THE IMPACT OF ELECTRONIC TRADING ON THE BASIS AT WINNIPEG COMMODITY EXCHANGE

A PLAN B PROJECT

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1. INTRODUCTION

Instruments (contracts) traded on commodity exchanges include futures, options and other derivatives. Trading in these instruments began with floor trading, also called open outcry systems. In open outcry systems, traders assembled in a pit in the exchange and traded commodities by indicating their bids or offers to others in the pits. Commodity futures markets help with price discovery and provide a way to hedge for producers and buyers of commodities. However, commodity trading has moved to electronic trading from open outcry systems, following the trend in financial securities trading.

With the shift to electronic trading, futures contract users like farmers and processors can place their hedges directly without going to the floor. There have been a number of studies trying to gauge the impact of the shift to electronic trading from open outcry. However, most of these studies concentrate on financial futures. Commodities are inherently different from financial securities. The storage and transportation cost is a significant part of the cost of the commodity futures contract, unlike a financial futures contract. Moreover, agricultural commodities are perishable and their prices may be seasonal. Unlike stocks, commodities are also consumption assets. Futures contracts may also have a relationship with the underlying cash market. Such features may mean that the impact of electronic trading may be different on agricultural futures than on other futures contracts. Electronic trading has been found to affect areas like bid-ask spreads, transaction costs and speed of information dissemination. If the shift to electronic trading systems leads to better performance on parameters like liquidity, trading costs and price efficiency, it would benefit the users of these futures contracts as well as improve the overall efficiency of the commodity markets. Other implications of electronic trading include increased volumes and faster information dissemination due to easier access to the markets.

2. OBJECTIVE

In this paper, the impact of electronic trading on commodity futures contracts is studied using data from the Winnipeg Commodity Exchange (WCE). The WCE began as a grain exchange in 1887 and moved to electronic trading on December 20, 2004. The last day of open outcry trading was on December 17, 2004, after which it shifted to electronic trading. It was the first commodities exchange to switch completely to electronic trading. This also provides us with a longer time series of data to study. WCE was acquired by Intercontinental Exchange (ICE) in August 2007 and has become ICE Futures Canada.

This event provides us with an opportunity to study the impact of electronic trading on commodity markets. In particular, the impact of electronic trading on the relationship between the cash and the futures prices is studied. This is important because, if the shift to electronic trading reduces transaction costs or bid-ask spreads, the difference between futures price and cash price must change due to the change in the cost of owning the futures contract. If a relationship between the cash and futures prices can be established, then, a test of structural change in the relationship can be done to determine the impact of electronic trading on the relationship. A change in the cash-futures relationship can occur due to a change in the transaction costs or due to a change in the fundamental factors affecting the relationship. Since, the event studied here is a one-time event and the date of the event is known, we can identify the impact of fundamental factors, if any and hence, identify the impact of electronic trading.

3. LITERATURE REVIEW

Various papers have tried to study the impact of shifting to electronic trading on financial securities and their markets. A brief review of the literature on the impact of electronic trading on various markets is presented here. This study gives us an idea of the various factors that can be affected due to the shift to electronic trading.

3.1 PRICE MOVEMENT

Madhavan (2000) has studied whether dealer intermediation (the presence of a broker) may exist due to the costs of placing a limit order. A limit order requires that the order execute only when a particular price is reached. This required constant monitoring in earlier days when bandwidth was a constraint with the exchanges. However, with the advances in technology and the improvement in exchange bandwidths, such constraints have been removed. Technology allows persons to place all kinds of orders on most exchanges. Some exchanges are yet to implement trading of complex option strategies online, in which case, dealer intermediation becomes necessary. For example, if a person wants to trade a complex option strategy involving various legs on the NYBOT, then a suitable price for such an option would generally be made available by the floor brokers. However, most exchanges are slowly implementing technology which would allow for trading complex strategies online.

Vila and Sandman (1995) and Pirrong (1996) find that prices are less sensitive to volumes in automated than traditional markets. One of the reasons for this could be that the floor traders know when there are orders from clients and so they adjust their prices in response to demands.

For example, if a client sent a large buy order to his broker on the floor of the exchange, then the traders on the floor raise their prices as soon as they know about the buy order. In electronic trading the identity of the counterparty is not known. This helps persons to manage their trading so that they do not impact the prices significantly.

Domowitz and Steil (2001) found that electronic systems incorporate information into the price faster than traditional systems. Ates and Wang (2005) study the contribution to price discovery of E-mini index futures versus floor traded S&P 500 and NASDAQ 100 index futures. They use information shares to determine the relative contribution. They find that E-mini index futures, which are traded electronically, contributed to a larger extent to price discovery than floor traded index futures. Their empirical results suggest that operational efficiency and relative liquidity jointly determine the rate of price discovery in electronic trading versus open outcry systems. Chaboud and Weinberg (BIS Papers No.12) test changes in volatility and large intraday movements as an indicator of reduced liquidity. They find no evidence of reduced liquidity due to the introduction of electronic trading in the 1990's. Studies by Jiang et al. (2002) and Madhavan (1996) suggest that electronic trading lowers price volatility.

Pirrong (1996) studies Bund contracts traded on LIFFE, an open outcry system during 1992-93, and DTB, an electronic system, and finds that automated systems are deeper and more liquid.

Martens (1998) argues, using Bund futures traded on LIFFE and DTB, that open outcry systems will be more efficient with respect to price discovery in a fast moving market, mostly due to the way prices can be released by changing the hand signal. On the other hand, in periods of low volatility, electronic systems are more efficient in price discovery, thus, suggesting that the systems complement each other.

If electronic trading leads to reduced price movement, then it would lead to lower volatility and hence lower risk in the market. If the movement of the futures price is affected by electronic trading, then it would imply a change in the relationship between cash and futures price, which is being tested in this paper.

3.2 BID-ASK SPREADS

Aitken et al (2004) study LIFFE, SFE and HKFE, which shifted to electronic trading in 1999-2000. They show evidence of decrease in bid-ask spreads after shifting to electronic trading. However, like Martens (1998), they find that the performance of electronic trading systems deteriorates during periods of high volatility. Cheng, Fung and Tse (2005) study the impact of switching to electronic trading on the relative pricing efficiency between the Hang Sang Index futures and its options contracts traded on the Hong Kong exchange. They find that electronic trading leads to lower bid-ask spreads and less price clustering.

Sarkar and Tozzi (1998), suggest that although open outcry systems were more effective to trade highly active contracts, electronic trading has the potential to enhance operational efficiency and reduce costs. Tse and Zabotina (2001) find that electronic trading systems reduce spreads while open outcry systems have higher market quality due to smaller variance of pricing error and higher information content. Information content is measured by studying the bid-ask spreads in response to trades.

Sporleder (1984) was one of the early papers to look at the impact of electronic trading on agricultural markets. However, it was limited to a theoretical analysis due to the lack of data. His model shows that electronic trading could reduce buyer and seller concentration, information asymmetry and increase pricing efficiency.

If the bid-ask spreads did decrease as mentioned by the papers, it would imply a reduction in the cash-futures spread, which is being tested in this paper. It should be noted that the cash futures relationship could be affected by many other factors, making the impact of bid-ask spreads insignificant.

3.3 POLICY IMPLICATIONS

The report by Committee on the Global Financial System (BIS) on 'The implications of electronic trading in financial markets' (2001) looks at foreign exchange and fixed income markets where electronic trading was first introduced. They come to the conclusion that electronic trading is more cost efficient and offers the potential to make markets more transparent.

Electronic trading raises a host of issues and potential problems. For example, if the exchange goes down or connection gets lost, users of the electronic trading systems could be at a disadvantage. Another aspect is the usage of exchange bandwidth. One user should not be allowed to monopolize the information flow, which requires imposition of bandwidth costs on users of electronic trading. However, the restriction on bandwidth may not be the same for all users. A firm with a billion dollars to invest should not be subject to the same bandwidth requirements as an individual with a few thousand dollars since the firm would need to watch the price constantly. Electronic trading also has to implement trading limits as in open outcry systems.

Allen et al. (2001) look at policy implications of shifting to electronic trading in the areas of regulation, competition and financial stability. With respect to financial stability they look at operational problems that can arise due to the increased emphasis on IT and telecom. They give a broad overview of the various factors that need to be considered when moving to electronic trading.

While the above papers have looked the impact of electronic trading on a particular aspect of markets, this paper will look at the more general futures-cash relationship. This will help evaluate the changes due to electronic trading on the futures market as a whole, in the area of commodities markets. A shift in the basis would directly affect the users of commodity markets, by either increasing or decreasing the costs of using futures markets. In order to test for a structural change in the cash-futures relationship, we start with a study of structural change and co-integration.

4. MODEL DEVELOPMENT

The purpose of this section is to find the relationship between the cash and futures prices and also to study the methods used to test for a change in the cash-futures relationship. A linear relationship is developed and the structural change tests needed to study the changes in a linear relationship is presented. An overview of the relevant structural change literature is presented here.

4.1 STRUCTURAL CHANGE

A structural change is a shift in the relationship between two variables. The shift may be sudden or gradual and could be at a known point in time or an unknown point. The most common test for structural change is the Chow test. This test is used when the variables are stationary and there is only one known break point. The Chow test looks at the variances of the sub-samples to determine if there is a structural change. The Chow test can be extended for multiple known break points, systems of equations and for non-linear equations. When the break point is unknown, the test proposed by Quandt (1960) can be used. The Quandt test tests for the null hypothesis of constant coefficients against the alternate of structural change at some unknown time, with varying error variance. The CUSUM test is used for testing structural change by plotting the test statistic at each point in the series and testing if the plot crosses the critical points. The CUSUM test is used when there is a systematic movement of coefficients as against the Quandt test, which is used when the structural change may not be systematic. In the next section, a brief introduction to stochastic variables and co-integration is followed by tests for structural change for co-integrated systems.

4.2 CO-INTEGRATION

A stochastic process is a process (evolution of the variable) which has some degree of uncertainty as to how it might evolve over time. That is, the value of the variable in the next instant cannot be determined with certainty. The counterpart of a stochastic process is a deterministic process, whose value in the next instant can be determined with certainty. An example of a deterministic process is the location of a particle that has been dropped from a certain height in vacuum. An example of a stochastic process is a stock price, whose value in the next instant is not known. Futures prices are stochastic in nature. If they were not stochastic in nature, then their prices would be known with certainty, thus, eliminating the need for a futures price. Stochastic processes have certain properties which describe them. These properties are also known as the moments of the processes, which describe its distribution. The first moment about zero is called the mean and the second moment about zero is called the variance. Stochastic processes which have fixed moments across time are said to be stationary processes. That is, the process can be described independent of time and the analysis of the process can hold independent of time. A stochastic process that is correlated with itself at different points in time is said to be auto-correlated.

Two time series variables, in this case the futures and cash price, are said to be co-integrated if they themselves are non-stationary, but a linear combination of them is stationary. That is, if futures price is a random walk and the cash price is also a random walk, but, a linear combination of them is a stationary time series, then the futures price and cash price are said to be co-integrated. If it can be shown that futures price and cash price are integrated of order one, a test of structural change in their relationship can be done. Co-integration need not apply only for two variables. Multiple variables can also be co-integrated. Engle and Granger (1987) have shown that running ordinary least squares regressions on time series variables can lead to spurious results and that the proper method of analyzing the relationship between two time series variables is to study their co-integration.

Perron (1989) studied structural change in non-stationary variables and developed tests for structural change. However, his model assumed a known break point. Hansen (1992) suggested tests for structural change in co-integrated systems for both known and unknown break points. He prescribes three tests to determine the presence of a structural change in the co-integrated relationship. In the case when the break point is known, he calculates the F statistic that is similar to the Chow test. When the timing of the structural change is unknown, he proposes three tests. These are the SupF test, MeanF test and the LC test. To compute these tests, the F statistic, which is computed when the break point is known, is computed at each point in the time series and its supremum and mean are used as the SupF and MeanF values. The LC test is also based on the F statistic values. All the tests are for the same null hypothesis of co-integration with no structural change. The alternate hypothesis is no co-integration. If the desire is to test for a swift change in the regime, then the SupF test is appropriate. However, if one wishes to test whether or not the specific model is a good model that captures the stable relationship, then the MeanF test is appropriate. If the likelihood of the parameter variation is relatively constant throughout the sample, then the computationally simple LC test is appropriate. In our case, we will be using the SupF test due to the sudden change to electronic trading.

4.3 CO-INTEGRATION OF COMMODITY PRICES

The difference between the cash and the futures price is known as the basis. If the basis is stationary, then the cash and the futures prices can be considered co-integrated, if both the prices are integrated of the same order. However, the basis depends on a number of parameters like the interest rate and the cost of storage and transportation. Baillie and Myers (1991) find that commodity futures prices are not co-integrated with spot prices. They model futures prices on cash prices of commodity prices as follows:

$$f_{t,k}-p_t = r_{t,k}+d$$

where $f_{t,k}$ is the futures price at time t for delivery at time t+k, p_t is the cash price at time t, $r_{t,k}$ is the yield on holding a riskless bond between t and t+k and d is a risk premium. Using this relationship they find that cash and futures prices are not co-integrated. They show this by showing that the basis is not stationary. This would mean that the movement in cash prices tells us nothing about futures prices and vice versa.

Brenner and Kroner (1995) show theoretically why cash and futures prices need not be co-integrated in commodity markets. They argue that if interest rates or transportation costs are non stationary, then the cash and futures prices need not be co-integrated. They use a model similar to the one used by Baillie and Myers (1991), but use the log of prices. Heaney (2002) tests the ability of futures price to predict future cash price. Their results support the Brenner and Kroner (1995) model which says that futures price may not predict future cash price if the cost of carry is non stationary. However, Coppola (2008) finds evidence of co-integration between oil spot and futures prices.

In this paper we will test for stationarity followed by co-integration of cash and futures prices and test for a structural change in their co-integrating relationship. Consider the following equation.

$$y_t=b_i x_t+u_t$$

In the above equation, if y_t and x_t are non-stationary process, then we can test for co-integration of y_t and x_t. If they are co-integrated, we get an estimate of b_i, which is a constant. However, if there is a structural change in the co-integrating relationship, b_i need not be a constant. We will use the method proposed by Hansen (1992) to test for structural change in co-integrated equation. This method uses a single test with the null of co-integration with no structural change, which is appropriate in our case. If the null is rejected, it means cash and futures are not co-integrated, in which case, there is no structure to test for a structural change. Boetel and Liu (2008) test for structural change in the presence of co-integration in the US beef and pork prices. In this paper a similar approach is followed to test for co-integration.

4.4 CASH FUTURES RELATIONSHIP

In this paper, a test for structural change in the co-integrating relationship between the cash and futures prices of the commodities traded on the WCE is done. The relationship is modeled as follows.

$$f_t=k_1c_t+k_2+e_t \qquad -(1)$$

In the above equation, f_t and c_t represent the futures price and the cash price at time t respectively. The linear relationship could be explained as follows. The futures price of a commodity is the sum of the cash price for the same quantity and the cost of carrying the commodity from now to the delivery date of the future.

To test whether futures prices and cash prices are co-integrated, it is necessary to ensure that they both are integrated of the same order. If the two co-integration variables are not integrated of the same order, then the error terms in the co-integration regression can have varying covariance matrices. In particular, to ensure that both cash and futures prices are random walks, we need to ensure that they are both integrated of order one with no trend or drift. That is, the variables must be as follows.

$$y_t=b_1y_{t-1}+u_t \qquad -(2)$$

The test for this is known as the unit root test. The hypothesis is that $b_1>=1$. If b_1 is less than unity, then the time series variable converges with the passage of time if the error term is stationary. To test that cash and futures time series data is I (1), the procedure is as follows. First the variable is tested to see if it has a unit root.

Hypothesis 1:

H0: y_t has a unit root. $b_1>=1$.

The alternate hypothesis is that there is no unit root. That is:

H1: y_t does not have a unit root. $b_1<1$.

Then the time series is differenced once. This reduces the variable to its error terms. If the first difference is stationary, then the error term can be said to be stationary and so the variable can be concluded to be I (1).

Hypothesis 2:

H0: Dy_t has a unit root.

H1: Dy_t does not have a unit root.

If cash and futures prices are I(1), then it can be said that the prices follow a random walk if the error term is a white noise. In order to ascertain that the prices are indeed I(1), two tests are proposed. They are the Philip Perron test and the Augmented Dickey Fuller tests. Both tests are similar with the difference being that while the Augmented Dickey Fuller test uses additional lags of the first difference variables to test for unit root, the Philip Perron test uses the Newey West standard errors to account for serial correlation. The null hypothesis for both the tests is that the process has a unit root. If we cannot reject the null hypothesis on the prices, then we run the tests on the differences of the prices. If the prices are as described in (2), then the differences should not have a unit root. Then the cash and futures prices would be I(1) each.

If cash and futures prices are I (1), then we can test for co-integration of the prices and test for a structural change in the co-integrating relationship. We will use the Engle and Granger (1987) method to test for the presence of co-integration of prices. Once co-integration has been established, we will use Hansen (1992) to determine if there was a structural change in the time series. Since the cash price is based on the same contract size as the futures price, the hypotheses would be that k_1=1. k_2 represents the basis. The null hypothesis for a structural change is that b_1 remains a constant during the shift to electronic trading on December 20, 2004. The following is the hypothesis for our model based on Hansen (1992).

Hypothesis 3:

H0: k_1=1 and is constant during the shift to electronic trading and the cash and futures prices are co-integrated.

H1: There is no co-integration.

We can apply the tests proposed by Hansen (1992) to test for structural change when the relationship between the variables may be a co-integrating relationship. The tests are called the SupF test, MeanF test and LM test. The SupF test was initially proposed by Quandt (1960). For all these tests, the null hypothesis is that there is co-integration with constant slope. The alternate hypothesis is that there is no co-integration. This method will also graphically illustrate the structural change test, which would give a better intuition of the impact of shifting to electronic trading. The value of the test statistic is computed at each data point to test for a change in the co-integrating relationship. The F statistic computed at each point is plotted against the critical values to test for structural change. The F statistic is plotted on a graph and tested whether it crosses the critical values for the SupF, MeanF and LC tests. In our case, since the break point is known, the SupF test holds more significance. It tests whether there was a rapid change in the structure of the co-integrated equation. We will allow the data to determine a break point without pre-specifying the break point. If the data finds a break point, then we check if the break point was at the time of the shift to structural change to test the impact of electronic trading.

5. DATA

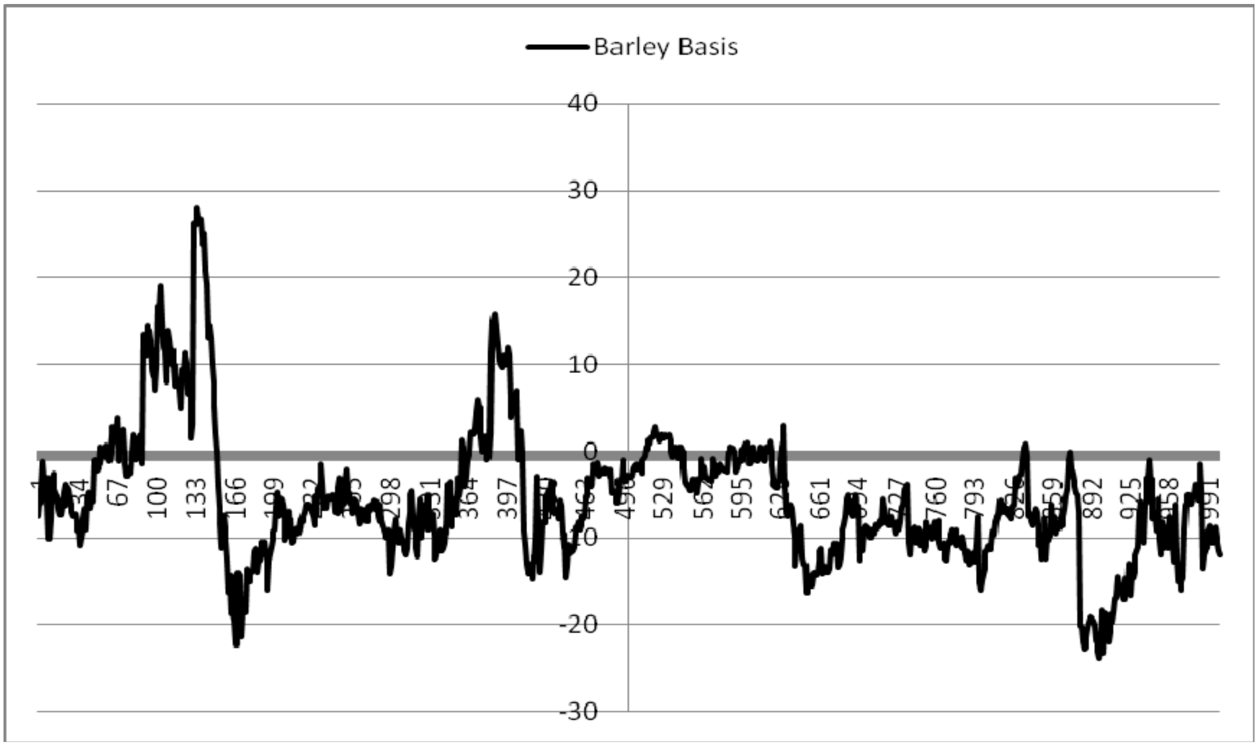
The data for the analysis was taken from the website of WCE. The cash prices are based on the prices at the delivery locations. Hence, Western Barley (AB) has a single cash price, Canola (RS) has four cash prices and Feed Wheat (FW) has two cash prices. The different cash prices are numbered to identify them separately. The canola cash prices tend to be the same most of the time since the location of the delivery point for three of the cash prices are the same. In all the analyses only data from 500 trading days before and after the date of shift to electronic trading, Dec 12, 2004, is used. That is, data from December 24, 2002 to December 22, 2006 is used. Daily closing prices are used in the analysis. This reduces the impact of other events that may affect the relationship between the prices. The different numbers and their corresponding delivery locations are as follows.

Barley: Only one cash price is used which is based on the cash price at the Lethbridge No.1 elevator in Canada.

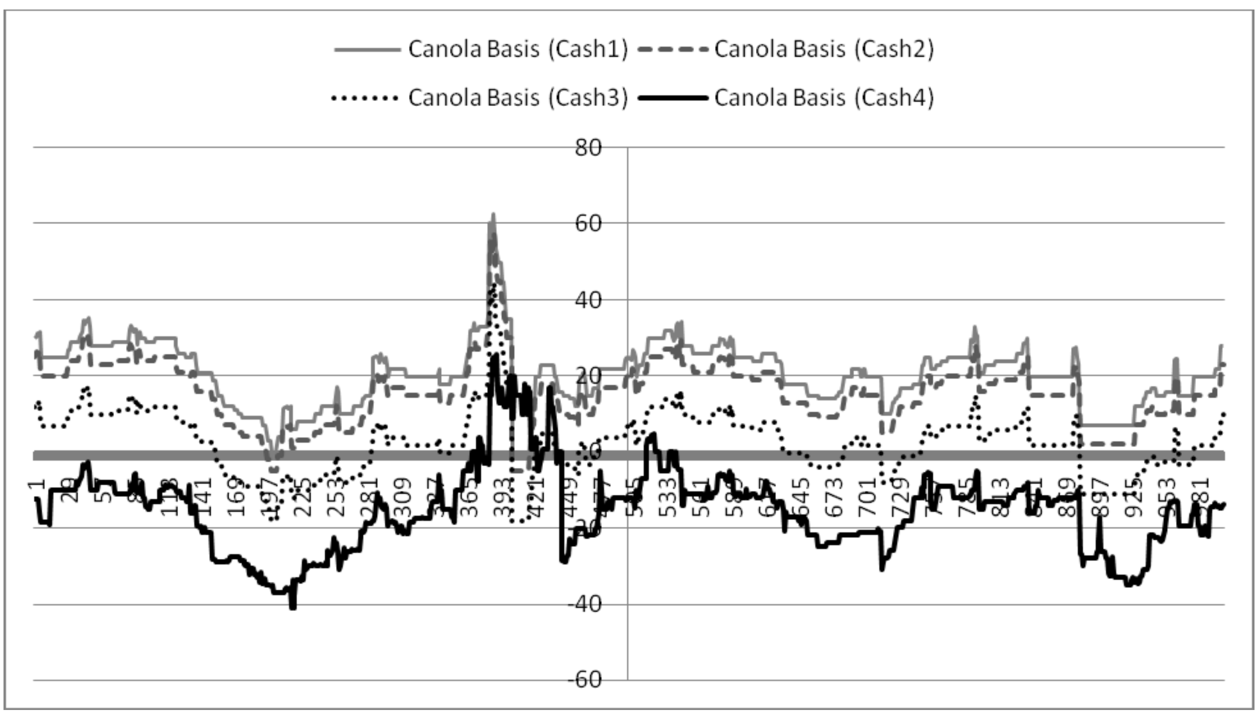
Canola: Four cash prices are used. Cash1, Cash2 and Cash3 are for delivery Instore, Vancouver, Canada. They have a fixed price relationship. Cash2 is at $5 discount to Cash1 and Cash3 is at $13 discount to Cash2. Cash4 is the best bid of the par region cash price.

Feed Wheat: Cash1 is for delivery at the track at Thunder Bay, Canada and Cash2 is the cash price based on the best bid in the par region.

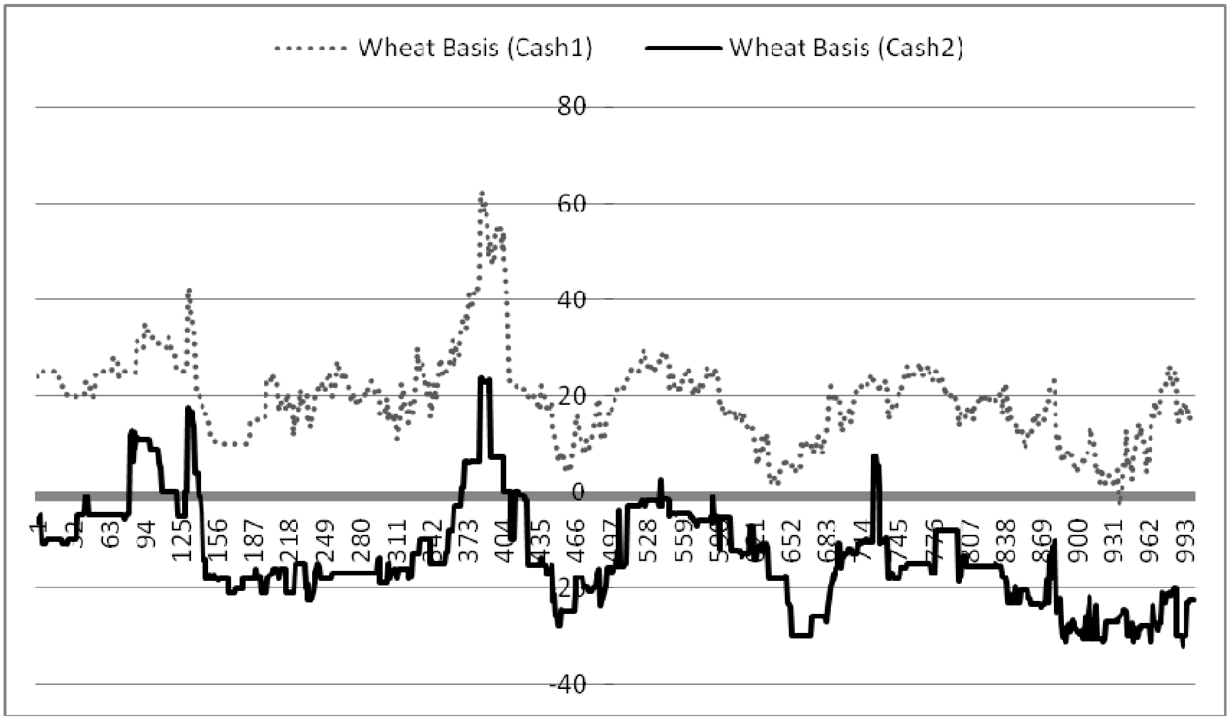
The following graphs illustrate the basis prices of the different commodities using the different cash prices.



Graph 1: Barley Basis for 500 trading days before and after the date of shift to electronic trading, Dec 20, 2004. Closing prices of nearby futures and daily cash prices are used to compute the basis.



Graph 2: Canola Basis for 500 trading days before and after the date of shift to electronic trading, Dec 20, 2004. Closing prices of nearby futures and daily cash prices are used to compute the basis.



Graph 3: Wheat Basis for 500 trading days before and after the date of shift to electronic trading, Dec 20, 2004. Closing prices of nearby futures and daily cash prices are used to compute the basis.

The summary statistics of the basis for different commodities are as follows.

Barley Basis	Before	After	Total
Mean	-3.23	-7.73	-5.48
Variance	74.76	32.84	58.79

Table1: Mean and variance of the barley basis for 500 trading days before and after the shift to electronic trading. The mean and variance of the total sample is also provided.

Canola Basis1	Before	After	Total
Mean	20.50	20.41	20.46
Variance	105.58	43.09	74.11
Canola Basis2	Before	After	Total
Mean	15.50	15.41	15.46
Variance	105.58	43.09	74.11
Canola Basis3	Before	After	Total
Mean	2.50	2.41	2.46
Variance	105.58	43.09	74.11
Canola Basis4	Before	After	Total
Mean	-14.74	-15.86	-15.30
Variance	175.58	63.56	119.48

Table2: Mean and variance of the canola basis for 500 trading days before and after the shift to electronic trading. The mean and variance of the total sample is also provided.

Wheat Basis1	Before	After	Total
Mean	22.45	16.33	19.39
Variance	99.89	54.75	86.60
Wheat Basis2	Before	After	Total
Mean	-9.96	-16.69	-13.32
Variance	116.22	80.65	109.66

Table3: Mean and variance of the wheat basis for 500 trading days before and after the shift to electronic trading. The mean and variance of the total sample is also provided.

6. STRUCTURAL CHANGE ANALYSIS

The various cash and futures prices are tested for their order of integration, after which they are tested for structural change and co-integration.

6.1 UNIT ROOT TESTS

The test for order of integration of cash and futures prices is conducted using the Augmented Dickey Fuller test (ADF) and the Philip Perron (PP) test static. The ADF test gives the Z(t) statistic whose 5% critical value is -1.95. If the statistic is greater than the critical value, then, the null of unit root cannot be rejected. The PP test gives two estimates, the Z(rho) and the Z(t) statistic. The 5% critical values for Z(rho) and Z(t) are -8.1 and -1.95 respectively. If the statistic is greater than the critical values, then we cannot reject the null hypothesis of unit root. The results of the tests on the three futures prices and the seven cash prices are as follows.

BARLEY	**ADF** **Z(t) (5% Critical value = -1.95)**		**Philip Perron** **Z(rho) (5% Critical value = -8.1)** **Z(t) (5% Critical value = -1.95)**	
Barley Futures	-0.346	Cannot reject null	-0.169	Cannot reject null
			-0.353	Cannot reject null
Differenced Barley Futures	-29.932	Reject null	-957.618	Reject null
			-29.954	Reject null
Barley Cash	-0.497	Cannot reject null	-0.175	Cannot reject null
			-0.461	Cannot reject null
Differenced Barley Cash	-28.573	Reject null	-1092.568	Reject null
			-29.442	Reject null

Table4: Unit root test results for barley prices. The results show that both cash and futures prices are I(1).

From the above table it can be seen that the null hypothesis of a unit root in the time series cannot be rejected in the futures prices or in the cash prices. However, the null hypothesis is rejected in the differenced time series. This shows that the difference of the individual prices does not have a unit root. Hence, we can conclude that barley cash and futures prices are integrated of order one. That is they are I (1) and follow a random walk.

CANOLA	**ADF** **Z(t) (5% Critical value = -1.95)**		**Philip Perron** **Z(rho) (5% Critical value = -8.1)** **Z(t) (5% Critical value = -1.95)**	
Canola Futures	-0.659	Cannot reject null	-0.287	Cannot reject null
			-0.657	Cannot reject null
Differenced Canola Futures	-31.892	Reject null	-1030.164	Reject null
			-31.894	Reject null
Canola Cash 1	-0.643	Cannot reject null	-0.276	Cannot reject null
			-0.636	Cannot reject null
Differenced Canola Cash 1	-31.280	Reject null	-1025.090	Reject null
			-31.309	Reject null
Canola Cash 2	-0.647	Cannot reject null	-0.282	Cannot reject null
			-0.640	Cannot reject null
Differenced Canola Cash 2	-31.280	Reject null	-1025.090	Reject null
			-31.309	Reject null
Canola Cash 3	-0.658	Cannot reject null	-0.299	Cannot reject null
			-0.652	Cannot reject null
Differenced Canola Cash 3	-31.280	Reject null	-1025.090	Reject null
			-31.309	Reject null
Canola Cash 4	-0.684	Cannot reject null	-0.314	Cannot reject null
			-0.696	Cannot reject null
Differenced Canola Cash 4	-31.289	Reject null	-939.394	Reject null
			-31.315	Reject null

Table5: Unit root test results for canola prices. The results show that both cash and futures prices are I(1).

The results for canola are similar to barley. The cash and futures prices can be concluded to be integrated of order one i.e. I (1).

FEED WHEAT	ADF Z(t) (5% Critical value = -1.95)		Philip Perron Z(rho) (5% Critical value = -8.1) Z(t) (5% Critical value = -1.95)	
Wheat Futures	-0.477	Cannot reject null	-0.264	Cannot reject null
			-0.482	Cannot reject null
Differenced Wheat Futures	-28.967	Reject null	-953.289	Reject null
			-29.089	Reject null
Wheat Cash 1	-0.681	Cannot reject null	-0.273	Cannot reject null
			-0.612	Cannot reject null
Differenced Wheat Cash 1	-25.139	Reject null	-852.511	Reject null
			-25.643	Reject null
Wheat Cash 2	-0.830	Cannot reject null	-0.548	Cannot reject null
			-0.843	Cannot reject null
Differenced Wheat Cash 2	-34.130	Reject null	-1064.782	Reject null
			-34.162	Reject null

Table6: Unit root test results for wheat prices. The results show that both cash and futures prices are I(1).

From the above results, it can be concluded that the cash and futures prices in wheat are also integrated of order one. Since all the cash and futures prices are integrated of order one, co-integration tests can be run.

6.2 CO-INTEGRATION TESTS

We will use the method prescribed in Engle and Granger (1987) to test for the presence of co-integration in cash and futures prices. Here, the null hypothesis is that there is no co-integration. The alternate hypothesis is that co-integration cannot be rejected.

H0: There is no co-integration

H1: There is co-integration

The results of the Engle and Granger (1987) method are as follows. Constant and trend were not included in the unit root test.

	Z(t)	**5% critical value based on MacKinnon (1996)**	**Result**
Barley	-9.814	-3.478	Reject null of no co-integration
Canola (Cash1)	-5.347	-3.479	Reject null of no co-integration
Canola (Cash2)	-5.414	-3.479	Reject null of no co-integration
Canola (Cash3)	-6.708	-3.479	Reject null of no co-integration
Canola (Cash4)	-6.049	-3.479	Reject null of no co-integration
Wheat (Cash1)	-4.591	-3.481	Reject null of no co-integration
Wheat (Cash2)	-4.592	-3.481	Reject null of no co-integration

Table7: Engle and Granger (1987) two step method to test for no co-integration. The results show the Z(t) values obtained in the ADF test on the residuals of a linear regression of the nearby futures price on the cash price. The null hypothesis of no co-integration is rejected in all cases.

The above table shows that we reject the null hypothesis of no co-integration in the cash and futures prices. On the basis of this co-integration test, we will proceed to conduct the Hansen (1992) test to determine the presence of a structural change in the basis in each of the commodities.

In order to test for structural change in the presence of co-integration of cash and futures prices, we will use the method prescribed by Hansen (1992), in which the three tests, MeanF, SupF and L_C are prescribed to test for parameter instability in a co-integrated model. The null hypothesis is that the coefficient is constant and the variables are co-integrated. The alternate hypothesis is that there is no co-integration. The co-integration equation is modeled as follows.

$$f_t=k_1c_t+k_2+e_t$$

In the above equation, f_t is the futures price, c_t is the cash price. The null hypothesis is that f_t and c_t are co-integrated with no structural change.

H0: f_t and c_t are co-integrated and k_2 is constant

H1: f_t and c_t are not co-integrated.

Since the cash price is based on the same contract size as the futures price, the constant k_1 should be 1 and k_2 is the basis. The results of the tests are as follows. The standard errors are noted under the equation. A p value greater than 0.05 means we cannot reject the null at 5% critical level. Since our main test is to test for a sudden structural change due to the shift to electronic trading, we look at the SupF test statistic. If its p value is above 0.05, then we cannot reject the null hypothesis.

The results of the tests are as follows.

BARLEY	**Estimate**	**Standard Error**	
k_1	0.931	0.040	
k_2	14.182	5.291	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	5.350	0.200	Cannot reject null

Table8: Co-integration without structural change test results for barley cash and futures prices. The null hypothesis of co-integration without structural change cannot be rejected since the p value of the SupF test is greater than 0.05.

CANOLA with Cash1	Estimate	Standard Error	
k_1	1.010	0.035	
k_2	-23.988	12.184	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	4.100	0.200	Cannot reject null
CANOLA with Cash2	**Estimate**	**Standard Error**	
k_1	1.010	0.035	
k_2	-18.937	12.010	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	4.100	0.200	Cannot reject null
CANOLA with Cash3	**Estimate**	**Standard Error**	
k_1	1.010	0.035	
k_2	-5.802	11.558	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	4.100	0.200	Cannot reject null
CANOLA with Cash4	**Estimate**	**Standard Error**	
k_1	1.008	0.051	
k_2	12.744	16.135	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	2.767	0.200	Cannot reject null

Table9: Co-integration without structural change test results for canola cash and futures prices. The null hypothesis of co-integration without structural change cannot be rejected since the p value of the SupF test is greater than 0.05.

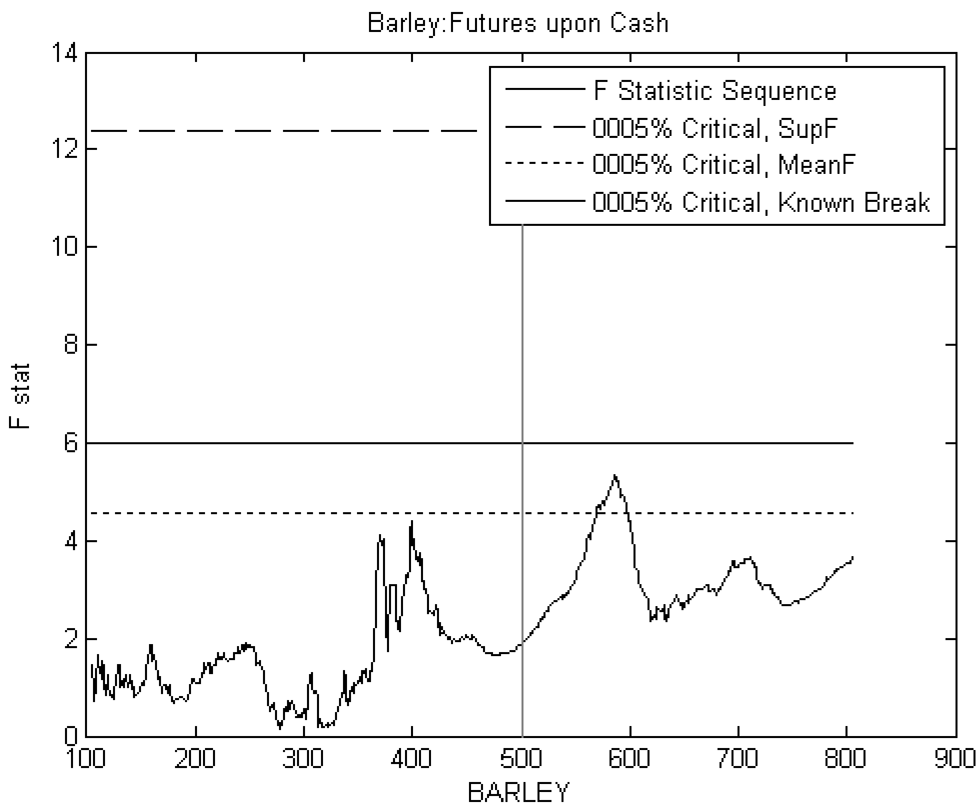
WHEAT with Cash1	Estimate	Standard Error	
K_1	0.925	0.045	
K_2	-8.920	6.577	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	10.604	0.122	Cannot reject null
WHEAT with Cash2	**Estimate**	**Standard Error**	
k_1	0.998	0.071	
k_2	13.538	8.062	
	Test Statistic	P value (>=0.2 is shown as 0.2)	Result at 5% level
SupF	7.199	0.200	Cannot reject null

Table10: Co-integration without structural change test results for wheat cash and futures prices. The null hypothesis of co-integration without structural change cannot be rejected since the p value of the SupF test is greater than 0.05.

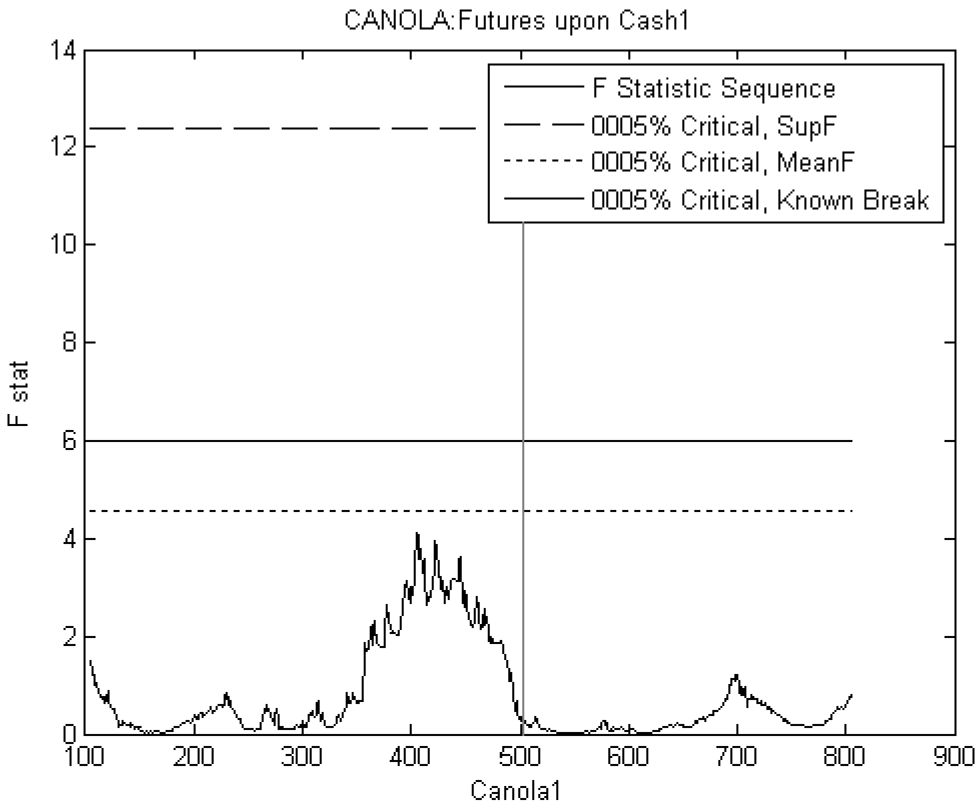
From the above tables, we find that in all the cases, we cannot reject the null hypothesis of co-integration with a constant parameter at a critical level of 5%. From this we can come to the conclusion that the shift to electronic trading did not lead to a structural change in the basis. A constant basis would mean that the shift to electronic trading did not make a significant change in the transaction cost to the end consumer.

In the next section, we look at the tests for no structural change with co-integration at different points in the sample. It is a test of structural change when the break point is not known. Even though our break point is known, this study is included to illustrate the co-integration of cash and futures prices. The figures show the F statistic at each point in the sample and when the F statistic crosses the critical point, one can reject the null of co-integration with constant parameters.

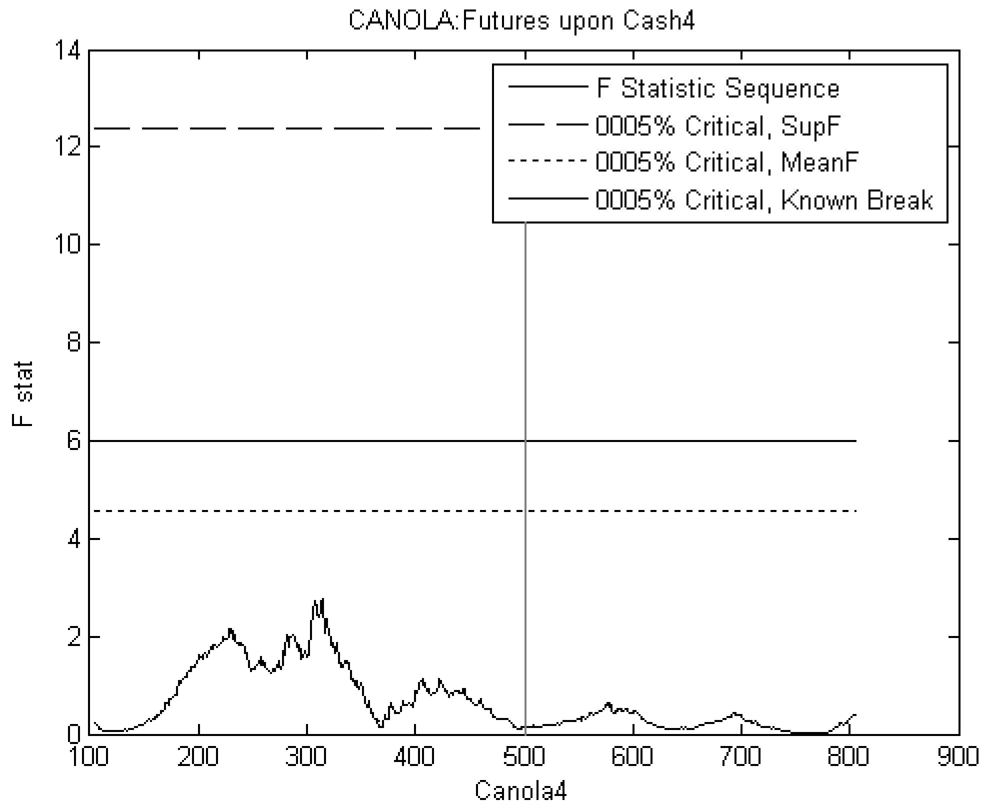
The X axis shows the data points in according to date so that the 500 on X axis denotes the date 12/20/2004, when the exchange shifted to electronic trading. The data before 500 pertains to the F statistic sequence before electronic trading and after 500 to post the shift to electronic trading. Only 400 days before and after the shift are considered here. The values MeanF, SupF and LC are computed from the F statistic sequence. The black plot is the F statistic while the horizontal lines denote the 5% critical value for rejecting the null hypothesis of co-integration with constant parameters.



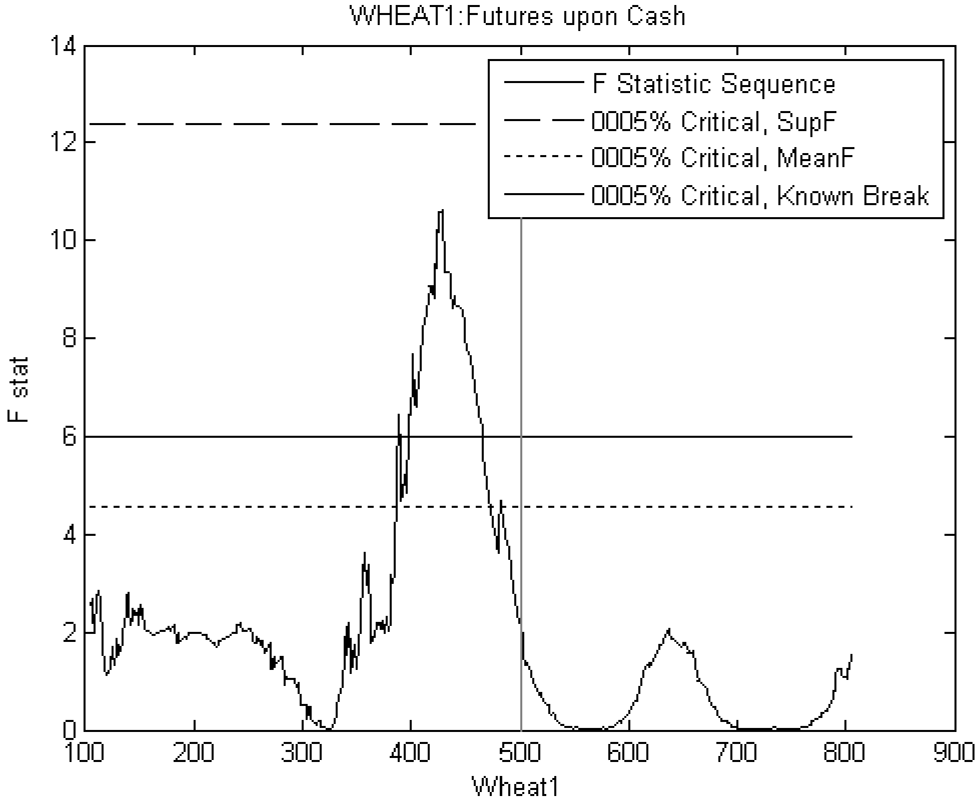
Graph4: Plot of the F statistic for barley. The null hypothesis is co-integration without structural change. The SupF test is used when a sudden shift in the regime is expected. This is relevant to the experiment conducted in this paper. The other tests are used when the shift is gradual or regular. The plot is for 400 trading days before and after the shift to electronic trading. The point at 500 on the X axis corresponds to the date of shift to electronic trading, December 20, 2004.



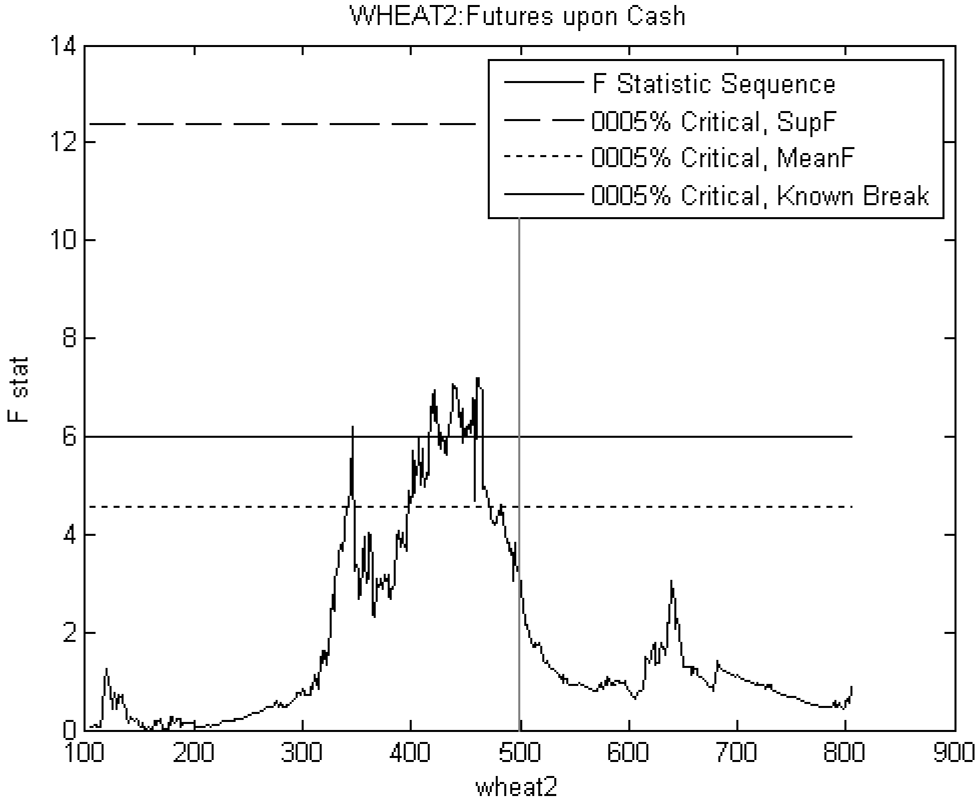
Graph5: Plot of the F statistic for canola. The null hypothesis is co-integration without structural change. The SupF test is used when a sudden shift in the regime is expected. This is relevant to the experiment conducted in this paper. The other tests are used when the shift is gradual or regular. Results of cash2 and cash3 are omitted since they are similar to cash1. The plot is for 400 trading days before and after the shift to electronic trading. The point at 500 on the X axis corresponds to the date of shift to electronic trading, December 20, 2004.



Graph6: Plot of the F statistic for canola with cash4. The null hypothesis is co-integration without structural change. The SupF test is used when a sudden shift in the regime is expected. This is relevant to the experiment conducted in this paper. The other tests are used when the shift is gradual or regular. The plot is for 400 trading days before and after the shift to electronic trading. The point at 500 on the X axis corresponds to the date of shift to electronic trading, December 20, 2004.



Graph7: Plot of the F statistic for wheat. The null hypothesis is co-integration without structural change. The SupF test is used when a sudden shift in the regime is expected. This is relevant to the experiment conducted in this paper. The other tests are used when the shift is gradual or regular. The plot is for 400 trading days before and after the shift to electronic trading. The point at 500 on the X axis corresponds to the date of shift to electronic trading, December 20, 2004.



Graph8: Plot of the F statistic for wheat. The null hypothesis is co-integration without structural change. The SupF test is used when a sudden shift in the regime is expected. This is relevant to the experiment conducted in this paper. The other tests are used when the shift is gradual or regular. The plot is for 400 trading days before and after the shift to electronic trading. The point at 500 on the X axis corresponds to the date of shift to electronic trading, December 20, 2004.

The figures show that while there was seemed to be a minor shift in the co integrating equation, it was not significant enough. Only wheat shows any statically significant change in the co-integrating relationship, which could be due to changes in the factors affecting wheat prices during that time. Wheat prices fell from $155.5/tonne on July 12, 2004 to $68/tonne on February 21, 2005, while the cash prices did not move as much. The basis fell from $55.5/tonne and $22.59/tonne to $26/tonne and -$2/tonne. This is seen from the graph of the basis. This could be attributed to the poor harvest that was expected in USA which led to higher futures prices. Canada however, was not affected climatically, leading to lower cash prices in Canada. Such wide sudden movements in the basis could seem to affect the co-integrated relationship of the cash and futures prices. However, it needs to be noted that the relationship stabilized later. Other figures show how the impact of electronic trading on the co-integrated cash-futures relationship was not significant. Hence, we can conclude that the shift to electronic trading did not significantly affect the basis or the co-integrated relationship of the cash and futures prices of the commodities traded on the WCE. Another factor to be noted in the graphs is the lower F statistic values after the shift to electronic trading. This shows that the cash and futures prices were co-integrated and the relationship was very stable after the shift to electronic trading. This would mean a more stable basis and hence, a better hedging mechanism for hedgers.

7. CONCLUSION

The results of this paper show that the shift to electronic trading has not significantly affected the cash-futures relationship of the commodities traded on the WCE. It also shows the co-integrated relationship of the cash and the futures prices. Indeed, any change in the co-integration relationship would have affected the hedge ratio, or the basis, thus affecting the ability of futures to predict futures cash prices or act as a hedge to traders of commodities. While this paper has not looked at the impact of electronic trading on aspects like volatility and liquidity, it has shown that the basis and the hedge ratio have remained constant. This paper has also lent support to the fact that in commodities, the cash and futures prices are indeed co-integrated.

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