectively; this could be the result of imperfect information. If producers and traders in the auction market do not have up to date information about price in the foreign market, they cannot respond quickly to profitable opportunities.

This could be improved by facilitating information network from the international market to the local market. Telecommunication infrastructure and the advancement of mobile technology is the key as most coffee farmers in Ethiopia living in rural areas. The availability of reliable information on what is happing in the international market strength the farmers bargaining power.

2. The poor price transmission coefficient may also reflect the presence of limited market infrastructures due to a number of factors mainly transportation facilities. Investment in transportation infrastructures increase speeds and save fuel consumptions so that it reduces resources costs for transportations.

This study also suggested that future research might focus on the institutional arrangement of coffee organization in Ethiopia. These including cooperative organizations, the farmers technology, information, transportation, storage and inventory system management and other issues related to profit distribution among producer, auction, foreign and whole sellers.

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Software used

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http://www.stata.com/stata10/

2. EVIEWS 5

http://www.eviews.com/

APPENDIXES

Appendix 1. Unit root test of PPN, APN and FPN

Null Hypothesis: PPN has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.012030	0.2816
Test critical values:	1% level	-3.461783	
	5% level	-2.875262	
	10% level	-2.574161	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(PPN) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-15.06238	0.0000
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(APN) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.71673	0.0000
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: FPN has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.863115	0.3493
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

*MacKinnon (1996) one-sided p-values.

Null Hypothesis: D(FPN) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.28081	0.0000
Test critical values:	1% level	-3.461938	
	5% level	-2.875330	
	10% level	-2.574198	

*MacKinnon (1996) one-sided p-values.

Appendix 2, Johansen cointegration test

Sample (adjusted): 1992M05 2009M04
Included observations: 204 after adjustments
Trend assumption: Linear deterministic trend
Series: PPN APN FPN
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.115910	37.50846	29.79707	0.0053
At most 1	0.041643	12.37630	15.49471	0.1398
At most 2	0.017969	3.699083	3.841466	0.0544

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.115910	25.13216	21.13162	0.0129
At most 1	0.041643	8.677215	14.26460	0.3140
At most 2	0.017969	3.699083	3.841466	0.0544

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PPN	APN	FPN
0.056638	-0.159265	0.074879
0.121716	-0.055109	-0.038892
0.043274	-0.016818	0.018650

Unrestricted Adjustment Coefficients (alpha):

D(PPN)	0.161547	-0.335871	-0.641670
D(APN)	1.861218	0.145408	-0.332063
D(FPN)	-0.244791	0.930158	-0.301838

Appendix 3, cointegration Equations

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

APN	PPN	C
1.000000	-0.956913	-24.41444
	(0.16007)	
Log likelihood	-1256.064	

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

FPN	APN	C
1.000000	-1.524814	23.16700
	(0.14027)	
Log likelihood	-1275.217	

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

FPN	PPN	C
1.000000	-1.739442	4.486493
	(0.32861)	
Log likelihood	-1261.157	

Appendix 4, Vector error correction model,

4.A . APN-PPN

Sample(adjusted): 1992:03 2009:04
Included observations: 206 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1	
APN(-1)	1.000000	
PPN(-1)	-1.068778	
	(0.10952)	
	(-9.75865)	
C	-17.00206	
Error Correction:	D(APN)	D(PPN)
CointEq1	-0.140259	0.059697
	(0.04744)	(0.04130)
	(-2.95628)	(1.44554)
D(APN(-1))	0.277351	0.226225
	(0.07794)	(0.06784)
	(3.55856)	(3.33464)
D(APN(-2))	-0.030971	0.029730

	(0.07986)	(0.06951)
	(-0.38782)	(0.42769)
D(PPN(-1))	-0.049980	-0.157814
	(0.09195)	(0.08004)
	(-0.54355)	(-1.97172)
D(PPN(-2))	0.060260	-0.004235
	(0.08774)	(0.07637)
	(0.68678)	(-0.05545)
C	-0.067367	-0.004852
	(0.42416)	(0.36921)
	(-0.15882)	(-0.01314)

4.B. FPN-APN

Vector Error Correction Estimates
Date: 08/18/10 Time: 19:10
Sample (adjusted): 1992M03 2009M04
Included observations: 206 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
FPN(-1)	1.000000	
APN(-1)	-1.481929	
	(0.11430)	
	[-12.9652]	
C	19.01113	
Error Correction:	D(FPN)	D(APN)
CointEq1	-0.091366	0.105883
	(0.02703)	(0.03023)
	[-3.37998]	[3.50310]
D(FPN(-1))	0.280305	-0.065785
	(0.06800)	(0.07604)
	[4.12191]	[-0.86514]
D(FPN(-2))	0.001219	-0.088114
	(0.06717)	(0.07510)
	[0.01815]	[-1.17326]
D(APN(-1))	0.065950	0.304714
	(0.06547)	(0.07320)
	[1.00738]	[4.16259]
D(APN(-2))	0.089063	0.063273
	(0.06781)	(0.07583)
	[1.31335]	[0.83445]
C	0.002820	-0.058861
	(0.37701)	(0.42156)
	[0.00748]	[-0.13962]

4.C. FPN –PPN

Vector Error Correction Estimates
Date: 08/18/10 Time: 19:15
Sample (adjusted): 1992M03 2009M04
Included observations: 206 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
FPN(-1)	1.000000
PPN(-1)	-1.687647 (0.25645) [-6.58085]
C	0.066983

Error Correction:	D(FPN)	D(PPN)
CointEq1	-0.061072 (0.02122) [-2.87807]	0.032387 (0.02127) [1.52303]
D(FPN(-1))	0.300776 (0.06781) [4.43567]	0.067128 (0.06795) [0.98784]
D(FPN(-2))	-0.052455 (0.06740) [-0.77832]	-0.113411 (0.06754) [-1.67917]
D(PPN(-1))	0.023608 (0.07546) [0.31285]	-0.019461 (0.07562) [-0.25735]
D(PPN(-2))	0.220923 (0.07443) [2.96809]	0.074621 (0.07459) [1.00039]
C	-0.001729 (0.37912) [-0.00456]	-0.019925 (0.37993) [-0.05244]