PAIRS TRADING TO THE COMMODITIES FUTURES MARKET USING COINTEGRATION METHOD

Cüneyt Ungever, (Phd Candidate)

Istanbul Commerce University, Turkey

Abstract:

This paper investigates pairs trading strategy by using the cointegration method among the 10 most popular agricultural future markets. It is found that only in 2 pairs shows trading signal. The pairs trading strategy is performed in two stages that are the formation period and the trading period with daily futures data from 2004 to 2015. After the formation period was constructed, it is assumed that the cointegration error continues to hold the trading period same as it does for the formation period. The pairs trading strategy is created by the long position cotton and the short position coffee and also long position cotton and short position the livecattle. It is found that the profitability of this strategy worked well in both formation period and trading period.

Keywords: *Pairs Trading, Cointegration Approach, Futures Market, Commodities, Statistical Arbitrage*

1. Introduction:

The Pairs trade, also known as a statistical arbitrage strategy or a convergence trading strategy, is a market neutral trading strategy. The conception of pairs trading is the simultaneous buying and selling two historically correlated securities. This investment strategy requires buying the under-valued security (long position) while short selling (short position) the over-valued security, thus keeping the market neutrality (Vidyamurthy, 2004).

Jesse Livermore, the most famous trader of all time, was the first pairs trader in the late 1800s. Livermore's strategy was to monitor "sister stocks", or two similar stocks in the same industry (Ehrman, 2006). In 1980s, Nunzio Tartaglia, a quantitative analyst, gathered a team of physicists, mathematicians and computer scientists to reveal arbitrage opportunities in the equity markets. Tartaglia's team developed high tech trading programs by using complex statistical methods. The first objective of Tartaglia's trading programs was to select pairs of securities whose prices tended to move together (Gatev, Goetzmann, and Rouwenhorst, 1998). Tartaglia's team had been very successful in trading these pairs in 1987, but in 1989, after two years of bad performance, Morgan Stanley halted its operation. Despite of a couple of bad years of performance, the pairs trading became a very popular market-neutral strategy among individuals and institutional traders as much as hedge funds.

In this paper, the profitability of pairs trading strategy is studied by using Johansen cointegration method in the commodities future market over the period of 2004-2015. In the academic literature, in order to apply pairs trading strategy, interestingly, neither cointegration method nor commodities future markets have received little attention. This study, first, seeks to identify pairs of commodities by using Johansen's Test for cointegration and then in this study the pair of commodities is modeled by using the Vector Error Correction Modeled (VECM). The VECM model obtained from residual series plays a primary role to implementing a pairs trading strategy.

This paper proceeds as follows. The next section reviews the literature. Section 3 describes the data and methodology, Section 4 reveals empirical results and trading strategies. Section 5 summarizes and concludes the paper.

2. Literature Review

There are four main methods to implement the pairs trading in the academic literature:

1-Distance Trading Method, 2-Stochastic Spread Method, 3-Combine Forecast Method 4-Cointegration Method

2.1-The Distance Method

The distance method, the most common method Gatev et al. (1998, 2006), is one of the most referenced papers in the pairs trading. The study by Gatev *et al.* (1998) has been used in distance-trading approach to test the pairs trade in the U.S. stocks with daily data from the period 1962 to December 1997. Gatev et al. (2006) extended and updated the analysis of 2002. Their first research showed that the average annualized excess return is 12% of top pairs, and concluded that the pairs payoff is not strictly linked to a classical mean reversion effect. Their second research also showed that the average annualized excess returns is 11% for self-financing portfolio of pairs. Abnormal returns are compensation to arbitrageurs for enforcing the "Law of One Price". Do and Faff (2009) replicated the Gatev (1998) methodology with the recent data. They found that the strategy is still profitable but it is declining. Perlin (2009) found that the pairs trading strategy worked well in the Brazilian financial market and also an implementation of pairs trading strategy leads a positive excess return. Broussard and Vaihekoski (2012) used the Finnish stock market data from 1987 to 2008 under different weighting structures and trade initiation conditions. They found that the excess return is 12.5%.   Papadakis and Wysocki (2008) examined the impact of accounting information events on the profitability of the pairs trading strategy by using the U.S stock pairs from 1981 to 2006. They found that the drift in stock prices, following earnings announcement and analyst's earning forecast, has a significant effect on the pairs trading. Engelberg, Gao and Jagannathan (2009) analyzed the source of profits from the pairs trading. They found that the profitability of pairs trading is positively related to the way of information spreads across the stocks in the pair and in the frictions that suppress this information flow. Jacobs and Weber (2011) analyzed returns in different information settings by using the data of the U.S. stocks and eight major stock markets from 1960 to 2008. They found that pairs opening on high distraction days generate higher returns than pairs opening on low distraction days. Mori and Ziobrowski (2011) compared the performance of the pairs trading in the U.S. REIT market with the U.S general stock market over the period of 1987 to 2008. They found that the REIT market provided superior profit opportunities between 1993 and 2000 because of special characteristics of REIT and these profits disappeared after 2000. Nath (2003) tested the U.S. Treasury securities. He concluded that the pairs trading strategy produces abnormal returns compared to various benchmarks between 1994 and 2000. Muslumov (2009) did a research about the Istanbul Stock Exchange and found that the average excess return of 5.4% for the top 20 best pairs trading portfolios. Huck (2013) used S&P 500 stocks and demonstrated the high sensitivity of the return to changes in the length of the formation period and that data-snooping bias cannot explain the positive excess return obtained in some cases.

2.2- Stochastic Spread Method

A stochastic approach has been used in the pairs trading by Elliott, Van der Hoek and Malcolm (2005**)** and Do *et al,* (2006), Rampertshammer (2007), Mudchanatongsuk, Primbs and Wong (2008), Herlemont (2008), Bogomolov (2010), Kanamura, Rachev and Fabozzi (2010). Elliot (2005) proposed a mean reverting that is Gaussian Markov chain model for the spread. The appropriate investment decision is based on the predictions of the spread and is calibrated from market observations. Do et al. (2006) investigated the stochastic approach and agreed with the work of Elliot et al. (2005). This model has three major advantages from the point of the empirical perspective. Do et al (2006) suggested that the long term mean of the level differences in two stocks should not be constant and they proposed the stochastic residual spread method to pairs trading. Mudchanatongsuk et al. (2008) offered a stochastic control approach to the problem of pairs trading, obtained the optimal solution to the problem in closed form through Hamilton-Jacobi-Bellman equation and provided closed form maximum likelihood estimation values for the parameters in this model. Kanamura et al. (2010) applied the pairs trading strategy to energy futures market from 2000 to 2008 by using a mean reverting process of the futures price spread. They found that the stable profit can be made with the pairs trading but the profit of cross commodities may not be improved. Bogomolov (2010) investigated all three methods of the pairs trading used by Elliot et al. (2005) -distance trading, stochastic spread and co-integration approach to Australian stock exchange. He found that all three methods showed a good performance before calculating transaction costs but later he saw that transaction costs severely diminished returns of all methods especially the return of the stochastic spread method.

2.3-Combine Forecast Method

The method of combine forecast is described by Huck (2009, 2010). He used multi-criteria decision making methods (MCDM) and neural networks methods to test pairs trading strategy by using S&P 100 stocks. These two methods are based on three stages: 1-forecasting, 2-ranking and 3-trading. The combine forecast method is developed without the reference to any equilibrium model. Huck (2009, 2010) proposed that the method offers much more trading possibilities and could detect the "birth" of the divergence that other methods cannot achieve.

2.4-Cointegration Method

The cointegration approach described by Banerjee (1993), Gilespi and Ulph (2001), Hong and Susmel (2003), Vidyamurthy (2004), Lin, McRae and Gulati (2006), Galenko, Popova and Popova (2007), Schmidt (2008), Puspaningrum (2009), Chiu and Wong (2012). Vidyamurthy (2004) uses the Engle-Granger 2 steps method for co-integration and develops trading strategies based on the assumed dynamics of portfolio. He presented both of a parametric and a non-parametric empirical approaches to conduct his analysis. Lin at al. (2006) developed a procedure that implants a minimum profit condition in the pairs trading strategy. They found that the five-step strategy is feasible for commonly used parameter values. Schmidt (2008) used the Johansen test for cointegration to identify pairs of stock and then mean-reverting residual spread modeled as a Vector-Error-Correction-Model (VECM). He used 17 financial stocks listed on the Australian Stock market dated from 2002 to 2007. Schmidt research did not address to the profitability of the pairs trading strategy. Puspaningrum (2009) tried to find the optimal pre-set boundaries for pairs trading strategy by using the cointegration method. The objective was to develop a quantitative method to assess the average trade duration, the average inter-trade interval and the average number of trades and then at the end of these assessments, the objective is to use them to find the optimal pre-set boundaries. In the term of maximizing the minimum total profit for co-integration error following an AR (1) process, the optimality is improved by assembling the cointegration technique, the cointegration coefficient weighted rule, and the mean first-passage time using an integral equation approach. Chiu at al (2012) investigated the optimal dynamic of the pairs trading strategy of cointegrated assets by using the mean-variance portfolio selection criterion. They suggested that arbitrageurs do not make an investment when cointegration disappears in the market. Thus, the time- consistent optimal trading strategy does not necessarily resemble to either relative value or long-short strategies.

3. Data and Methodology

The data used in the study consists of the daily logarithmic closing prices of Soybean ZS (CBOT), Corn ZC (CBOT), Wheat ZW (CBOT), Rough Rice ZR (CBOT), Oats ZO (CBOT), Live Cattle LE (CME), Lean Hog HE (CME), Cocoa CJ (ICE), Coffee "C" KT (ICE), and Cotton TT (ICE) futures traded on the CBOT, CME and ICE (Figure 2) analyzed.

There is a link between real interest rates and real commodity prices. When the Fed cut interest rates between 2001-2004 and 2008-2011, real commodity prices started to increase. In 2008 and in 2011 commodity prices spiked (Figure 1). After 2014, commodity prices started to decline as an expectation of interest rate rise in 2015 (Figure 2 and 6). This paper addresses to profits of pairs trading strategy when the period of commodity prices peaked in 2008 and 2011, and the strategy is re-tested when commodity prices started to decline. The daily rolling three-month future closing price data is obtained from the Bloomberg database. For each futures security, the nearby futures contract was employed and rollovers into next contract occurred on the last day of the month before contract expiration. Public holidays in different indexes were filled by the last date closing price. The average transaction cost per contract is set to 1 cent (0.5bp) but the transaction costs are ignored. It is assumed that the cointegration vector continues to hold the trading period. The value of the long/short positions for each day was set to $100,000.

The pairs trading strategy is implemented in two stages, which are similar to Gatev et al. (GGR): the formation

period and the trading period. There is no standard rule for deciding the lengths of the formation period and trading period. The formation period needs to be long enough to determine cointegration relationship actually existing, but not so long that there is not enough information left for the analyze for the trading period. The trading period needs to be long enough to have opportunities to open and close trades and test the strategy but it cannot be too long because it is possible that the cointegration relationship between two tested commodities may change. The time period for the formation period and the trading period is covered from December 1st, 2004 to May 1st, 2015. In order to find the maximum number of cointegrated pairs, the whole formation period is divided into 5 sub-periods. The formation period contains 7 years of logarithmic daily data of 1765 observations (1.12.2004-1.12.2011), of 1500 observations, of 1250 observations, of 1000 observations, and of 750 observations. The trading period contains 3.5 years period of 859 observations (2.12.2011-1.05.2015).
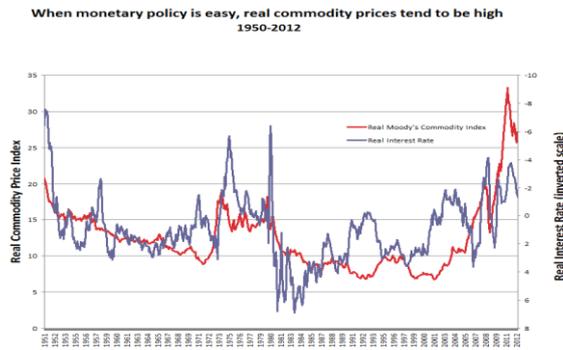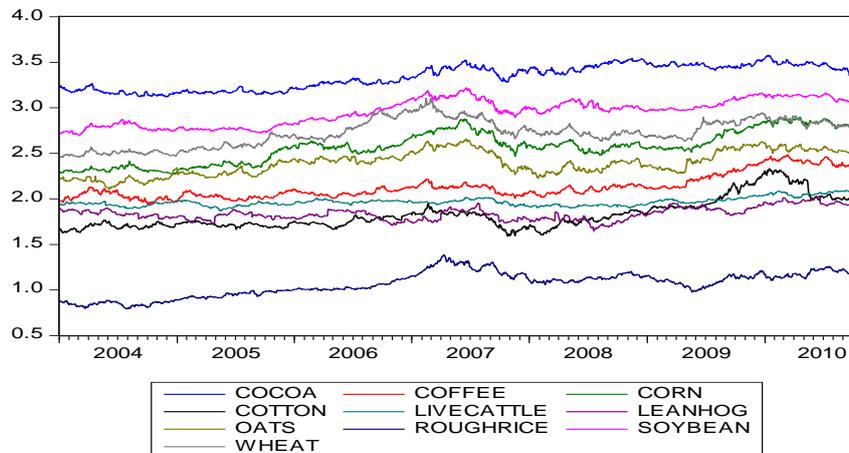
Figure 1 (Source: Jeffrey Frankel, HKS)

Figure 2

4. Trading Strategies and Empirical Results

4.1. Pairs Selection

The important step of the strategy consists of identifying potential pairs. First, to test for a unit root in the individual price series, the Augmented Dickey-Fuller and Phillips-Perron tests are applied. The ADF and PP unit root test results of the variables in their levels and first difference values are shown in Table 1. All the unit root tests are performed with time trend and intercept (*) and intercept (**), for all variables in their levels; and the tests are performed with their first difference values. The specification of the test regression is automatically selected using the Akaike-criterion. ADF and PP tests for the level data, the null hypothesis is not rejected at the 1% significance, indicating that all variables are not stationary. Using the ADF and PP test, the null hypothesis is rejected for all first difference equations at the 1% level of significance. So according to this test, all variables are I (1) that reach the significant level of %1 in the one lag of data. Second, to test for cointegrated pairs with intercept term, the Johansen test is run for all possible combination of pairs. There are 45 possible pairs. The numbers of cointegrated pairs with 5 sub-periods are represented in table 2. In a first row, there are 7 cointegrated pairs that are Soybean-Wheat, Corn-Oats, Cotton-Coffee, Cotton-Lean Hog, Cotton-Live Cattle, Wheat-Rough Rice, and Lean Hog-Live Cattle are significantly cointegrated in the period between 2004 and 2011 (Table 2 and 3). In the second row with 1500 observations for the data of 2005 to 2011 show that there are 6 cointegrated pairs (cotton-coffee, cotton-livecattle, livecattle leanhog, roughrice-soybean, roughrice-wheat soybean-wheat). In the third row, using 1250 observations, there are 4 cointegrated pairs (cotton-coffee, roughrice-soybean, roughrice-wheat, and soybean-wheat). In the forth row, using 4 years data of 2007 through 2011 with 100 observations, there are only 2 cointegrated pairs (roughrice-wheat, soybean-wheat). In the fifth row, using 3 years data of 2008 through 2011 with 750 observations, there are 2 cointegrated pairs (cotton-coffee, soybean-wheat). These 5 sub-periods indicate that the maximum number of cointegrated pairs is found in the period of between 2004 and 2011.

The integration equations with 1765 observations (2004-2011):

Log Coffee(-1) - 0.6666*Log Cotton(-1) -0.443

Log Corn(-1) -1.0513*Log Oats(-1) +0.308

Log Cotton(-1) -2.5023*Log Live Cattle(-1) +0.003

Log Cotton(-1) -3.9873*Log Lean Hog (-1) +0.002

Log Wheat (-1) -1.4943*Log Soybean(-1) + 0.344

Log Wheat (-1) -1.2731*Log RoughRice(-1) +0.001

Log LeanHog(-1) -1.2871*Log LiveCattle(-1) -0.626

In the figure 3, two diagrams are illustrated by residuals for coffee/cotton and cotton/liveCattle that both are stationary moving around zero. Even though some periods, for coffee/cotton pair (a), after 2007 and 2011 and for cotton/livecattle pair (b), a period of 2004, 2005 and 2011, it takes quite a long time to return zero. Finally, after

analyzing 7 pairs whether an AR (1) model is fitted or not, only 2 pairs are cointegrated and their cointegration errors are an AR (1) model. The standard deviation of coffee/cotton pair is 0.0493 and the standard deviation of cotton/livecattle is 0.1086.

Figure 3: Plot of Coffee/Cotton and Cotton/Live Cattle Residual Series against Time

a) Plot of C/TT Residual Series
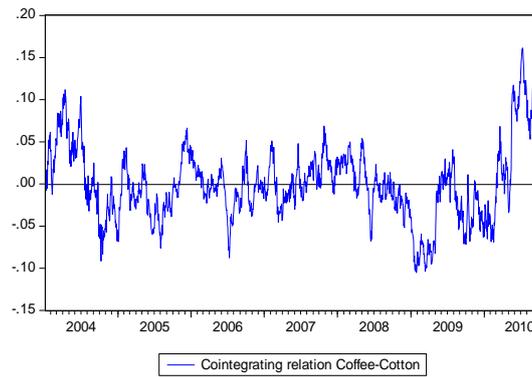
b) Plot of LE/TT Residual Series
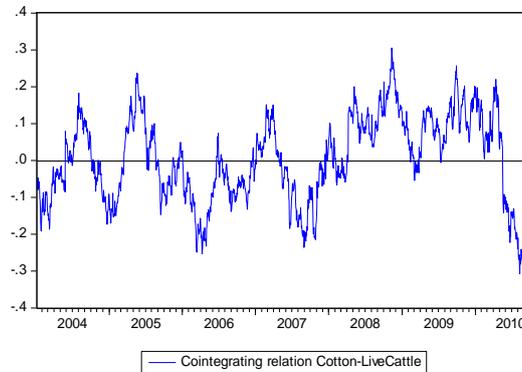
4.2. Implementing Pairs Trading Strategy

In order to apply the pairs trading strategy, two trading rules should be followed. The first rule is to set up an upper bound and a lower bound for +-1.5 standard deviation. Second rule, when the cointegration error is higher than or equal to the upper bound (+1.5std deviation) at the time t_0, a trade is opened by selling number of Cotton shares at the time t_0 and by buying number of Coffee shares at the time t_0 and when the cointegration error gets back to its mean at the time t_1, the positions are closed out while short position Coffee and long position Cotton.

In the same strategy applied to the lower bound, when the cointegration error is lower than or equal to the lower bound (-1.5std deviation) at the time t_0, a trade is opened by selling Coffee and by buying Cotton at the time t_0 and when the cointegration error gets back to its mean at the time t_1, the positions are closed out while buying Coffee and selling Cotton.

Profit per trade before transaction costs

#: Quantity of Commodity,

Π: Price of Commodity

Profit Upper Bound=#Shares (Π Cotton t_1-ΠCotton t_0) +#Shares (Π Coffee t_0-ΠCoffee t_1)

Profit Lower Bound=#Shares (Π Cotton t_0-ΠCotton t_1) +#Shares (Π Coffee t_1-ΠCoffee t_0)

The figure 4 shows that during the formation period, pairs of residuals show sufficient levels of mean reversion so that the portfolio could be traded regularly enough to make a profit.
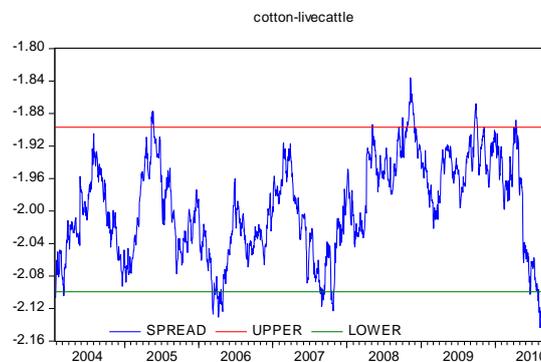
Long Cotton and Short Coffee: Log Coffee (-1) - 0.6666*Log Cotton (-1)-0.443 and

Long Cotton and Short Livecattle: Log Cotton (-1) -2.5023*Log Livecattle (-1) +0.003

Figure 4: Residual Series with Pre-Determined Upper and Lower Bound

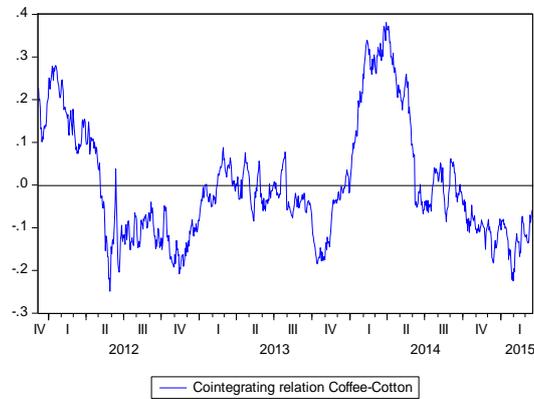**a) Plot of C/TT Residual Series**
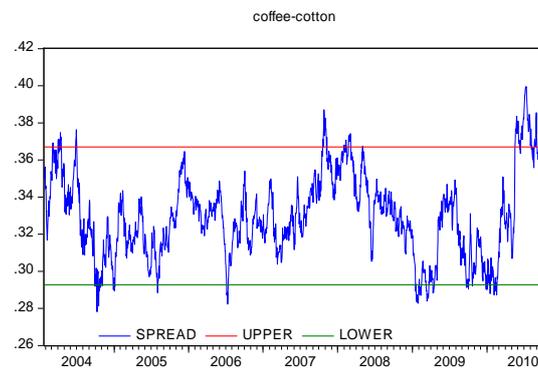
b) Plot of LE/TT Residual Series

During the formation period for coffee-cotton pair, 4 out of 5 trades are completed. While the average trade duration is 72.8 days, the total profit is $69,123. When the average return per trade is 6.14%, the average annualized return is 21.25%pa. For the pair of cotton-livecattle, 5 trades are completed. While the average trade duration is 106 days, the total profit is $633,655. When the average return per trade is 199.1%, the average annualized return per trade is 477.33%.

Figure 5: Cointegration Error for the Trading Period

a) Plot of C/TT Residual Series

Cointegrating relation Coffee-Cotton

b) Plot of LE/TT Residual Series

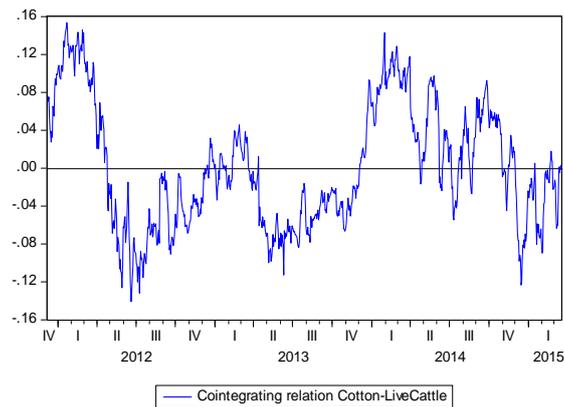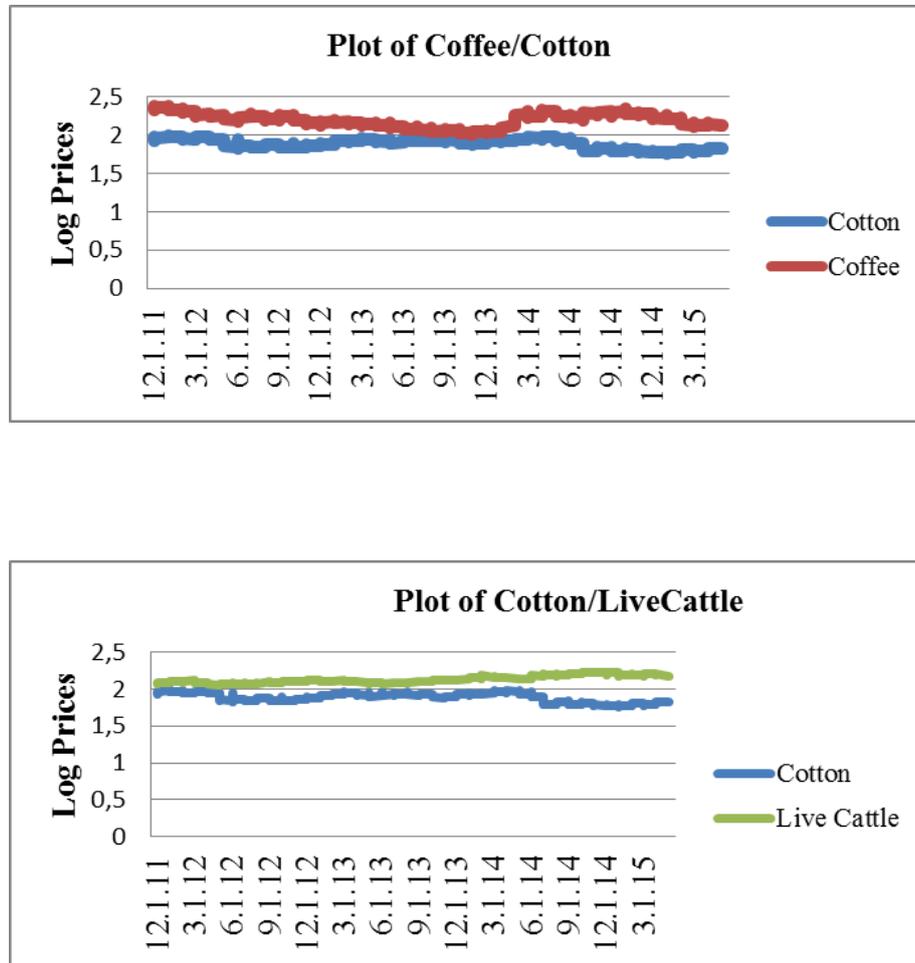Cointegrating relation Cotton-LiveCattle

Figure 6: Log Prices for The Trading Period

The figure 5 shows the cointegration error for the trading period but it is assumed that the cointegration relationship in the formation period still continues to hold in trading period. The figure 6 presents the logarithmic prices of the 2 pairs. Since May 2011, almost all agricultural commodity prices have been in a long-term crash due to an increasing supply, a competition and a reduced demand. During 2012 and 2013, coffee and cotton prices were declined dramatically. After the first quarter of 2014, nearly all commodity prices increased except cotton prices peaked in May 2014 but after that cotton prices suffered a rapid decline. Meanwhile live cattle futures prices have increased gradually. The upward trend started in 2009, with largest price increase occurring in 2014. The standard deviation of coffee/cotton pair is 0.098 and the mean of coffee/cotton is 0.492. During the trading period for the coffee/cotton pair, 2 trades are completed and the average trade duration is 159 days. Also, for the coffee/cotton pair, the total profit is $48,909, the average return per trade is 11%, and the average annualized is 17.4% pa. In the case of cotton/livecattle pair, the standard deviation is 0.2311 and the mean is -3.599. For cotton/livecattle, 3 trades are completed and the average trade duration is 142 days. The total profit is $372,343, the average return per trade is 202% and the average annualized return is 358.5% pa.

5. Conclusion

A Pairs trading strategy is widely popular in the finance world. In this paper, the concept of cointegration in pairs trading is applied to the agricultural future market. First unit root is tested and then Johansen test is applied to identify the cointegrated commodity pairs and to find the cointegration error. Only 7 out of 45 agricultural future market pairs conclude that they are cointegrated with the Johansen approach. As a result of the pair trading strategy, coffee-cotton and cotton-livecattle, two cointegrated pair of agricultural future contracts is obtained. Pairs trading strategy is applied to both the formation period and the trading period. Annualized profit for coffee-cotton and cotton-live cattle pairs; from formation period are 21.25% pa and 199.1% pa, from trading period are 17.4% pa and 358.5% pa, respectively. Tests of these periods show that the pairs trading strategy is outperformed. This study finds that pairs trading in commodity futures markets earn statistically a significant return.

This paper does not address the source of the profitability of pairs trading strategy from the characteristic of agricultural futures prices: extrinsic events such as climatic, political and governmental forces, strong mean reversion, high volatility, large price spikes and interest rates. The relationship between real interest rates and real commodity prices plays an important role in the prices of commodities. The result of easy monetary policy is associated with low real interest rates since 2008, which boosts the prices of agricultural commodities. The findings of this study reveal that the strategy of pairs trading is also outperformed during this period. Overall, the relative value arbitrage strategy relies on the trader's ability not only to identify to find but also to capture the divergence and mean-reversion movement. The strong mean reversion and the high volatility may cause high excess returns from the pairs trading strategy, especially in the pair of cotton-live cattle trades. In a stable economic and a financial environment, certain opportunities may be lost due to the low volatility in the relationship between the two related commodities to make a trade profitable.

In the future research, changing the length of formation/trading period, copula approach, Kalman filtering techniques, risk adjustment, and some trading rules would be useful for estimating profit patterns of the pairs trading strategy.

Table 1:Unit Root Test

	ADF	ADF (-1)	PP	PP(-1)
Soybean	*-1.8791	*-40.7345	*-1.9368	*-40.7219
	**-1.8803	**-40.7332	**-1.9389	**-40.7214
Corn	*-2.0573	*-40.7188	*-2.0530	*-40.7032
	**-2.05792	**-40.7274	**-2.0541	**-40.7120
Wheat	*-1.8925	*-42.9061	*-1.8466	*-42.9111
	**-1.8935	**-42.8990	**-1.8494	**-42.9031
Live Cattle	*-2.2553	*-16.6035	*-2.2666	*-42.4429
	**-2.2573	**-16.5798	**-2.2741	**-42.4303
Lean Hog	*-3.1620	*-40.4566	*-3.1447	*-40.4667
	**-3.1627	**-40.4548	**-3.1465	**-40.4660

Table 1. Continue

Rough Rice	*-1.8277	*-38.1270	*-2.1982	*-38.3315
	**-1.8286	**-38.1337	**-1.8330	**-38.1218
Oats	*-2.3025	*-38.3153	*-2.2209	*-38.5551
	**-2.3032	**-38.3253	**-2.1988	**-38.3417
Cocoa	*-2.0711	*-28.6208	*-2.2467	*-42.0056
	**-1.1041	**-28.5957	**-1.2316	**-41.9792
Cotton	*-1.9730	*-38.5660	*-2.0215	*-38.6303
	**-1.9737	**-38.5769	**-2.0221	**-38.6410
Coffee	*-2.3168	*42.0085	*-2.3258	*-42.0114
	**-2.3176	**-42.0167	**-2.3274	**-42.0196

The critical t-statistic values for the ADF test are – 3.1281 at the 10% confidence level, - 3.4124 at the 5% confidence level and – 3.9633 at the 1%confidence level

*Trend + Intercept models applied

**Intercept no trend

Table 2:Cointegration Analysis

Period	Time Span	Cointegrated Pairs
1/12/2004-1/12/2011	1765 observations	TT-KT, ZC-ZO, TT-LE, TT-HE, ZW-ZS, ZW-ZR, HE-LE
20/12/2005-1/12/2011	1500 observations	TT-KT, TT-LE, LE-HE, ZR-ZS, ZR-ZW, ZS-ZW
18/12/2006-1/12/2011	1250 observations	TT-KT, ZR-ZS, ZR-ZW, ZS-ZW
14/12/2007-1/12/2011	1000 observations	ZR-ZW, ZS-ZW
11/12/2008-1/12/2011	750 observations	TT-KT ,ZS-ZW

Table 3: Number of pairs co-integrated

	Soybean	Corn	Wheat	Live Cattle	Lean Hog	Rough Rice	Oats	Cocoa	Cotton	Coffee
Soybean		No	Yes	No	No	Yes	No	No	No	No
Corn	No		No	No	No	No	Yes	No	No	No
Wheat	Yes	No		No	No	Yes	No	No	No	No
Live Cattle	No	No	No		Yes	No	No	No	Yes	No
Lean Hog	No	No	No	Yes		No	No	No	No	Yes
Rough Rice	Yes	No	Yes	No	No		No	No	No	No
Oats	No	Yes	No	No	No	No		No	No	No
Cocoa	No	No	No	No	No	No	No		No	No
Cotton	No	No	No	Yes	Yes	No	No	No		Yes
Coffee	No	No	No	No	Yes	No	No	No	Yes	

References

Bianchi, J.R., Drew, E.M., Zhu, R. (2009), Pairs Trading Profits in Commodity Futures Markets, Unpublished Paper, Queensland University of Technology, Griffith Business School

Bogomolov, T. (2010), Pairs trading in the land down under. Finance and Corporate Governance Conference 2011 Paper. Bundoora, Australia.

Bogomolov, T. (2013), Pairs Trading Based on Statistical Variability of The Spread Process, Quantitative Finance, 13:9, 1411-1430

Bowen, D., Hutchinson, M.C., O' Sullivan, N. (2010), *High Frequency Equity Pairs Trading: Transaction Costs, Speed of Execution and Patterns in Returns.* The Journal of Trading, 5(3), 31-38.

Broussard, J.P., Vaihekoski, M. (2012), *Profitability of pairs trading strategy in an illiquid market with multiple share classes.*

Journal of International Financial Markets Institutions & Money, 22, 1188-1201.

Caldeira, F.J., Moura, V.G. (2012), Selection of a Portfolio of Pairs Based on Cointegration: The Brazilian Case, Federal University of Rio Grande do Sul, Federal University of Santa Catarina, Brazil

Chen, J.H., Chen, J.S., Li, F. (2012), Empirical Investigation of Equity Pairs Trading Strategy, http://ssrn.com/abstract=1361293

Chiu, C.M., Wong, Y.H. (2012), Dynamic Cointegrated Pairs Trading: Time-Consistent Mean-Variance Strategies

Do, B., Faff, R. (2010), *Does Simple Pairs Trading Still Work?* Financial Analyst Journal, 66(4), 83- 95.

Do, B., Faff, R. (2010), *Are Pairs Trading Profits Robust to Trading costs?* The Journal of Financial Research, 35(2), 261-287.

Do, B., Faff, R., Hamza, K., (2006), A New Approach to Modeling and Estimation for Pairs Trading, Unpublished Paper, Monash University

Ehrman, S.D., (2006), The Handbook of Pairs Trading-Strategies Using Equities, Options & Futures, John Wiley & Sons, Inc., New Jersey

Elliott, R.J., Van der Hoek, J., Malcolm, W.P. (2005), *Pairs Trading.* Quantitative Finance, 5(3), 271– 276.

Engelberg, J., Gao, P., Jagannathan, R., (2009), An anatomy of pairs trading: the role of idiosyncratic news, common information and liquidity. Unpublished working paper. University of North Carolina, University of Notre Dame, Northwestern University.

Frankel, A.J.(2014), Effects of Speculation and Interest Rates in a "Carry Trade" Model of Commodity Prices, Journal of International Money and Finance, 2014

Fung, D.A.(1999), A primer on hedge funds. Journal of Empirical Finance, 6(3): 309-331.

Galenko, A., Popova, E., Popova, I.(2007), Trading in The Presence of Cointegration

Gatev, E.G., Goetzmann, W.N., Rouwenhorst, K.G. (1999), *Pairs Trading: Performance of a Relative Value Arbitrage Rule.* NBER working paper, No. 7032.

Gatev, E., Goetzmann, W.N., Rouwenhorst, K.G. (2006), *Pairs Trading: Performance of a Relative-Value Arbitrage Rule.* The Review of Financial Studies, 19(3), 797-827.

Herlemont, D., (2004), Pairs Trading, Convergence Trading, Cointegration, Unpublished Paper,YATS Finance and Technologies

Heymans, A., (2008), Managing an Agricultural Commodities Portfolio in South Africa with Pairs Trading, PhD Thesis, The Centre for Business Mathematics and Informatics of The North-West University

Hillebrand, E., (2003), A mean-reversion theory of stock-market crashes. Working Paper. Center of Finance & Risk Management, Gutenberg University.

Huck, N. (2009), Pairs selection and outranking: an application to the S&P 100 index. European Journal of Operational Research 196, 2, 819-825.

Huck, N. (2010), *Pairs trading and outranking: The multi-step-ahead forecasting case.* European Journal of Operational Research, 207, 1702–1716.

Huck, N. (2013), The High Sensitivity of Pairs Trading Return, Applied Economic Letters, 20:14, 1301-1304.

Huck, N., Afawubo, K.(2015), Pairs Trading and Selection Methods: Is Cointegration Superior? Applied Economics, 47,6, 599-613

Jacobs, H., Weber, M. (2011), Losing sight of the trees for the forest? – Pairs trading and attention shifts. Unpublished working paper. University of Mannheim.

Jacobs, H., Weber, M., (2013), Losing Sight of The Trees for The Forest? – Attention Allocation and Anomaliesm

Kanamura, T., Rachev, S., Fabozzi, F. (2010), A profit model for spread trading with an application to energy futures. The Journal of Trading 5, 1, 48-62.

Lin, Y., McCrae, M., Gulati, C. (2006), Loss protection in pairs trading through minimum profit bounds: a cointegration approach. Journal of Applied Mathematics and Decision Sciences 2006, 4, 1-14.

Miao, J.G. (2014), High Frequency and Dynamic Pairs Trading Based on Statistical Arbitrage Using a Two-Stage Correlation and Cointegration Approach, International Journal of Economics and Finance, 6,3,Canadian Center of Science and Education

Mori, M., Ziobrowski, A.J. (2011), *Performance of Pairs Trading Strategy in the U.S. REIT Market.* Real Estate Economics, 39(3), 409–428.

Mudchanatongsuk, S., Primbs, A.J., Wong, W. (2008), Optimal Pairs Trading: A Stochastic Control Approach, 2008 American Control Conference, Washington

Muslumov, A.A.Y. (2009), The profitability of pairs trading in an emerging market setting: Evidence from Istanbul stock exchange. The Empirical Economics Letters, 8(5): 495-500.

Nath, P. (2003), High frequency pairs trading with U.S. treasury securities: Risks and rewards for hedge funds. Unpublished Working Paper, London Business School.

Nicholas, J.G. (2000), Market neutral investing. Long/short hedge fund strategies. Bloomberg Professional Library: Bloomberg Press.

Papadakis, G., Wysocki, P. (2008), Pairs trading and accounting information. Unpublished working paper. Boston University School of Management, MIT Sloan School of Management.

Perlin, M., S. (2009), *Evaluation of pairs-trading strategy at the Brazilian financial market.* Journal of Derivatives & Hedge Funds, 15(2), 122-136.

Pizzutilo, F. (2013), A Note on The Effectiveness of Pairs Trading for Individual Investors, International Journal of Economics and Financial Issues, 3,3, 763-771

Puspaningrum, Lin, Y.X., Gulati, C. (2009), Finding the optimal pre-set boundaries for pairs trading strategy based on cointegration technique. Working Paper No. 2109. Centre for Statistical and Survey Methodology, University of Wollongong.

Puspaningrum, H. (2012), Pairs Trading Using Cointegration Approach, PhD Thesis University of Wollongong School of Mathematics and Applied Statistic

Schmidt, D.A. (2008), Pairs trading: A co-integrating approach. Finance Honours Thesis, University of Sydney. Retrieved July 2013, from University of Sydney. Available from: http://ses.library.usyd.edu.au/bitstream/2123/4072/1/Thesis_Schmidt.pdf.

Xie, W., Wu, Y. (2013), *Copula-Based Pairs Trading Strategy. W*orking paper, available at SSRN: http://ssrn.com/abstract=2209209.

Vidyamurthy, G. (2004), Pairs trading: Quantitative methods and analysis. John Wiley & Sons.

Yu, S. (2011), Pairs - Trading on divergent analyst recommendations. Journal of Investment Management 9, 4, 75-95.