EMPIRICAL ANALYSIS OF AGRICULTURAL COMMODITY PRICES

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EMPIRICAL ANALYSIS OF AGRICULTURAL COMMODITY PRICES

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Thesis Abstract

Mustafa Safa Öz, “Empirical Analysis of Agricultural Commodity Prices”

In the last ten years, Turkey has imported, on average, 60 percent of cotton used in the country from the USA. Hence, the relationship between cotton prices in Turkey and the USA is of significant importance. In this research, first, I test whether the law of one price (LOOP) rule holds for cotton prices in the USA and in Turkey, or not. Not only testing the LOOP is important, but testing the asymmetry between these two markets is important, as well. For testing, I use (i) Threshold Autoregression model (TAR), (ii) Momentum Threshold Autoregression model (M-TAR), and (iii) MTAR with consistent estimate of threshold level. I verify the presence of negative asymmetry between these markets. In other words, cotton market in Turkey shows greater response to falling prices than to rising prices in the USA cotton market.

The relations between agricultural commodity prices and crude oil prices are also very important in the economics literature. As a second research question, I investigate the relationship between crude oil prices, cereal prices (corn and wheat), and cotton prices in major international markets considering the impacts of the financial crisis in 2008. I find that there exists a cointegration relationship between crude oil prices and wheat prices. Also, I find evidence of a cointegration relationship between corn prices and cotton prices, corn prices and wheat prices, cotton prices and wheat prices with regime shifts. The timings of regime shifts are as expected. This leads to the conclusion that the financial crisis in 2008 has changed the relationship between commodity prices.

Tez Özeti

Mustafa Safa Öz, "Tarımsal Emtia Fiyatlarının Deneysel Analizleri"

Son on yılda, Türkiye ortalamada pamuk ithalatının yüzde 60'nı Amerika Birleşik Devletleri' nden gerçekleştirdi. Bu yüzden, Türkiye' deki pamuk fiyatı ile Amerika'daki pamuk fiyatı arasındaki ilişki çok önemlidir. Tezimin ilk bölümünde, Amerika'daki pamuk fiyatı ile Türkiye'deki pamuk fiyatı arasında tek fiyat kanunu geçerli mi diye test ettim. Sadece tek fiyat kanunun olması önemli değil, bu iki piyasa arasında asimetrik ilişkinin olup olmaması da önemlidir. Bunun için (i) Eşik otoregresyon modelini (ii) Ivmeli eşik otoregresyon modelini ve (iii) Tutarlı tahminli ivme eşik otoregresyon modelini kullandım. Bu iki piyasa arasında negatif asimetri olduğunu doğruladım. Bir başka deyişle, Türkiye'deki pamuk fiyatları Amerika'daki pamuk fiyatlarındaki düşüşe, yükselişten daha fazla tepki veriyor.

Tarımsal ekonomi literatüründe petrol fiyatları ile emtia fiyatları arasındaki ilişki çok önemlidir. Tezimin ikinci bölümünde, petrol fiyatı, mısır fiyatı, buğday fiyatı ve pamuk fiyatı arasındaki ilişkiyi araştırdım. Petrol fiyatı ile buğday fiyatı arasında eşbütünleşme ilişkisi buldum. Ayrıca, mısır fiyatı ile pamuk fiyatı arasında, mısır fiyatı ile buğday fiyatı arasında ve pamuk fiyatı ile buğday fiyatı arasında rejim değişikliğine uğramış eşbütünleşme ilişkisi buldum. Rejim değişikliklerinin zamanlaması da beklendiği gibi çıktı. Bu da son finansal krizin emtia fiyatları arasındaki ilişkiyi değiştirmesine sebep olduğu sonucunu çıkartmamıza neden oldu.

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General Introduction

Cotton Production and Consumption in the World

Cotton is a natural fiber harvested from the cotton plant. It is also one of the mostly used natural fibers in existence today. Globally, thousands of hectares of land are used to produce cotton. According to the International Cotton Advisory Committee (ICAC), for the period 2005 to 2010, the average land devoted to cotton production worldwide is 32.5 million hectares. India has the largest cotton production area in the world. Then, respectively, China, USA, Pakistan, Uzbekistan and Brazil follow India. The Table 1 shows cotton acreages of leading producers from 2004 to 2010.

Table 1 – World Cotton Production Areas (Thousand Ha)

Country	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
India	8.786	8.677	9.144	9.439	9.373	10.120	11.999
China	6.261	5.698	6.199	6.317	6.317	5.419	5.499
USA	5.284	5.586	5.152	4.245	3.063	3.112	3.884
Pakistan	3.229	3.100	3.075	3.055	2.850	3.110	3.300
Uzbekistan	1.419	1.432	1.432	1.450	1.391	1.317	1.339
Brazil	1.179	856	1.097	1.077	840	836	1.399
Turkmenistan	550	600	600	642	674	607	650
Burkina Faso	566	646	716	407	466	420	500
Argentina	375	305	400	304	285	430	624
Zimbabwe	320	320	400	308	375	340	425
Tanzania	471	245	409	450	400	348	350
Turkey	*698*	*600*	*630*	*500*	*365*	*280*	*450*
Myanmar	290	284	310	310	310	310	310
Others	6.370	5.988	5.126	4.332	3.947	3.644	4.147
World	35.798	34.337	34.690	32.836	30.656	30.293	32.680
Source: ICAC							

Considering the recent years, although a significant increase in cotton planting is not recorded, production quantities due to high fiber yield remained positive until the 2008/09 period. Table 2 shows the world cotton yield from 2004 to 2010.

Table 2 – World Cotton Yields (Ton/Ha)

Country	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10*	2010/11*
Australia	4,3	4,9	4,5	4,4	4,8	4,4	4,8
Israel	4,5	3,7	4,3	4,3	4,3	4,4	4,4
Turkey	3,8	4,1	4,3	4,3	3,7	4,1	4,1
Brazil	3,3	2,9	3,2	3,7	3,8	3,7	3,8
Syria	4,3	4,3	3,2	3,7	3,7	3,3	3,3
China	3,3	3,4	3,5	3,9	3,9	3,3	3,3
Mexico	3,5	3,1	3,9	3,5	3,7	3,3	3,1
Venezuela	1,3	1,3	1	1,3	1,2	3	3
Tunisia	1,5	1,5	1,5	1,5	1,5	2,7	2,7
Bulgaria	1,1	1,1	1	0,9	0,9	2,7	2,7
South Africa	2,1	2,5	2,2	2,7	1,9	2	2,4
Greece	3,1	3,4	2,8	3,3	2,8	2	2,4
USA	2,4	2,3	2,3	2,4	2,2	2,1	2,3
Colombia	1,8	1,7	1,7	2,3	1,7	2	2
Egypt	2,6	2	2,4	2,3	2,3	2	2
Peru	2,1	2,2	2,3	2,4	2,4	2,4	2,5
World	2	2	2	2,2	2,1	1,8	1,9

Source: Food and Agricultural Organization - (*) Forecast

As for the cotton production in the world, China is the biggest country in cotton cultivation. In 2009/2010, China's cotton production was 7 million tons. The effects of the last financial crisis in the USA gave rise to the loss of its second position in the cotton production to India. Table 3 shows the cotton production in the world from 2006 to 2011. As shown in the Table 3, cotton production in Turkey decreases year by year due to low cotton prices, high input cost (high oil prices, high fertilizer prices) and the increase in other commodity prices (corn, wheat, and vegetables). In the second section of this thesis, I am going to focus on the relationship between cotton prices, other commodity prices, and oil prices.

Table 3 – World Cotton Production (1000 Tons – Fiber)

Country	2006/07	2007/08	2008/09	2009/10	2010/11
China	7,729	8,056	7,991	7,076	6,600
India	4,746	5,225	4,921	5,117	5,300
USA	4,700	4,182	2,790	2,654	3,900
Pakistan	2,155	1,938	1,960	2,155	1,900
Brazil	1,524	1,602	1,193	1,252	2,000
Uzbekistan	1,165	1,165	1,002	871	900
Turkey	849	675	457	380	500
Australia	294	139	327	348	900
Others	4,258	3,830	3,218	2,930	3,379
Total	26,573	26,138	23,400	22,403	24,891
Source: United States Department of Agriculture (USDA)					

As shown in Table 4, China is the biggest cotton consumer in the world. India, Pakistan and Turkey follow China, respectively. While the highest level of world consumption was in 2006/07, cotton consumption decreased in 2008 in parallel to the decline in production in the world. But after 2008, cotton consumption started to increase. In 2009, world cotton consumption was 23.9 million tons and in 2010, it was 25.3 million tons.

Cotton Production and Consumption in Turkey

Textile industry is very significant in Turkey both for exports and employment. Cotton is the most widely used input for yarn production. But synthetic fibers are also a substitute of cotton yarn in which oil is used as input. So, the relation between crude oil prices and cotton prices is crucial and it is investigated in section 2.

Table 4 – World Cotton Consumption (1000 Tons - Fiber)

Country	2006/07	2007/08	2008/09	2009/10	2010/11
China	10,886	11,104	9,580	10,342	10,000
India	3,941	4,050	3,865	4,246	4,500
Pakistan	2,613	2,613	2,449	2,504	2,200
Turkey	1,589	1,350	1,110	1,219	1,300
Brazil	996	1,002	914	958	1,002
Bangladesh	697	762	816	871	800
USA	1,074	998	781	740	800
Others	5,157	4,976	4,421	4,469	4,516
Total	26,953	26,854	23,937	25,349	26,017
Source: USDA					

There are mainly four regions where cotton is produced in Turkey, Aegean Region, Southeastern Anatolia Region, Çukurova Region, and Antalya Region. In 2010, half of the cotton production took place in the Southeastern Anatolia Region, 28 percent is produced in Aegean Region and the remaining part is produced in Çukurova and Antalya Regions. Figure 1 shows these percentages in a pie chart.

Due to the extreme decrease in cotton prices, high input cost and non-competitive conditions with other countries, farmers in Turkey suffered from producing cotton in the last 10 years. This causes a significant decline in cotton production. So, Turkey does not meet its cotton consumption and this leads to import of cotton in significant amounts. Today, Turkey imports two-third of its cotton demand. Figure 2 shows the graph of consumption, production and import of cotton in Turkey in the last 10 years.

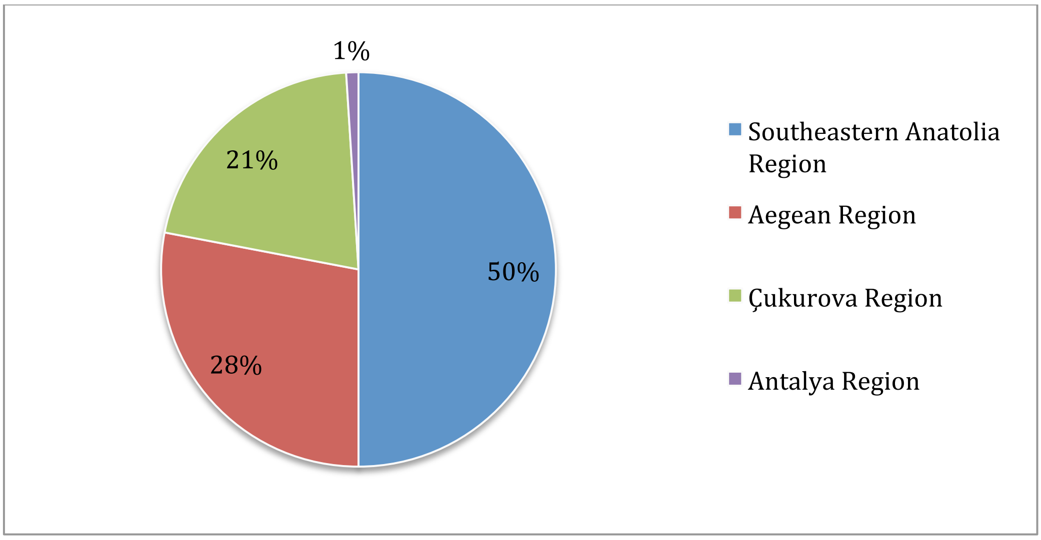

Figure 1: Cotton Acreage In Turkey. (Source: Izmir Merchantile Exchange)

In 2011, it is expected that cotton production will increase by 50 percent compared to the last year. As shown in Figure 2, generally, cotton production decreased over time while imports increased. For example, in 2009, cotton production decreased from 420,000 tons to 380,000 tons while imports increased from 635,000 tons to 960,000 tons.

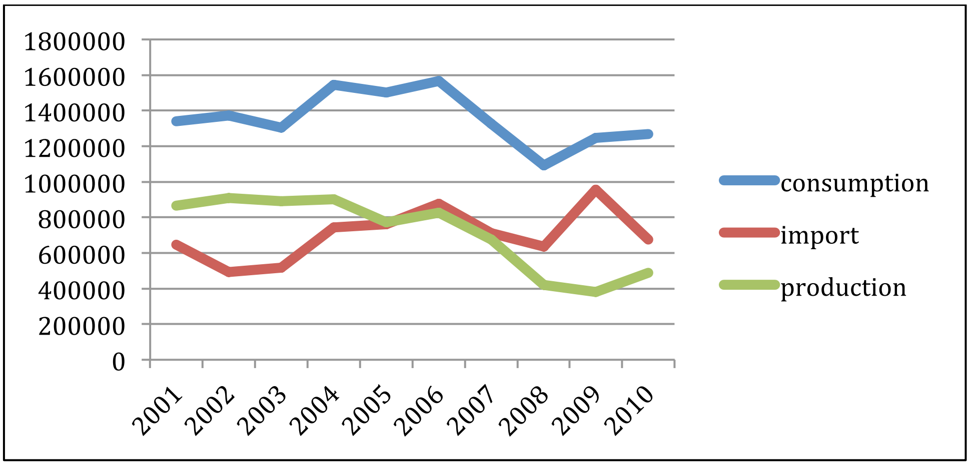

Figure 2: Cotton consumption (tons), production (tons) and import (tons) in Turkey. (Source: Izmir Merchantile Exchange)

Between 2006 and 2008, imports also decreased and this led to a decrease in consumption. In the season 2009/2010, cotton consumption increased worldwide which led to big declines in the stocks. So, there was an upward move in the cotton prices. After that season, cotton production has increased.

There are some primary factors that influence cotton prices in the world such as production and consumption statistics, estimated carryover levels, government and private stocks, and the ratio of ending stocks to consumption, as well as China's cotton trade balance (Cotton Trading Manual of International Cotton Advisory Committee, 2005).

Cotton Trading in the World

Some definitions in Table 5 presented are essential for cotton trading.

Table 5: Important Definitions About Cotton Trading

Cotlook Indexes (A and B)	Daily prices published by a private company. A index is an average of the cheapest five quotations from a current selection of the 16 cotlook quotations for principal Uplands cottons traded internationally.
New York Board of Trade (NYBOT)	No. 2 contract is the most important price indicator where cotton futures are traded 24 months forward.
Basis	It is the difference between New York cotton futures price and actual cotton price.
Cotton Merchants	They are the links between the farmer and spinning mill. They provide markets for cotton growers and they supply cotton to spinning companies by giving exact specification about the cotton that they sell, such as quality and the staple length of the cotton.
Source: Cotton Trading Manual of International Cotton Advisory Committee (ICAC)	

Considering the Liverpool A index, in Figure 3, there is a negative relationship between stocks to use ratio of cotton and Liverpool AA index. They always move in the opposite direction.

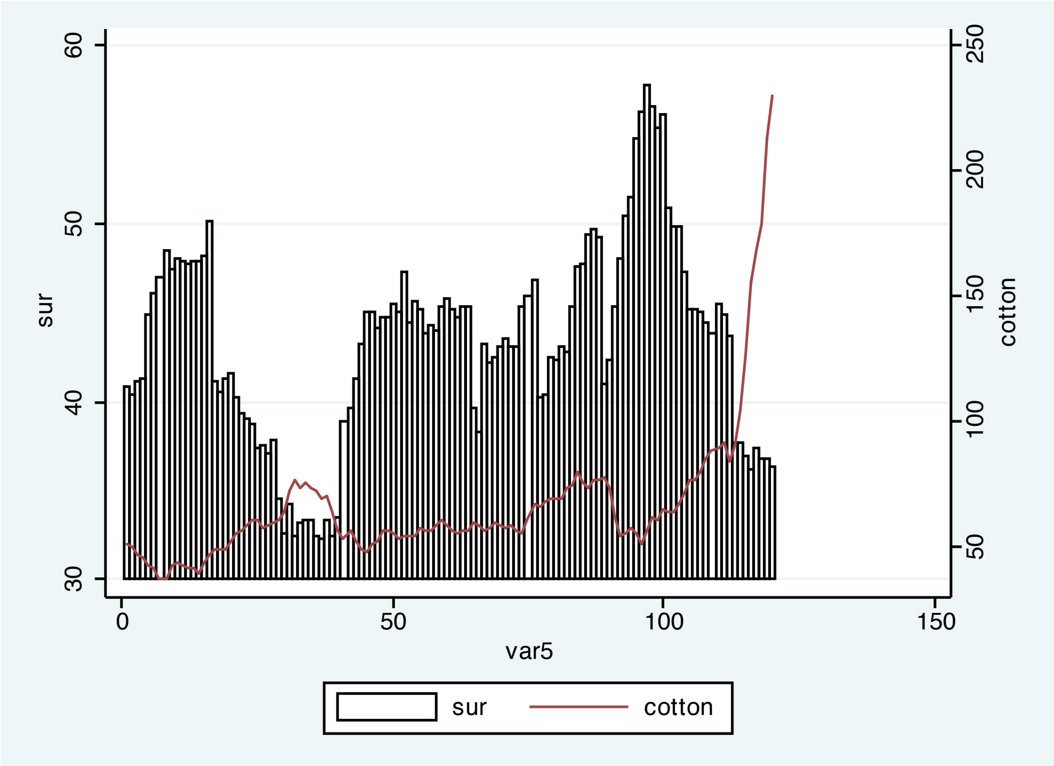

Figure 3: Cotton: "A" Index (US cents/pound) and World Stocks/Use (percentage)

Cotton Trading in Turkey

In Turkey, cotton is priced at the Izmir Mercantile Exchange (IME). Caliskan et al. (2007) explains the details of how cotton price is determined at the IME.

Every weekday, at 12:20 trading opens when an IME employee invites the traders to enter the pit and take their seats. Exactly 10 minutes after the opening, trade finishes. Traders start a conversation to tie a contract. The contract must consist of 3 conditions. First, the quality of the cotton should be specified such as Standart 1, Garanti or Bergama. Second, a contract must include a specific price in Turkish Liras for one kilogram of cotton. Finally, the payment terms such as "in advance" or "in one week" must be in the contract. If both sides agree on these conditions, than the contract is signed.

The pit is closed at exactly at 12:30. However, the trade continues until 13:15. After the prices are taken from each side at the pit, between 12:30 and 13:15 traders and brokers continue to make offers and at the same time they make call to their clients (spinners, ginners) to give information about the offers.

After 13:15, the Closing Price Committee, which consists of leading sellers and buyers, exchange brokers and merchants, comes together. They write the daily price report and then the price is settled.

Introduction and Literature Review

In the last ten years, Turkey has imported, on average, 60 percent of cotton used in the country from the USA. The remaining part is imported from 85 countries, such as Greece, India, and Turkmenistan. But their individual shares are much smaller than the share of the USA. So, the relationship between cotton prices in Turkey and cotton prices in the USA is of significant importance. In this chapter, the question "are cotton merchants, ginning and spinning factories and farmers in Turkey aware of the cotton prices in the USA?" is tested. In other words, do the cotton prices in the USA have an affect on the settlement of Turkey's cotton prices? Moreover, is there any arbitrage opportunities for speculators in cotton markets by buying cotton in the USA and selling it in Turkey, or vice versa? Finally, does the law of one price (LOOP) rule hold for cotton prices in the USA and in Turkey?

Not only testing the LOOP is important, but also testing the asymmetry between these two markets is also important. The Threshold Autoregression (TAR) model, Momentum Threshold Autoregression (MTAR) Model and Consistent Estimate of Threshold with MTAR Model are used to test the asymmetry between these markets.

Before introducing these models, some information about the transportation cost and other costs faced while importing cotton from the USA needs to be given. Let's say cotton price is 4.48 US$/kg. in the USA. The transportation cost from USA to Turkey is 0.05 US$/kg (based on recent numbers). So, the cotton price is 4.53 when cotton reaches the Istanbul Port or the Mersin Port. There is also another cost, which is called "nationalization". It is around 1.5 or 2 cent per kilogram. Also there is an insurance cost which is around 2 cent per kilogram. In total, cotton price will be around 4.57 US$ per kilogram in Turkey (these values are calculated with the help of a cotton merchant at the IME).

LOOP has an extensive literature in economics. Many financial economists tested LOOP for a lot of instruments such as interest rates and purchasing power parity. In addition to that, many agricultural economists investigated LOOP for many commodities among different countries. Some of them tested the spatial price transmission and some of them tested vertical price transmission (the relation between retail and wholesale prices) along the supply chain.

Alam et al. (2010) investigate the relationship between the world market and domestic market prices of rice for Bangladesh. They use monthly data and apply both Engle and Granger (1987) bivariate and Johansen's (1988) multivariate cointegration test. They find that there is a long run equilibrium relationship between the world and the domestic prices and the relationship is uni-directional, meaning that, the domestic prices adjust to the world prices but not vice-versa. Getnet et al. (2005) test the price transmission between producer prices and wholesale prices of white teff, a major staple in Ethiopia. They conduct the Autoregressive Distributed Lag model to do a cointegration analysis. The results show that the wholesale price of white teff in the central consumer market is a major short-run and long run determinant of the producer price in the local supply markets.

Enders and Siklos (2001) propose an extension to the Engle and Granger's (1987) testing strategy by permitting asymmetry in the adjustment toward equilibrium in two different ways. They investigate whether there exists cointegration among interest rates for instruments with different maturities, or not. They find that there exist asymmetries between short-term interest rates and long-term interest rates. Abdulai et al. (2000) applies threshold autoregressive model to the maize market in Ghana. He validates presence of asymmetries among some cities of Ghana. Again, Abdulai et.al (2010) use the same model to investigate the asymmetry in the Swiss Pork market. Their results show that producer prices and retail prices are asymmetric in Swiss pork market. Enders and Chumrusphonlert (2004) analyze purchasing power parity in the pacific nations by using threshold autoregression model. Their results support that in the long run purchasing power parity holds for most Asian countries but the adjustment mechanism is asymmetric. They also find that asymmetric adjustments of nominal exchange rates play an important role in eliminating deviations from long-run PPP. Awokuse and Wang (2009) test the nonlinear threshold dynamics on asymmetric price transmission for three U.S. dairy products (butter, cheese, and fluid milk) using threshold error correction models. They find that price transmission of changes between producer and retail stages of the marketing chain is asymmetric for butter and fluid milk, but not for cheese prices.

Spatial price transmission has a significant impact on a special commodity price among countries. If LOOP rule does not hold for a certain commodity, then there may be some arbitrage opportunities by buying this commodity from one country and selling it to the other country.

Many economists focused on spatial price transmission by examining the relation of a commodity price in two or more different countries, or regions. They use the following regression model:

$$P_t^1 = \alpha_0 + \alpha_1 P_t^2 + \varepsilon_t \quad (1)$$

where P_t^i (i=1,2) is the price of a certain commodity in region i and ε_t is a random error term. The examination of the price adjustment is done by testing the joint hypothesis that the constant term, α_0, is equal to zero and the coefficient term, α_1, is equal to one. After that, the importance of the difference between short-run price adjustment and long-run price adjustment has emerged. Ravallion (1986) develops the Autoregressive Distributed Lag model to examine the short-run and long-run spatial price transmission. His results show that if there exists a long-run relation between the price series, then one can test the short-run relation by using the error correction model.

Testing the hypothesis that the price series are stationary or not is very important while examining the price adjustment. If both price series, P_t^i(i=1,2), are non-stationary, then the regression (1) can give misleading results for searching for the market integration. These types of regressions are called *spurious* regression. Because of that, many authors perform cointegration tests and use error correction models to identify spatial price transmission. Up to now, all of these studies were concentrated on symmetric price adjustment in the literature. But, many commodities can show asymmetric price transmission from one market to another market. So, the examination of the asymmetric price transmission is very crucial in order to clearly define the relationship of a homogenous good between two markets.

Asymmetric price transmission of a commodity means that the response of the local market price of that commodity is different to an increase or a decrease in central market price of the commodity. If there exist positive asymmetry, then the speculators in the local market will believe that local traders influence the prices more rapidly to an increase in prices in central market than a decrease in prices in the central market. The central market and local market can be two countries where the former one is the exporting country and the latter one is the importing country.

The market integration or asymmetric price adjustment of a commodity is very important for speculators and traders. Commodity price changes often send signals to inventory holders, leading to either accumulation or release of stocks. The anticipation of price increases in the central market in the next period creates an incentive for traders to increase their stock holdings by buying larger quantities of a given commodity at the present date. The increased supply from inventories in the local market puts downward pressure on prices so that they do not rise as much as they would in the absence of inventories. If on the other hand, central market prices are expected to decline, there is an incentive for traders to reduce their inventory holdings, which tends to moderate the initial downward pressure on local market prices in the next period. In either event, current local market price will not adjust fully to a change in the current central market price (Wohlgenant, 1985).

Data and Methodology

Cotton prices differ from each other according to characteristics such as color and fiber length. In Turkey, nine types of cotton are grown which are “Ege Garanti”, “Ege Standart-1”, “Ege Standart-2”, “Diyarbakır Gold”, “Hatay Ekstra”, “Çukurova Ekstra”, “Çukurova Standart-1”, “Güneydoğu Ekstra”, “Güneydoğu Standart-1”. In this study, the Ege Standart-1 type of cotton prices are used. The reciprocal of this cotton type in the USA is Memphis cotton. They are not totally of the same type but their features are very close to each other. In other words, spinning factories in Turkey import Memphis cotton as an equivalent of Ege Standart-1. The correlation matrix of Memphis cotton prices and Ege cotton prices is given in Table 18 in

Appendix. Figure 7 in Appendix shows the price difference graph between Memphis and Ege cotton prices.

The Turkish cotton price data used in this analysis is based on monthly observations of cotton prices of Ege Standart-1 type obtained from IME in Izmir. The Memphis cotton price data is obtained from the U. S. Department of Agriculture, USDA. The data cover the period from January 2001 to January 2011 with 121 observations. Cotton prices in Turkey are quoted in Turkish Lira in the IME originally and they are converted to the US Dollar based on the prevalent exchange rate to keep consistency with Memphis prices.[1] Dollars per kilogram is used as the unit for both series.

In this study, TAR model is used to examine the asymmetric price adjustment of cotton prices in Turkey to the cotton prices in the USA. It is a nonlinear time series model, which is introduced by Tong (1983). Since it is not easy to test the threshold process, the model introduced by Tong (1983) has not been applied widely. For testing the asymmetry, Enders and Granger (1998) and Enders and Siklos (2001) develop a generalization of the standard Dickey–Fuller test with asymmetric adjustment by proposing the M-TAR that allows for capturing the possibility of asymmetric movements in time-series data.

Consider the relationship between the two market prices of a commodity as follows:

$$P_t^1 = \alpha_0 + \alpha_1 P_t^2 + \mu_t \tag{2}$$

[1] The exchange rate may impact a commodity prices but, in this study, I focus on the relative movements in prices.

where P_t^i(i=1,2) are integrated of order 1, I(1). In other words, they are both nonstationary in levels but stationary in the first difference. α_0 is the intersection point or constant term and α_1 is the coefficient term. μ_t is the error term that can be serially correlated. According to Engle and Granger (1987), testing the cointegration relation between these two price series consists of two steps. Step 1 is the Ordinary Least Square estimation of equation (2). Step 2 is the stationarity test of the residuals obtained from step 1 as follows:

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \qquad (3)$$

where ε_t's are white noise. the price series P_t^i(i=1,2) are cointegrated if we can reject the null that $\rho = 0$.

This process is applicable if we are interested in symmetric long-run adjustment. But, many commodity prices exhibit asymmetric price transmission. The above model is not appropriate for analyzing the asymmetric market integration. So, the TAR model is applied.

Consider the modified model of equation 3 as:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \qquad (4)$$

where I_t is the Heaviside Indicator function such that:

$$I_t = \begin{cases} 1, & \mu_{t-1} \geq \tau \\ 0, & \mu_{t-1} \geq \tau \end{cases} \qquad (5)$$

where τ is the threshold level. It has to be estimated for better results, but for some cases taking the threshold level as zero, $\tau = 0$, is appropiate. In this study, it is taken as zero for the TAR model and MTAR model but then the consistent estimate of the threshold level is found and MTAR model is applied with this consistent level. The results are compared and the best model for the price series is derived.

For now, $\mu_{t-1} = 0$ can be considered as a long-run value of the price series. If $\mu_{t-1} \geq 0$, then the adjustment will be $\rho_1\mu_{t-1}$; if $\mu_{t-1} < 0$, then the adjustment will be $\rho_2\mu_{t-1}$. If $\rho_1 = \rho_2$, then there is no evidence of asymmetric price adjustment. The rejection of the null that $\rho_1 = 0 = \rho_2$ implies that these two price series are cointegrated. Therefore the *asymmetric error correction model* is performed to examine the short-run relation of the price series, which is expressed as follows:

$$\Delta P_t = I_t\rho_{1,1}\mu_{t-1} + (1 - I_t)\rho_{2,1}\mu_{t-1} + \sum_{j=1}^{k} \beta_{2j}\, \Delta P_{t-j} + v_t \qquad (6)$$

where $\rho_{1,1}$ and $\rho_{2,1}$are the speed of adjustment parameters of ΔP_t.

In equation (4), if the residuals are serially correlated, then equation (4) can be generalized to include higher order processes as follows:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{p-1} \gamma_i\, \Delta\mu_{t-i} + \varepsilon_t \qquad (7)$$

where the optimal lag length, p, can be obtained by using the Akaike Information Criteria (AIC) or the Schwartz Information Criteria (SIC).

The Heaviside Indicator in (5) depends on the level of μ_{t-1} but the decay can also depend on the previous period's change in μ_{t-1}. This alternative approach is known as *Momentum Threshold AutoRegression* (MTAR) model. In other words, the Heaviside Indicator can be defined as follows:

$$I_t = \begin{cases} 1, & \Delta\mu_{t-1} \geq \tau \\ 0, & \Delta\mu_{t-1} \geq \tau \end{cases} \qquad (8)$$

This equation can be more useful than the equation (5) if the series exhibits more momentum in one direction than in the other direction. For instance, if $|\rho_1| < |\rho_2|$, then MTAR model shows little decay for positive $\Delta\mu_{t-1}$ but big decay for negative $\Delta\mu_{t-1}$.

Up to now, there is no harm to take the threshold level as zero, $\tau = 0$. Instead of taking it zero, Chan (1993) expressed a search method for finding a consistent estimate of threshold level. Consider the M-TAR model; the threshold level can be estimated consistently by first sorting the $\{\mu_t\}$ in ascending order such that $\Delta\mu_1 < \Delta\mu_2 < \cdots < \Delta\mu_T$ where T denotes the number of different observations. Then, apply the Momentum Threshold AutoRegression model for these observations. The estimated threshold level with the lowest sum of squared residuals (SSR) is the consistent estimate of threshold level.

The critical values Φ_μ and Φ_μ^* are given in Enders and Siklos (1998) where Φ_μ and Φ_μ^* are the test statistics for TAR model and M-TAR model, respectively.

To sum up, I follow the following estimation process. Firstly, the time series properties are analyzed by using unit root test and Johansen's (1988) cointegration test. Secondly, TAR, MTAR and Consistent M-TAR models are applied. Thirdly, Asymmetric Error Correction Model is conducted to observe the short-run dynamics of the series. Finally, I look at the AIC and SIC levels to decide on which model performs better.

Empirical Results

The time series properties of the price series were analyzed by using the Augmented Dickey-Fuller (1979) test. As shown in Table 6, both Memphis and Cotton prices are non-stationary in levels, but stationary in first differences. This shows that these series are integrated of order 1, I (1).

Table 6: Unit Root Test Results

Price Series	ADF level	1st. diff.
EGE	1.835639	-7.343277
MEMPHIS	1.089995	-6.426106
Note: The critical values are -3.486064, -2.885863, and -2.579818 for 1%, 5%, and 10% level, respectively.		

Since both series are integrated of order 1, it is possible to find a cointegration relation between these price series. So, Johansen's (1988) cointegration test is used. The results are shown in Table 7.

Table 7: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. Of CE(s)	Test Statistics	0.05 critical value	Prob.
$r = 0$	29.69138	15.49471*	0.0002
$r \leq 1$	1.081362	3.841466	0.2984
Note: r denotes the number of cointegrating vectors for cointegration test. (*) denotes the rejection of the hypothesis at the 5% level.			

The null hypothesis that there is no cointegration vector is rejected at 5% critical value. However, the null that there exists one cointegrating vector cannot be rejected with probability 0.3. It means that Ege and Memphis cotton prices have a long-run relation.

Table 8 gives the result of the Engle and Granger cointegration method.

Table 8: Engle and Granger's (1986) cointegration results

Prices	α_0	α_1	ρ_1	AIC	SIC
Memphis	0.06(1.6)	0.91(40.3)	-0.29(-4.50)	-2.10	-2.08
t-statistics are given in parenthesis.					

The constant value α_0 shows that Memphis and Ege cotton prices are linked to each other by a constant value $\alpha_0 = 0.06$. The estimated value of α_1 is 0.91. The test value for the null that $\rho_1 = 0$ is 7.89 which is above the critical value. Therefore, we can reject the null that there is no cointegration. In other words, Memphis and Ege cotton prices are cointegrated.

Next, the TAR model, MTAR model and Consistent-MTAR model are estimated, respectively. The results are given in Table 9.

Table 9: Results of TAR, MTAR and Consistent-MTAR models with Memphis as the Central Market.

Price Series	ρ_1	ρ_2	$\rho_1 = \rho_2$	AIC	SIC
TAR Model					
Memphis	-0.24(-2.72)	-0.36(-3.70)	0.90	-2.09	-2.04
MTAR model					
Memphis	-0.23(-2.33)	-0.42(-4.99)	2.30	-2.11	-2.07
Consistent-MTAR model					
Memphis	-0.14(-1.37)	-0.41(-5.20)	4.45	-2.15	-2.11
The t-statistics are given in the parenthesis.					

The Wald-Coefficient test is applied to test the null hypothesis that $\rho_1 = 0 = \rho_2$. For all the 3 models, the null hypothesis is strongly rejected. Therefore, Memphis and Ege cotton prices are cointegrated. Then, again, I apply the Wald Coefficient test to test the null hypothesis that $\rho_1 = \rho_2$. For TAR and MTAR models, the F-statistics show that we cannot reject the null. In other words, there is no evidence that asymmetric adjustment occurs between the price series. The critical values for F-distribution are given in Enders and Granger (1998).

As for the Momentum-Consistent Threshold model, the Chang (1993) process is applied to find the super consistent threshold level. The potential threshold levels were -0.06, -0.05, -0.04, -0.03, -0.02, -0.01, 0, 0.01, 0.02, 0.03, 0.04, 0.05, and 0.06. The MTAR model for all of these potential threshold levels is estimated. The minimum Residual Sum of Squares (RSS) is obtained at the value 0.02. So, the consistent estimate of threshold level is 0.02, $\tau = 0.02$. All the RSS value can be found in Appendix. Table 9 gives the Momentum-Consistent Threshold model parameters with threshold level 0.02. The null hypothesis $\rho_1 = \rho_2$ is tested by using theWald-Coefficient test. Since the test statistic is above the critical value, we reject the null. Therefore, we conclude that there exists asymmetric price adjustment between Ege and Memphis cotton prices. In other words, if cotton prices in Memphis increases by 1 unit, then cotton prices in Ege will adjust 14 percent in the next month. However, if cotton price in Memphis declines by 1 unit, then cotton prices in Ege will be eliminated by 41 percent in the next month.

Asymmetric price adjustment gives the long-run relation. To examine the short-run dynamics, the asymmetric error correction model described in equation (6) is conducted. The results are given in Table 10. The results show that price response to negative shocks is much stronger than to positive shocks, which indicates the negative asymmetry on these price series.

Table 10: Estimation of Asymmetric Error Correction Model

	Dependent variable: D (MEMPHIS)	Dependent variable: D (EGE)
$I_t \mu_{t-1}$	0.26(1.74)	-0.23(-4.82)
$(1 - I_t)\mu_{t-1}$	0.53(4.67)	-0.42(6.25)
$\Delta P_{memphis}(-1)$	0.69(6.79)	0.30(4.91)
$\Delta P_{ege}(-1)$	0.20(2.00)	0.16(2.75)
Adjusted R^2	0.35	0.67
Note that optimal leg length was chosen by using AIC and SIC. T-statistics are given in parenthesis.		

Lastly, the AIC and SIC values of TAR, MTAR, and Consistent-MTAR models are listed. The results are presented in Table 11. The results show that Consistent-MTAR model performs better than the TAR and M-TAR models, since AIC and SIC values of it are the smallest ones. The variance decomposition graphs and impulse response functions graphs can be found in the Appendix.

Briefly, any price change in Memphis cotton price has effects on risk management strategies for cotton producers, speculators, ginning companies, and textile industry in Turkey. Moreover, asymmetric price adjustment gives more details about the market integration for cotton prices. In our case, negative asymmetry between Ege prices and Memphis prices is found in Consistent MTAR model. In other words, the response of cotton prices in Turkey is much larger to the negative changes in cotton prices in the USA than to the positive changes in cotton prices in the USA. It means that investors or who have inventories in Turkey need to dissolve their inventories more quickly when Memphis prices decline than they need to accumulate inventories when Memphis prices rise.

Table 11: List of AIC and SBC values of 3 models.

MODEL	AIC	SIC
TAR	-2.096309	-2.049851
MTAR	-2.117101	-2.070643
Consistent MTAR	-2.158517	-2.111809

Conclusions

World cotton price has increased more than 150 percent in 2011 compared to last year, which makes it highly volatile. Prices increase or decrease very rapidly. Turkish cotton price sometimes does not adjust itself to world prices although there is no tax or barrier for importing or exporting of cotton. For example, in February 2011 and March 2011, there has been a significant gap between Turkish cotton prices and Memphis cotton prices with a size of around 80 cents per kilogram. So, it becomes very important to investigate the asymmetric price adjustment of cotton prices between Memphis and Ege Standart-1 type.

The TAR, MTAR, and Consistent-MTAR models are used to examine the asymmetric price adjustment. The results have shown that there is a cointegration relation between Ege and Memphis cotton prices. This result verifies that the cotton traders in Turkey take into account the cotton prices in Memphis. In other words, the USA is able to influence cotton price in Turkey. This is expected because Turkey imports most of the cotton from the USA. However, what is not expected is that this price adjustment is not symmetric. The consistent MTAR model clearly supports asymmetric price transmission from Memphis market to Ege market. In other words, cotton prices in Turkey show greater response to falling prices than to rising prices in cotton market in Memphis. Search cost can be an important reason for this result.

Another reason for asymmetric price adjustment can be that the production of cotton highly depends on natural conditions. Because of that, sometimes the price settlement in IME can be differ from the international markets (Telatar et al, 2002).

One of the policy implications of these results is that, price settlement by exchange markets is more suitable than inverventory process for the efficiency in Turkish market (Telater, 2002). The other implication is that, the result of negative price transmission shows that farmers, ginning factories and traders in Turkish cotton market are risk averse. They need to act more patiently to falling prices than to rising prices in Memphis market.

CHAPTER 2

LONG RUN RELATIONSHIP AMONG CRUDE OIL PRICES, CEREAL PRICES AND COTTON PRICES

Introduction

From April 2001 to April 2011, as shown in Figure 4, there have been 353 percent, 264 percent, 160 percent and 324 percent increases in crude oil prices, corn prices, wheat prices, and cotton prices, respectively. In 2008, at the beginning of the last financial crisis, the commodity prices and crude oil prices touched extremely high levels simultaneously compared with the past. The same story reoccurred at the beginning of 2011. The same prices responded, again, simultaneously and reached very high levels although the new levels were not as high as in 2008.

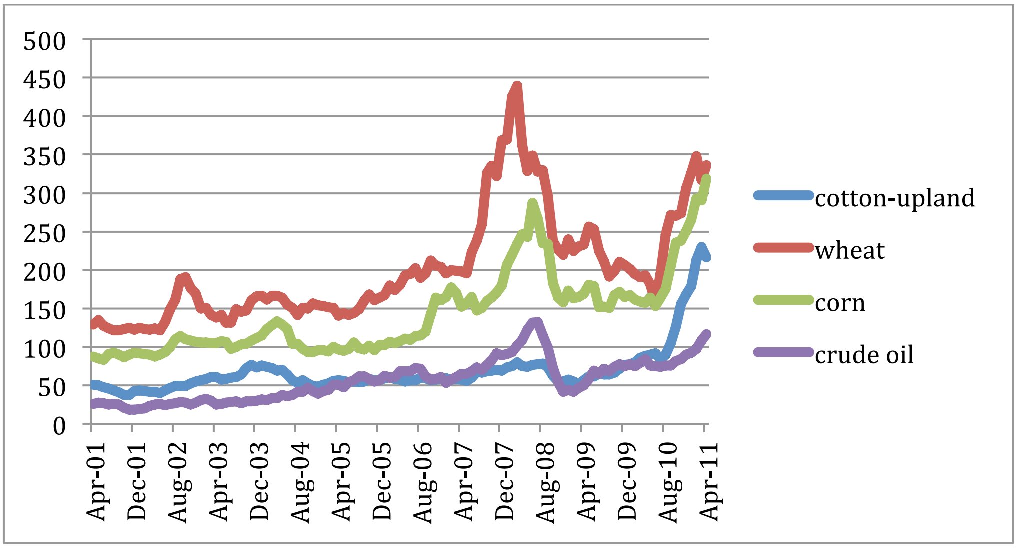

Figure 4: Crude oil prices ($/barrel), Corn prices ($/Mton), Wheat prices ($/Mton), Cotton prices (US cents/pound). (Source: International Monetary Fund (IMF))

The expansion on the quantity of dollar by the FED (Central Bank of the USA) policy seeks the eyes of the speculators to the commodity prices. FED trys to overcome the negative effects of the financial crisis by introducing a new policy, called quantitative easing. Quantitative easing is a kind of printing money. Since the interest rates are at historically low levels, the FED did not have too many alternatives to modify the interest rates. Instead, they decided to buy mortgage backed securities and treasury bills. By doing this, they released billions of dollars to the market, which diffused later to the commodity markets.

In recent years, the connections between agriculture and energy markets have increased due to the rise in the demand for biofuel. It was first produced to increase the octane level of gasoline after blended. Later, it is used in order to decrease the dependency to the fossil fuels by blending into the gasoline. The most recent blending level is 10%. In other words, ethanol is blended with gasoline by 10% level (Saghaian, 2010).

The political problems in the MENA (Middle East and North Africa) region and the worries about the supply of crude oil gave rise to a big jump in crude oil prices. Crude oil prices have been at very high levels in February and March 2011. This leads to arise of the question "Is it the time to alter the energy sources from crude oil to bioethanol and biodiesel?"

Ethanol production worldwide, as shown in figure 5, increased from 147 million gallons in 1975 to 23,400 million gallons in 2011. After 2000, as the crude oil prices went up, ethanol production increased exponentially. From 2000 to 2011, there has been a 418 percent increase in ethanol production.

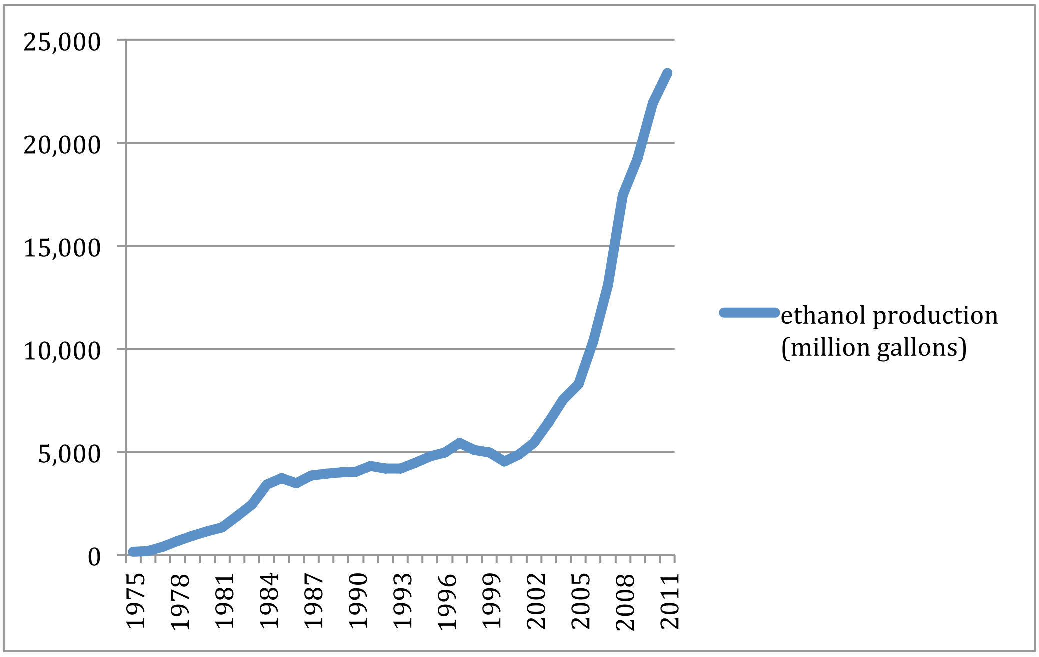

Figure 5: Ethanol production in the world (million gallons). (Source: Global Renewable Fuels Alliance)

Ethanol can be produced from many agricultural crops such as corn, wheat, cottonseed, and canola. Worldwide, a large portion of the growth in corn demand is associated with growth in the ethanol production. Figure 6 shows the flows among crude oil prices, cereals prices, and cotton prices. More ethanol production and plants means more demand for corn which in turn increases corn prices. Higher corn prices leads the farmers to grow corn rather than cereal crops and cotton in order to get more profits. More land devoted to corn cultivation gives rise to a decrease in the cultivation of commodity products such as wheat and cotton. This negative supply shock pushes cereal and cotton prices up.

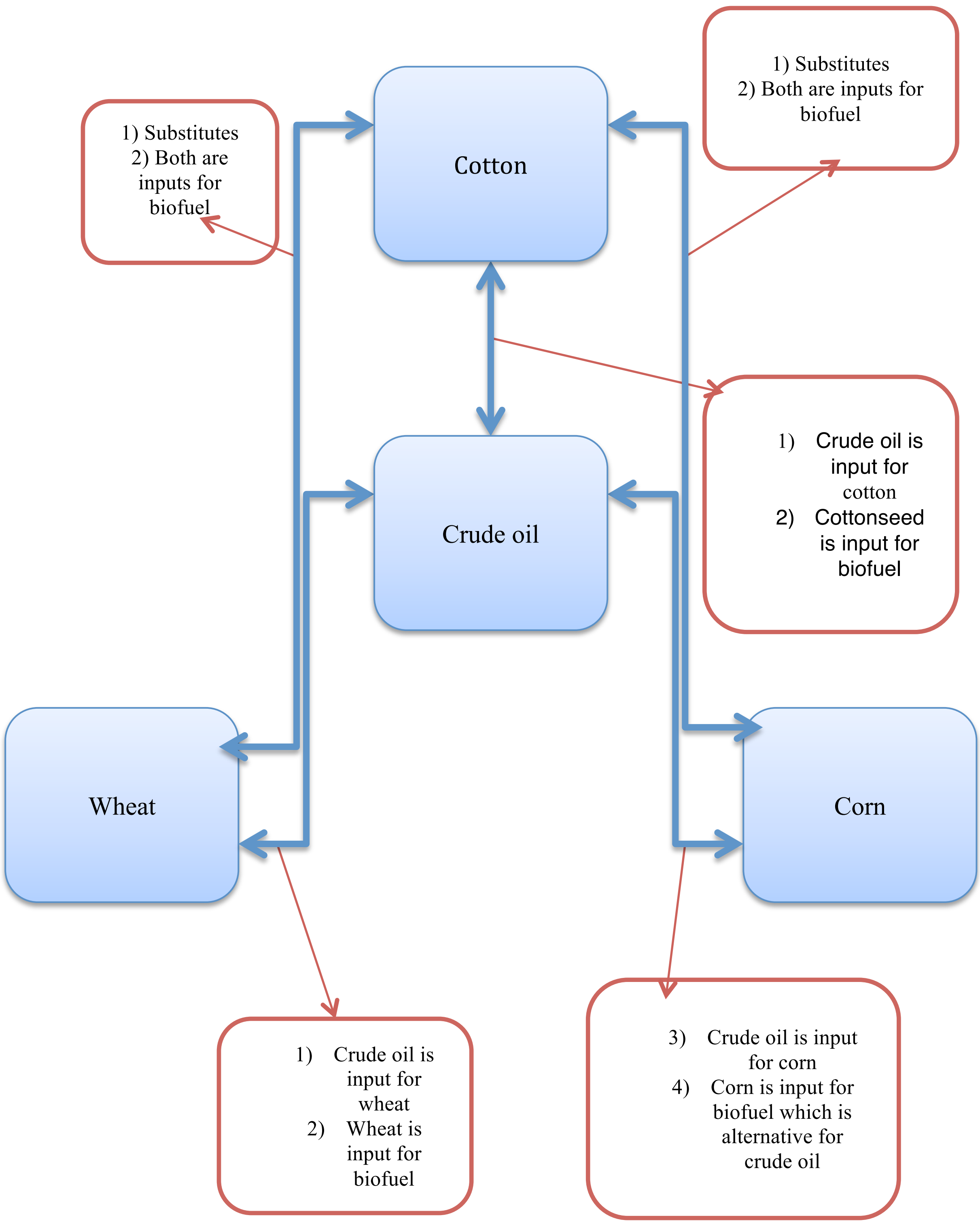

Figure 6: The interconnections between crude oil prices, cereals prices and cotton prices.

The increase in cereal prices is a major concern to most of the developing countries as they are the staple diet of the population and an increase in the price of wheat will affect the poor consumers much more than the well to do ones. Also, cotton can be used for high quality clothes. When people get richer they prefer to wear clothes made by cotton fiber to clothes made by polyester.

The apparent high correlation between crude oil and cereal prices begs the question as to the nature of the relationship of the two variables. Within this context, the examination of energy and agricultural sectors' interlinkages and their price moves are very important. Therefore, in this chapter, the bivariate cointegration relations between crude oil prices, corn prices, cotton prices and wheat prices are analyzed by using Engle and Granger's (1987) two step cointegration method and Gregory and Hansen's (1996) cointegration test which allows for structural breaks in the relation.

Literature Review

There are many studies that focus on the co-movement of the agricultural commodity prices. Yu et al. (2006) investigate the long-run interdependence between major edible oil prices and crude oil price. They find that there exists one cointegration relationship among edible oil prices and crude oil prices during the 1999-2006 time period. Their results also suggest that the influence of crude oil prices on edible oil prices is not significant over the study period. Campiche et al. (2007) examine the covariability between crude oil prices and corn, sorghum, sugar, soybeans, soybean oil, and palm oil prices between 2003-2007. They apply the Johansen's (1988) cointegration tests and find no cointegrating relationships for the 2003-2005 periods. For the period 2006-2007, only corn prices and soybean prices had cointegrating relationships with crude oil prices. Arshad and Hameed (2009) study the long-term relationship between crude oil prices and cereal prices. They apply the bivariate cointegration approach using Engle and Granger's (1987) two-stage estimation procedure. Their results support the existence of cointegration relation between two commodity prices.

Peri and Baldi (2010) analyze the asymmetric cointegration approach between vegetable oil prices and diesel prices in the EU for the 2005-2007 periods. They find that a two-regime threshold cointegration model occurred only for rapeseed oil and diesel prices. The cointegration relation differs if the divergence between the two price series is above or below the threshold level.

Using a different approach, Conley and George (2008) argue that continuous growth of biofuel industries and the increased demand for corn have important implications for the managers of grain farms and agribusinesses. Their results show that impacts of macroeconomic factors about ethanol in the U.S. would cause structural changes not only in production and marketing of corn, but also other crops such as wheat and cotton.

Rosegrant (2008) asserts that 30 percent of the increase in grain prices is a result of an increase in biofuel demand in the world. In the same context, Tyner and Taheripour (2007) argue that a large proportion of the corn price changes come from the increase in the oil prices.

The Econometric Model

I begin with a simple model to explain the relationship between crude oil and each of the commodity prices.

$$C_iP_t = \alpha_0 + \alpha_1 PP_t + \varepsilon_t$$

Where C_iP_t is the price of commodity i in period t and PP_t is the crude oil price in period t and ε_t is the white noise.

To investigate the long-run relationship between a commodity's price and crude oil price, first, unit root tests are conducted. Then, the cointegration test is applied. If both series are not stationary in levels but stationary in first difference, then they are integrated of order 1, I(1), as mentioned in detail in Chapter 1. According to Engle and Granger (1987), two I(1) series are cointegrated if a linear combination of them is stationary in levels. Cointegration means that cointegrated series may diverge from each other in the short run but they must move together in the long run. If there exist a cointegration relation between two series, then the error correction model (ECM), which gives us the speed of convergence to long run equilibrium and the short-run dynamics of the series, can be performed (please refer to Chapter 1 for further details).

Johansen's (1988) method is applied to investigate the cointegration relationship. In this method the null hypothesis is that there is no cointegration relation between the price series while the alternative hypothesis is that there exists cointegration relation. However, Johansen's (1988) method does not allow for a structural break in the cointegration relation. In other words, if there exists a cointegration relation with structural break, Johansen's (1988) method cannot capture this case. Instead, Gregory and Hansen's (1996) residual-based tests for cointegration in models with regime shift needs to be applied. Gregory and Hansen propose ADF, Z_α and Z_t type tests designed to test the null of no cointegration against the alternative of *cointegration in the presence of a possible regime shift*. They allow the cases where the intercept and/or slope coefficients have a single break of unknown timing. Their models are described as follow:

Model 1: Standard cointegration

$$C_iP_t = \alpha_0 + \alpha_1 PP_t + \varepsilon_t$$

This model is already described extensively in section 1.6. The structural change would be reflected in changes in the intercept α_0 and/or changes to the slope α_1.

A dummy variable is defined to model the structural change:

$$\varphi_{t\tau} = \begin{cases} 0 \; if \; t \leq [n\tau] \\ 1 \; if \; t > [n\tau] \end{cases}$$

where the unknown parameter $\tau \in (0,1)$ denotes the timing of the change point and $[n\tau]$ denotes the integer part.

The structural break may occur only in the intercept. It is called as *level shift* and denoted by C.

Model 2: Level Shift (C)

$$C_iP_t = \alpha_{01} + \alpha_{02}\varphi_{t\tau} + \alpha_1 PP_t + \varepsilon_t \qquad t = 1, \dots, n$$

where α_{01} represents the intercept before the shift and α_{02} represents the intercept after the shift. There can also be a time trend in the model. The new model is denoted by C/T.

*Model 3: Level shift with trend (*C/T)

$$C_iP_t = \alpha_{01} + \alpha_{02}\varphi_{t\tau} + \beta t + \alpha_1 PP_t + \varepsilon_t \qquad t = 1, \dots, n$$

There may also be a structural change in the slope vector, which permits the equilibrium relation to rotate as well as shift parallel. This model is called as *regime shift* and denoted by C/S.

Model 4: Regime shift (C/S)

$$C_iP_t = \alpha_{01} + \alpha_{02}\varphi_{t\tau} + \alpha_{11} PP_t + \alpha_{12} PP_t\varphi_{t\tau} + \varepsilon_t \qquad t = 1, \dots, n$$

where α_{01} and α_{02} are the same as in the models 2 and 3. α_{11} is the slope coefficient before the regime shift and α_{12} denotes the change in the slope coefficient.

If the timing of the regime shift were known, then the candidate cointegration relation could be found by testing the stationarity of the error terms in the models 2-4. However, in general, the regime shift timing is not known. Gregory and Hansen (1996) developed a test procedure that does not require any information about the timing of the structural break. They compute the cointegration test statistic for each possible regime shift $\tau \in T$ and take the smallest value (the largest negative value). Here, T is a compact subset of $(0,1)$. So, the test statistics are:

$$Z_\alpha^* = inf\ Z_\alpha(\tau),$$

$$Z_t^* = inf\ Z_t(\tau),$$

$$ADF^* = inf ADF(\tau).$$

Data and Empirical Results

The sample period chosen for this study is the monthly observation prices extending from April 2001 to April 2011. Crude oil price is the simple average of the three spot prices: Dated Brent, West Texas Intermediate, and the Dubai Fateh[2]. In addition, the mostly traded types of commodity prices are also chosen. Corn used in this study is the yellow number two-type. Cotton prices are the cotlook A-index prices. Hard Red Winter type wheat prices are also used. All price data are taken from the IMF. The descriptive statistics and the correlation coefficients are given in Table 12 and 13, respectively.

[2] The same model is applied to Dated Brent and West Texas Intermediate crude oil prices, but the results are similar.

Table 12: Descriptive Statistics (Crude oil prices (US$/barrel), Corn prices (US$/Mton), Wheat prices (US$/Mton), Cotton prices (US cents/pound)

	Crude oil	Corn	Wheat	Cotton
Mean	56.59	142.62	201.20	68.31
Median	56.47	120.26	181.88	58.82
Mode	65.1	107.82	-	73.59
Standard Deviation	27.06	57.09	72.00	32.42
Sample Variance	732.7234	2926.53	5184.93	1051.17
Minimum	18.52	83.16	121.46	37.22
Maximum	132.55	318.74	439.72	229.67

Table 13: Correlation matrix

	Crude oil	Corn	Cotton	Wheat
Crude oil	1.0000	0.8468	0.5716	0.8375
Corn	-	1.0000	0.7497	0.8777
Cotton	-	-	1.0000	0.5468
Wheat	-	-	-	1.0000

The Augmented Dickey Fuller test is performed to test the stationarity of the given data series. The results are shown in Table 14. The null hypothesis that there exists no unit root in level is rejected for all of the series but the null hypothesis is not rejected for differenced data series.

Table 14: Unit Root tests for crude oil, corn, wheat and cotton

	ADF	
Commodity	Level	First Difference
Crude oil	-1.38(1)	-6.24**(0)
Corn	0.24(1)	-8.36**(0)
Cotton	-0.34(3)	-4.53**(2)
Wheat	-1.35(1)	-8.56**(0)
(**) denotes 1% significance level. Figures in parenthesis give the lag length based on SIC.		

The SIC is used to find the optimal lag length for all of the price series. Crude oil, corn and wheat have lag length of 1 while cotton has lag length of 3.

Since all of the price series are not stationary in levels but stationary in differenced terms, which means that they are integrated of order 1 I(1), Engle and Granger's (1987) two-step cointegration model is performed by testing the stationarity of the regression errors. The results of Johansen's (1988) cointegration method are given in Table 15. The null hypothesis that there exists no cointegration vector is rejected only for crude oil and wheat prices bivariate case. This means that there does not exist any cointegration relation for all of the bivariate cases except crude oil prices and wheat prices. In Johansen's (1988) method, the alternative hypothesis is that there exists a cointegration relation between the price series, which does not capture the cointegration relation with structural break. If there exists a regime shift in the cointegration relation, it is not sufficient to employ Johansen's (1988) method. Instead, Gregory and Hansen's (1996) model, allowing for level shift or regime shift in the cointegration relation, is used. The empirical results are shown in Table 16. The critical values are given in Gregory and Hansen's (1996) paper. It is remarkable that the results are different from the results of Johansen's (1988) cointegration method. There does not exist any cointegration relation between crude oil prices and cotton prices by using Johansen's (1988) method. However, the results of Gregory and Hansen's (1996) model exhibit a cointegration relation between these price series with a possible regime shift. Similarly, although there does not exist any cointegration vector between corn prices and cotton prices, corn prices and wheat prices, wheat prices and cotton prices in the results of Johansen's (1988) method, the cointegration relation for all of these bivariate cases is verified by using Gregory and Hansen's (1996) models.

The breakpoints indicate the timing of the regime shift occurrence. For the corn prices and cotton prices, the regime shift occurred on August 2008. For the cotton prices and wheat prices, the structural break happened on August 2008. For the corn prices and wheat prices, the timing for the regime shift is June 2008. These dates actually overlap with the start of the last financial crisis (2008) in the world.

Therefore, the existence of the last financial crisis (2008) in the world, leads to structural changes in the relation among agricultural commodities.

Table 15: Johansen's Cointegration Test Results

	Crude oil-Corn		Crude oil-Cotton		Crude oil-Wheat		Corn-Cotton		Corn-Wheat		Wheat-Cotton	
Null	Max-Eigen Stats.	%5 critical value	Max-Eigen Stats.	%5 critical value	Max-Eigen Stats.	%5 critical value	Max-Eigen Stats.	%5 critical value	Max-Eigen Stats.	%5 critical value	Max-Eigen Stats.	%5 critical value
$r = 0$	9.34	14.26	6.26	14.26	14.94*	14.26	9.47	14.26	9.66	14.26	7.12	14.26
$r \leq 1$	0.55	3.84	0.12	3.84	1.16	3.84	0.01	3.84	0.08	3.84	3.15	3.84

(*) denotes the rejection of the hypothesis at the 5% level.

Table 16: Testing for regime shifts in commodity prices

	Crude oil- Corn		Crude oil-Cotton		Crude oil-Wheat		Corn-Cotton		Corn-Wheat		Wheat-Cotton	
	Test Stat.	Break Point	Test Stat.	Break Point	Test Stat.	Break point	Test Stat.	Break Point	Test Stat.	Break Point	Test Stat.	Break Point
ADF*												
C	-2.14	2004M07	-2.61	2009M08	-4.10	2004M09	-2.06	2006M08	-4.44*	2009M09	-2.70	2006M08
C/T	-2.85	2004M07	-2.72	2009M04	-4.35	2007M03	-3.14	2006M09	-4.41	2009M09	-3.33	2007M05
C/S	-2.75	2008M05	-4.71*	2009M04	-4.23	2006M06	-5.91**	2008M08	-5.56**	2008M06	-5.97**	2008M06
Z_t*												
C	-2.47	2004M09	-1.06	2009M08	-3.67	2004M06	-2.07	2006M08	-4.07	2009M09	-2.74	2006M08
C/T	-2.95	2004M10	-1.19	2009M08	-3.92	2007M03	-3.11	2006M08	-4.04	2009M09	-3.29	2006M08
C/S	-2.79	2004M06	-4.58	2009M03	-3.76	2006M07	-5.89**	2008M08	-4.80*	2008M07	-5.89**	2008M06
Z_α*												
C	-14.19	2004M09	-5.84	2009M08	-25.8	2004M07	-10.50	2006M08	-32.47	2009M09	-15.97	2006M07
C/T	-19.03	2004M09	-6.68	2009M08	-28.92	2007M02	-19.71	2006M09	-31.89	2009M09	-21.31	2006M08
C/S	-18.78	2004M06	-37.0	2009M03	-26.75	2006M05	-54.24**	2008M08	-41.85*	2008M06	-55.44**	2008M08

(**) and (*) denotes the rejection of the hypothesis at the 5% and 10% significance level, respectively. The numbers in the breakpoint boxes denotes the year and month that structural break occurs.

Cointegration implies Granger causality. In other words, if there exists a cointegration relation between two series, then one must Granger cause the other one. The Granger causality test is applied to the studied price series. The results are summarized in Table 17.

Table 17: Granger causality test

Null hypothesis	F-statistics	Probability
CORN does not Granger Cause CRUDE OIL	2.97030	0.08745*
CRUDE OIL does not Granger Cause CORN	0.15508	0.69444
COTTON does not Granger Cause CRUDE OIL	2.96899	0.03502**
CRUDE OIL does not Granger Cause COTTON	0.37443	0.77160
WHEAT does not Granger Cause CRUDE OIL	8.27872	0.00477***
CRUDE OIL does not Granger Cause WHEAT	0.34862	0.55603
COTTON does not Granger Cause CORN	3.48217	0.01833**
CORN does not Granger Cause COTTON	4.12437	0.00816***
WHEAT does not Granger Cause CORN	6.14775	0.01458**
CORN does not Granger Cause WHEAT	0.04516	0.83209
WHEAT does not Granger Cause COTTON	3.51478	0.01759**
COTTON does not Granger Cause WHEAT	1.42781	0.23850
(***), (**) and (*) denotes the rejection of the hypothesis at the 1%, 5% and 10% significance level, respectively.		

F-test results indicate that the hypotheses that all cereal prices and cotton prices do not Granger cause crude oil prices are rejected. The direction of Granger causality runs especially strong from cereals prices and cotton prices to crude oil prices. This relationship is unidirectional and there are no causality relationships going from crude oil prices to corn, wheat or cotton prices.

As expected, there is a bidirectional relationship between corn prices and cotton prices. However, there is a unidirectional causality relationship between wheat prices and corn prices. The direction of the causality flows from wheat prices to corn prices. Also, although wheat prices Granger cause cotton prices, cotton prices do not Granger cause wheat prices.

An unexpected result is that crude oil does not Granger cause cereal prices and cotton prices. It is important to note that Granger causality, a concept based on prediction, does not mean real causality. The fact that a variable Granger causes another variable only means past values of that variable have some information that could help predict future values of this variable (Saghaian, 2010).

Conclusions

The price transmission between commodity prices and crude oil prices is always an interesting theme for researchers. The investigation of this price transmission has become more important after the last financial crisis of 2008. I applied first the Johansen's (1988) cointegration test and then Gregory and Hansen's (1996) cointegration tests. The results of Gregory and Hansen's (1996) cointegration methods show that there exist cointegration between corn and cotton prices, corn and wheat prices, cotton and wheat prices and crude oil and cotton prices with regime shifts, although the Johansen's (1988) procedure could not capture the cointegration relations. The timings of the structural breaks are expected. All regime shifts occurred at the beginning of the last financial crisis. In other words, the structural breaks happened at the peak point of the prices or one period after that point. These results can be interpreted as the demand for commodity prices decreased altogether with the financial crisis.

The interesting result is that crude oil does not Granger cause any of the cereals prices or cotton. On the contrary, the results indicate that the corn, wheat and cotton prices Granger cause the crude oil prices. The result that corn prices and cotton prices Granger cause each other is expected since both corn and cotton are used as input for biofuel production. Also, these agricultural crops compete for land. For example, an increase in corn prices leads farmers to grow corn rather than cotton. Then, the supply of cotton decreases. One period after the decrease in cotton supply, the price of cotton increases. Therefore, an increase in corn prices Granger cause an increase in cotton prices with a one period lag. Wheat prices Granger cause both corn prices and cotton prices. However, neither corn prices nor cotton prices Granger cause the wheat prices.

The results found in this study can be important for farmers. The existence of cointegration relations between cereal prices and cotton prices supports the interconnections in Figure 6. In other words, farmers need to take into account not only price of the agricultural commodity that they produced but also the prices of other agricultural commodities.

Also, these results suggest that cointegration relation between commodity prices can be time variant. Big shocks, such as financial crisis and political crisis, can affect the long-run relation between commodity prices. Traders and Hedge Fund managers need to bear in mind that a financial crisis has significant effect on the co-movement of commodity prices.

APPENDIX

Table 18 Correlation Matrix(Memphis-Ege cotton prices)

	Memphis	Ege
Memphis	1	
Ege	0.9655	1

Table 19 Potential Threshold Levels

Threshold Levels	RSS
-0.06	0.791742
-0.05	0.807024
-0.04	0.807577
-0.03	0.805192
-0.02	0.796915
-0.01	0.796876
0.01	0.779578
0.02	**0.778113**
0.03	0.790711
0.04	0.794361
0.06	0.793251

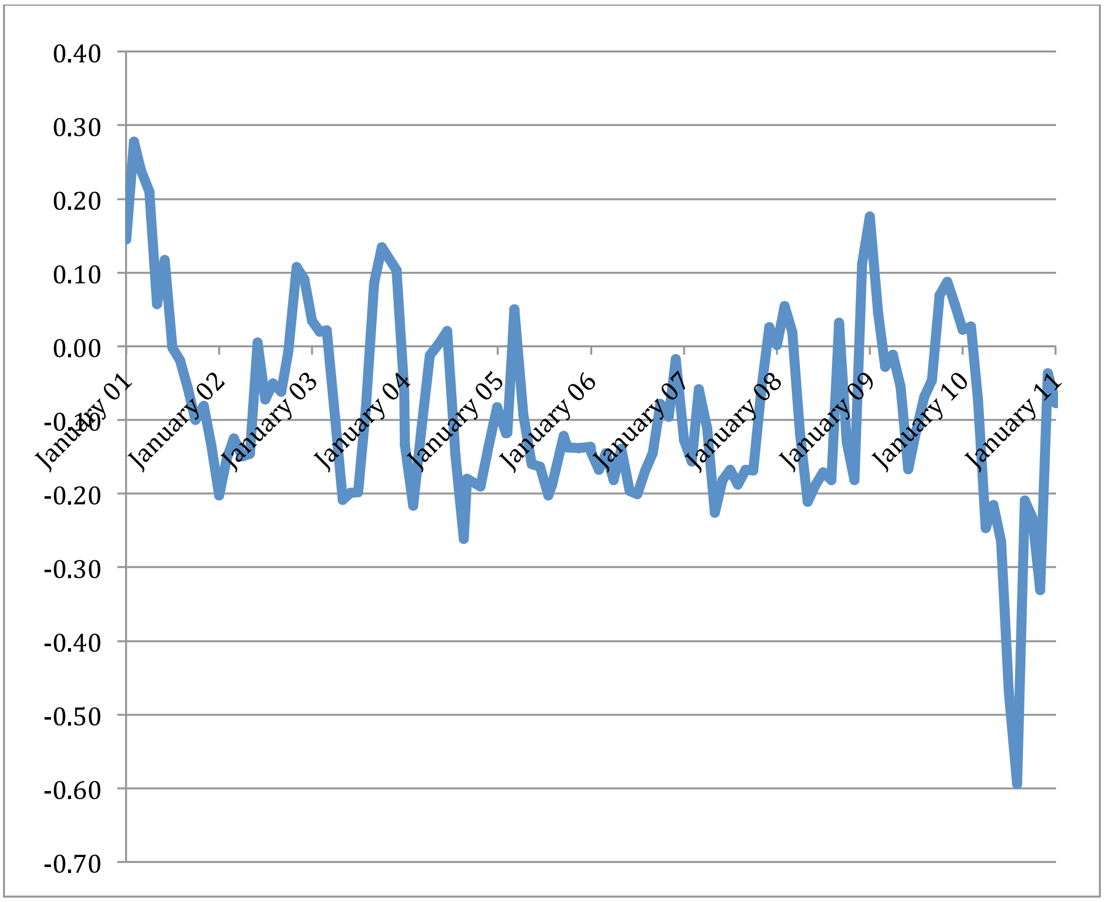

Figure 7 The Graph of Price Difference Between Memphis(USD/KG.) and Ege(USD/KG.)

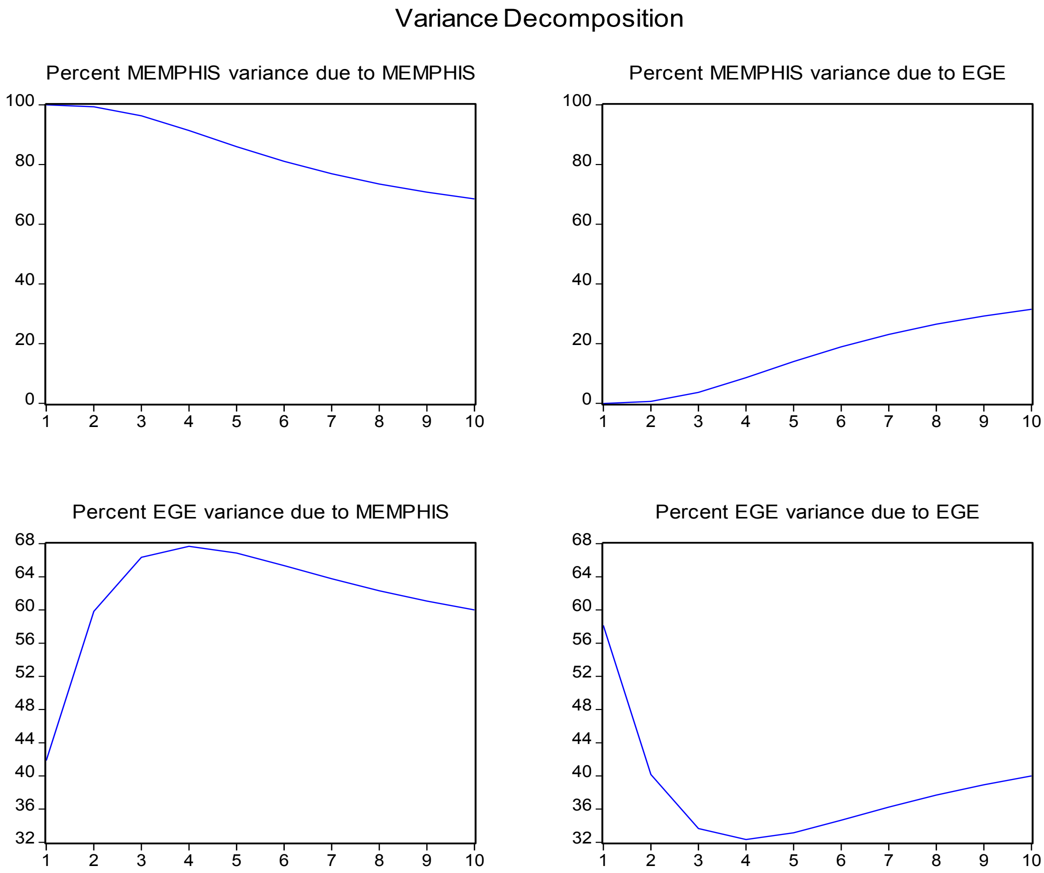

Figure 8 Variance Decomposition of cotton prices in Ege and Memphis

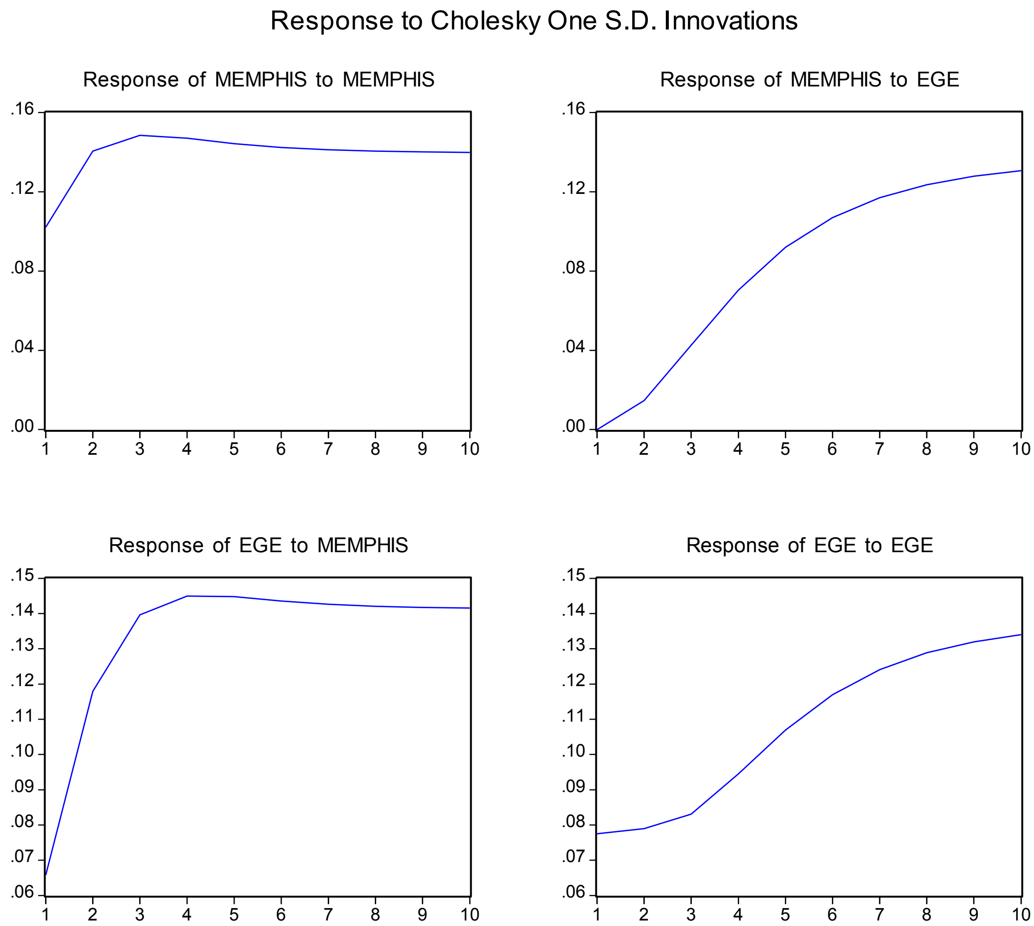

Figure 9 Impulse Response Functions of cotton prices in Ege to cotton prices in Memphis and vice versa.

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