LEAD-LAG RELATION BETWEEN FUTURES AND SPOT MARKET:

CASE OF RUSSIA

by

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A thesis submitted in partial fulfillment of
the requirements for the degree of

MA in Financial Economics

Kyiv School of Economics

2012

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Kyiv School of Economics

Abstract

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The paper empirically investigates intraday lead-lag relation between futures and spot market in Russia for period September 2007 to December 2011 using 5-minute data for futures and index prices. Three-stage-least-squares regression is used to estimate lead-lag relation. Results indicate that Russian market exhibit bi-directional relation between spot and futures markets. Also, it was found that on the expiration day only recent movements (up to 5 minutes) of the spot (futures) market are important for determination of the direction of the futures (spot) market. Findings are consistent across all contracts under scrutiny.

Result of the study are of interest for different groups of market participant: market makers, speculators and regulatory athority.

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ACKNOWLEDGMENTS

The author wishes to express gratitude to his thesis supervisor Professor Olesia Verchenko for her advice and useful comments. The author is grateful to all research workshop professors for their patience, valuable comments and guidance.

My special thanks to Dzmitry Sidarau for his help with getting the data for this research and for his support and advice during the course of the year.

GLOSSARY

CBOT MM. Chicago Board of Trade Major Markets

HF. High frequency financial data

Spot market. Financial market, in which financial instruments or commodities are traded for immediate delivery

Cash settlement. Settlement method where upon exercise of the futures the seller of the financial instrument does not deliver the underlying asset but transfers the associated cash position.

Expiration Date. The day on which futures contract is no longer valid and, therefore, ceases to exist.

View about the market. Belief about direction of the future market move.

RTS. Russian Trading System

UX. Ukrainian Exchange

FFMS. Federal Financial Markets Service

Chapter 1

INTRODUCTION

In this work I undertook a study of futures market efficiency in Russia. The efficient market hypothesis was first introduced by Eugene Fama in his seminal paper "The Behavior of Stock-Market Prices" in 1965. I will be studying efficiency of the Russian futures market by investigating lead-lag relationship between Russian stock index RTS and RTS futures to discover how long futures lead the index or vice versa. If such lead-lag relationship exists we can say that market is inefficient.

There are two main reasons for this research to be done for Russian market. The first reason is creation of the international financial centre in Moscow. This will require a lot of work from the regulatory stand point and it is of main interest to regulators such as Federal Financial Markets Service (FFMS) to decrease frictions on the market. In order to do this it is necessary to understand current state of affairs. The second one is that, the market for derivatives as a whole and futures in particular is relatively big(size of Russian stock market is $1 trillion, which is comparable to the size of the stock market in many developed, such as UK ($3.1 trillion), France ($1.9 trillion), Germany ($1.4 trillion), and larger than those of Sweden and Netherlands), liquid and fast growing. Similar studies were done for major developed markets (US, UK, Japan) but it is not done for Russia.

There are several other reasons why focusing on Russia is interesting. Firstly, Russia has a unique institutional setting. For example, when a company decides to become public it can place in shares on several exchanges simultaneously. Other feature is that capitalization is highly concentrated in three sectors: Financial, Energy and Metallurgy. Secondly, Russian financial market is one of the most actively developing markets in the world and is of huge interest to international investors. Finally, the newly established futures market in Ukraine can be considered as an offspring of the Russian RTS market, which is the main founder of the UX exchange and stands behind all its latest initiatives.

Understanding the lead-lag relation between the stock and futures market in Russia is interesting to market-makers because it helps them to set better quotes since prices are revealed through this lead lag relation. Also, it is of importance to investors because understanding of the lead lag relation provides useful information for development of trading strategies. For example movements in the futures market and be used to predict futures movements in the spot market Finally, marker regulator (FFMS for example) are interested in the understanding of the process of price discovery because it can give an idea of overall marker movement in advance and thus appropriate policy actions to stabilize the market can be taken in a timely fashion.

Let us look closer at the Russian stock market. The Russian stock market is known as the biggest market in Eastern Europe. There are four exchanges the Russian Trading System Stock Exchange (RTS), Moscow Interbank Currency Exchange (MICEX), Saint Petersburg Currency Exchange (SPCEX), and Stock Exchange Saint Petersburg (SPBEX). RTS & MICEX are the largest ones and right now they are merging, since the Russian government pushes hard to transform Moscow into the world's largest financial center. However, merger is still on the way, so from now and on I will be talking about the RTS. The RTS was founded in 1995, and in 2010 it became one of TOP10 derivative exchanges worldwide. The total value of contracts traded there exceeds 5 million per day ($7M-$10M). Every day more than 1 million trades with derivative instruments are executed. Also, the RTS is a fast growing market. Since 2008 the number of traded contracts has tripled (in 2010 there were 623,992,363 contracts traded on the exchange). If we look at the dynamics of futures trading (See Figure 1) it is clear that it is rising exponentially.

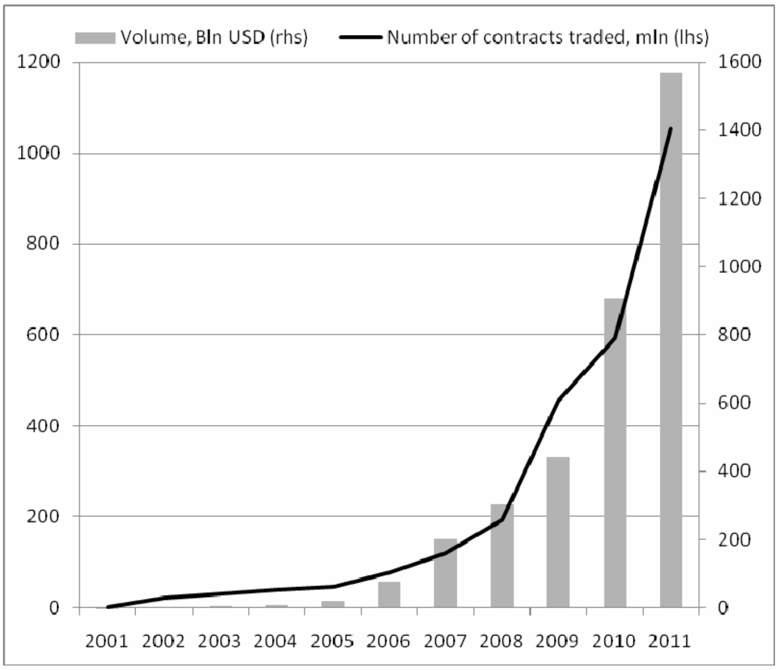


Figure 1: Exponential growth in futures trading

In this paper I will particularly focus on futures on RTS index because they comprise 43% of all trading in futures. (See Figure 2) On the top of this, the RTS is the only exchange, which has survived through all crises in Russia over the last 16 years. Thus, Russian market can be viewed as an attractive one in terms of both liquidity and size.

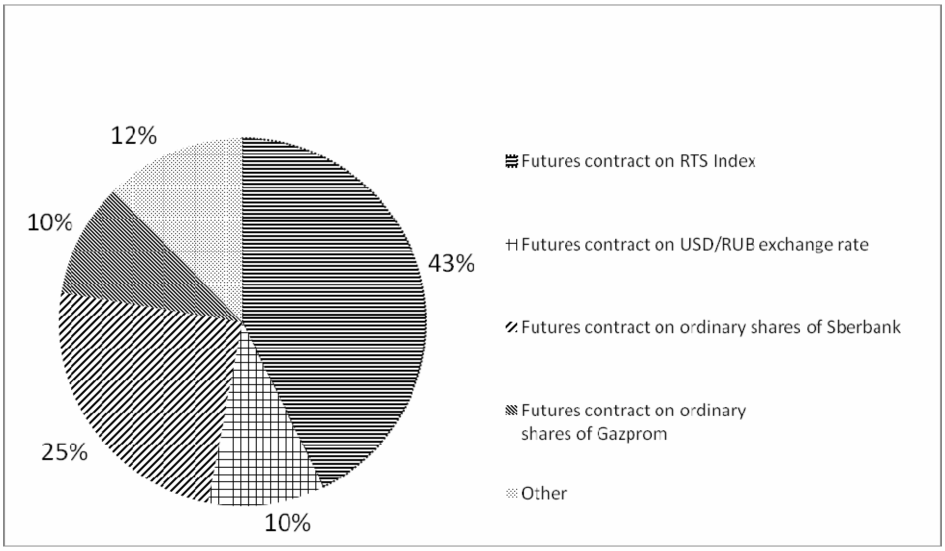


Figure 2: Futures trading breakdown by underlying asset

However, it is believed that market has many imperfections, which cause discrepancy in price between spot and futures markets. This discrepancy, if properly measured, can result in arbitrage profits. So it is of importance to investigate relations between futures and spot markets in order make understand to what extent they are correlated in Russia.

There is strong empirical evidence of the fact that lead-lag relation does not outlast for a long period of time, in fact they tend to last for less than half an hour according to Kawaller et al (1987); Stoll and Whaley (1990), and Brooks et al. (2001). Given this information it is clear that it is hardly possible to track this relationship using end-of the-day data. Thus, use will be made of high frequency data (5 minutes intervals) to investigate the relation between spot and futures market.

I will commence with inspecting whether the data is stationary or not. In the case of non-stationary I will transform the data. Next step will be to convert futures prices in to rubles in order to compare them with index values. To determine lead-lag relationship I will use three stage least square regression.

I expect to see that prices of the futures contracts are leading prices of the spot at most for 30 minutes. This expectation is build upon result of preceding works. As mentioned before I will use high-frequency data which are preferred because the nature of the lead-lag relationship is short term. Data is collected from the RTS Exchange and Finam Investment Company.

The paper is structured as following: Chapter 2 presents literature review, Chapter 3 presents methodology and data, in Chapter 4 will be devoted to empirical estimations and results. Finally, conclusions are presented and discussed in Chapter 5.

C h a p t e r 2

LITERATURE REVIEW

Since introduction of the first index futures contract in 1982 a lot of academic literature was devoted to investigation of the relationship between index futures market and underlying stock market. The whole set of available literature can be divided into two groups based on the market for which the study was conducted. For developed markets most of papers were written in 80's and 90's, while the literature for developing markets is developing now.

Intuitively the lead-lag relation between futures and spot market exists due to the difference in the speed at which new information is transferred into prices on spot and futures market. The speed of accommodation of new information tends to be higher for futures market then for spot because it is much easier and much faster to enter to or exit the position when operating on futures market then on spot market. In other words, by buying or selling futures an investor can express his view about the market very quickly because he needs to do a transaction only with one instrument (i.e. futures contract) whereas buying or selling spot might be very difficult because it requires a transaction with market portfolio (in case of RTS it is 50 stocks).

Developed markets literature. The first paper about lead-lag relationship between spot and futures market was written by Kawaller et al.(1987) where they investigated the relation between S&P 500 Index and S&P 500 futures contract using three stage least square regression. Results indicate that futures prices consistently lead index by twenty to forty minutes. On the other hand index movements do not cause futures to move. Herbst at al. (1987) undertook a study of lead-lag relation for Value Line Index and S&P 500 Index and the corresponding futures contracts. They have found that futures prices in general lead spot prices but spot price adjust very quickly to the changes in futures prices. Stoll and Whaley (1990) looked into time series properties of S&P 500 and MMI futures and underlying stock. Their results indicate that futures lead stock market on average by 5 minutes but some times up to 10 minutes. Kutner and Sweeney (1991) conducted a study of the relation between S&P 500 index cash and futures market to test wherther this two markets are casually related in the Granger sense. Results indicate that there is a strong relation between futures market and cash market where futures lead spot market. Chan (1992) looked at the lead lag relation between MMI and S&P 500 index cash and futures markets. He finds that futures market is leading cash market, which suggests that futures is the main source of information. Tang et al. (1992) investigated relation between Hang Sang index futures and the underlying Hang Sang index in Hong Kong. They use full-information estimation technique, Granger's definition of causality and Hsiao's operational test. Their conclusion is that the changes is cash prices are caused by changes in futures prices. Ghosh (1993) used the cointegration approach to investigate whether futures price changes are forecastable using the data for S&P 500 spot and futures market. His findings indicate that more information flows from futures market to the spot market than vice versa. Martikainen and Puttonen (1993) conducted a study of the lead-lag relation on Finnish stock market. Due to the nature of Finnish market short selling is prohibited. This study revealed that stock index futures returns show significant Granger causality with stock market returns, the futures market being the leading one. Booth, Martikainen and Vesa (1994) conducted a study of information flows between the US and Finnish futures and cash markets. They found that there is no causal relationship between cash markets but the US futures returns lead both Finnish cash and futures market. They concluded that the flows of information between financial markets of different the countries could be underestimated if futures are not taken into account. Tse (1995) using daily data exemined lead-lag relationship between the spot index and futures price of the Nikkei Stock Average using an error correction model. It was found that futures price affect spot index in the short-term adjustment, but not vice versa. Abhyankar (1995) looked into the UK futures and spot market. His results indicate that there is a strong contemporaneous relationship between the FT-SE 100 futures and cash markets and futures market is leading the spot market. This occures due to lower transaction and entering cost for futures market, and as a result new information is incorporated in to futures prices faster then into spot prices. Shyy et al. (1996) investigated the lead-lag relationship beetwen CAC futures with is traded on Matif and CAC cash index traded on the Paris Bourse.The error-correction model model was applied to minute-by-minute midquote points of bid/ask prices data were used. It was found that futures prices lead index prices. Nieto et al. (1998) used Johansen cointegration methodology to annalise Granger causality between daily Spanish stock index (Ibex 30) and futures prices. Their results prove that in the short run futures prices causes spot prices. In the long run spot causes futures prices to move. These Brooks et al. (1999) used cross correlations and cross bicorrelations to determine lead-lag releationship between FTSE and S&P 500 index futures and underlying stock index. However, contrary to results obtained from the traditional methodology. Lead lag relationship is detected less often and doesn't last long. Chua et al. (1999) investigated price discovey in three S&P 500 markets: spot index, index futures, and S&P Depository Receipts. Johansen's maximum likelihood estimator is applied to the intraday data to disclose cointegration relationships between the markets.The study reveals that these three markets are integrated with one long run stochastic trend. Futures markets is a dominant price discovery function among three markets.

Developing market literature. Min and Najand (1999) used intraday data to investigate lead-lad relationship in returns and volatility between cash and futures market in Korea. They have found that futures returns leads cash returns by as much as 30 minutes. With regards to volatility, bidirectional causality is more prevalent and the relation is very much sample dependant. Frino and West (1999) examined lead-lag relationship in returns futures on case index the Australian market for period between 1992 and 1997. They found that futures leads spot on average by twenty to twenty-five minutes. Year on year analysis indicated that time by which futures market lead stop has decreased and relationship between this two markets has strengthened. Bose (2007) looked into the Indian Stock Index Futures market to analyze its importance in the process of price discovery for stock market. If was found that significant information flow from the futures market to spot market exist. In the long run there is bidirectional flow of information. Also, it was determined that futures market readjusts faster after absorbing new information. Kavussanos et al. (2008) investigated the lead-lag relation between futures and spot market in Greece. Daily returns for FTSE/ATHEX-20 and FTSE/ATHEX Mid-40 stock index futures and underlying cash indices were taken. This study indicates that there is a bi-directional relationship between futures and cash and prices. Also, futures prices lead the cash index by responding faster to news than stock prices. Moreover, the speed at which new information is accommodated is higher in more liquid FTSE/ATHEX-20 market. Ching-Chung et al. (2008) applied VAR methodology, Granger causality test, and generalized impulse response function (GIRE) to the S&P 500, Nikkei 225 and the TAIFEX TAIEX index futures. Results indicate that interrelationship between futures and spot market is weaker in the mature US and Japanese markets than in the emerging Taiwanese market. Floros (2009) investigated price discovery between futures and spot market in South Africa over the period from 2002 to 2006 using four empirical methods: cointegration test, vector error correction model, Granger causality test, and an Error Correction model with TGARCH errors. Results indicate that bidirectional causality between futures and spot prices.

My paper is different from others in several ways. First of all, a lot of research was done to investigate arbitrage opportunities on developed markets (US, UK, Japan). Whereas very little is done for investigating this relation between spot and futures marker for developing markets and for Russia in particular. Thus bringing model to the data is very important since it hasn't been done yet. Secondly, given the size of the market it is of importance for both institution and regulators to understand how futures market affects spot market.

Chapter 3

METHODOLOGY AND DATA DESCRIPTION

Methodological framework will be based on the studies by Kawaller et al. (1987) and is adjusted to fit Russian financial market.

Institutional setting

RTS index comprises 50 Russian stock selected according to market capitalization and liquidity and is calculated by Moscow Interbank Currency Exchange every 15 second based on transaction prices of underlying stocks. Current capitalization of the index is 205 billion USD. There are no restrictions on short selling in Russia. Main trading session starts at 10am and lasts till 6:45pm. Evening trading session starts at 7pm and lasts till 11:50pm. Data from main trading session is used in this research.

Futures on the RTS index is a cash-settled contract the value of which in basis point is equal to the RTS index multiplied by 100. Minimal price change is 5 basis point. The value of a tick is determined as 10% of USD/RUB indicative exchange rate calculated by the Exchange. (i.e. futures contracts are dollar denominated).

Data

Futures on RTS index started trading on August 3rd 2005 and quickly became popular. Average daily volume by year is presented in the Table 1. Data indicates huge increase in volume which suggests that Russian financial market overall and futures marker particularly is interesting to the investors.

Futures contracts RTS index have expiration date in March, June, September and December. Code for contracts are formed in the following way: first we have «RI» same for all contracts, then we have one of the letter «U», «Z», «H», «M» which indicates month of expiration (H-March, M-June, U-September, Z-December) and finally year. For example RIZ1 is a contract on RTS index with expiration in December 2011. Sometimes I will use following notation for contracts RTS-12.11 which is the same contract RIZ1. The data set for this research is comprised of values of RTS index, 17 RTS futures contract which cover period from September 2007 to December 2011 quoted on per 5 minute during main trading session. Descriptive statistics are provided in the Table 2. Graphical representation of the data is provided in the Figure 3.

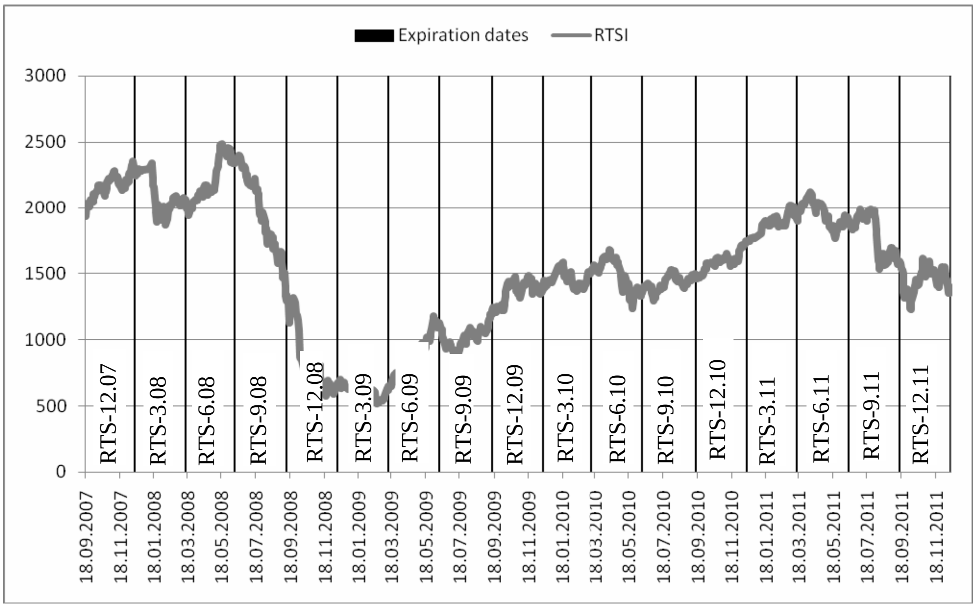


Figure 3: Evolution of the RTS index from Sep 2007 to Dec 2012

Period under scrutiny can be characterized by three features. Firstly, period captures pre crises state of the market, crises state and post crises recovery. During these phases we can observe different levels of volatility in the futures contracts and in the index value. This is interesting because lead lag relations tend to be change depending on the state of the market. Secondly, evening trading session was introduced on November 2nd 2009. Evening session allow marker participant to react to the global news and moves on the global markets (UK and US markets are open during evening session in Moscow) which helps to neutralize the morning gaps which occur because information that became available in the evening in Moscow cannot be transferred to the price due to the closed markets. This is interesting for our study because evening session allows information to be incorporated in the prices quicker and thus it might change lead lag relation. Finally, last contracts in our sample (RTS – 9.11 and RTS – 12.11) where trading during the recent turbulence on the financial markets and we can compare them with contracts that where traded when markets where more stable (RTS-3.11, RTS-6.11). This is interesting because we can compare the behavior of the lead – lag relations during period of turbulence and period of stable market.

Theoretical Framework

Previous studies indicate that past futures and spot prices contain valuable information about their own future prices and each other's prices. That is, value of RTS index is determined by its history and the past movements of RTS futures and other market information. On the other hand, changes in RTS futures price are determined by its history and changes in RTS index. This price relation will be tested by estimating distributed lags between first difference of the index and nearest futures. Specification will look as follows:

$$\begin{aligned} rtsi_t &= z_1 + \sum_{k=1}^{\infty} a_k rtsi_{t-k} + \sum_{k=0}^{\infty} b_k rtsf_{t-k} + e_{1t} \\ rtsf_t &= z_2 + \sum_{k=0}^{\infty} c_k rtsi_{t-k} + \sum_{k=1}^{\infty} d_k rtsf_{t-k} + e_{2t} \end{aligned} \tag{1}$$

where z_1, z_2 are intercept term RTSI and RTSF are log returns of index and futures respectively i.e.

$$\begin{aligned} rtsi_t &= \log RTSI_t - \log RTSI_{t-1} \\ rtsf_t &= \log RTSF_t - \log RTSF_{t-1} \end{aligned} \tag{2}$$

Differencing is needed to make the data stationary. System (1) represents a simultaneous-equations model where futures and spot prices may affect each other via b_0 and c_0. Thus we can't use OLS to estimate then because our result will be biased and inconsistent. Lets rewrite (2) as:

$$\begin{pmatrix} rtsi_t \\ rtsf_t \end{pmatrix} = \begin{pmatrix} A(L) & B(L) \\ C(L) & D(L) \end{pmatrix} \begin{pmatrix} rtsi_t \\ rtsf_t \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \tag{3}$$

where A(L), B(L), C(L), D(L) are polynomials in lag operator. To estimate (3) we need to decide how many lags to include in to the model parameterization. On the one hand the more lags we will include the less the chance of misspecification is. On the other hand including too many lags will result in the loss of degrees of freedom. Geweke (1977) suggests to keep generous number of lags for dependent variables in each equation and to minimize the chance of serially correlated errors, at the same time the number of lags for other variables should be kept low to retain power in hypothesis testing.

Now we can estimate (3) using three stage least square regression. This will give us at least two benefits comparing to OLS. First of all, because of potential simultaneity an instrumental variable is needed. Secondly, even in the absence of simultaneity errors might be serially correlated which will yield inefficient estimates if we will use OLS.

C h a p t e r 4

EMPIRICAL RESULTS

In this section result are presented. To estimate equation (3) I'm using 12 lags for futures and for index following Kawaller et al. (1987). Firstly, we are interested in coefficient b_0 and c_0 because they describe how current value of futures affects the index (b_0) and how current value of index affects the futures (c_0). Secondly, we will look how the relation between futures and spot market change it time by examining coefficients b_i, c_i i=1,…,12.

Table 3 present values of coefficients b_0 and c_0 for selected day for all contracts. First of all, data indicates that all values are significant. Secondly, data before and after December 2009 reveals structural change in the way how futures affect spot and vise versa. After December 2009 RTS futures affects RTS index in a greater way then it used to. Figure 3 presents this finding.

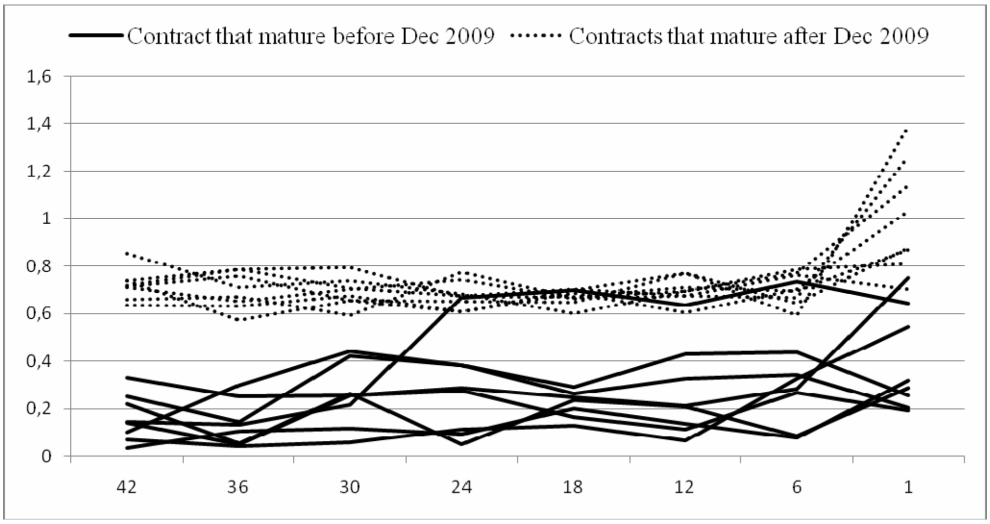


Figure 4: value of b_0 across all futures contracts. Time to maturity in day is on the Ox axis

There are two possible explanation of this result. Firstly this change may be due to a crisis. Secondly, it might be due to an introduction of the evening session. First reasons seems to be less plausible because if the crises would be the only reason we would see reverting patter when market stars to peak up. But it doesn't happen which lead us to the second reason – introduction of evening trading session which results in strengthening of the influence of futures on index.

On the other hand, after December 2009 effect of the RTS index on corresponding futures became less volatile and it diminishes when contract approaches expiration date. Figure 4 presents this finding.

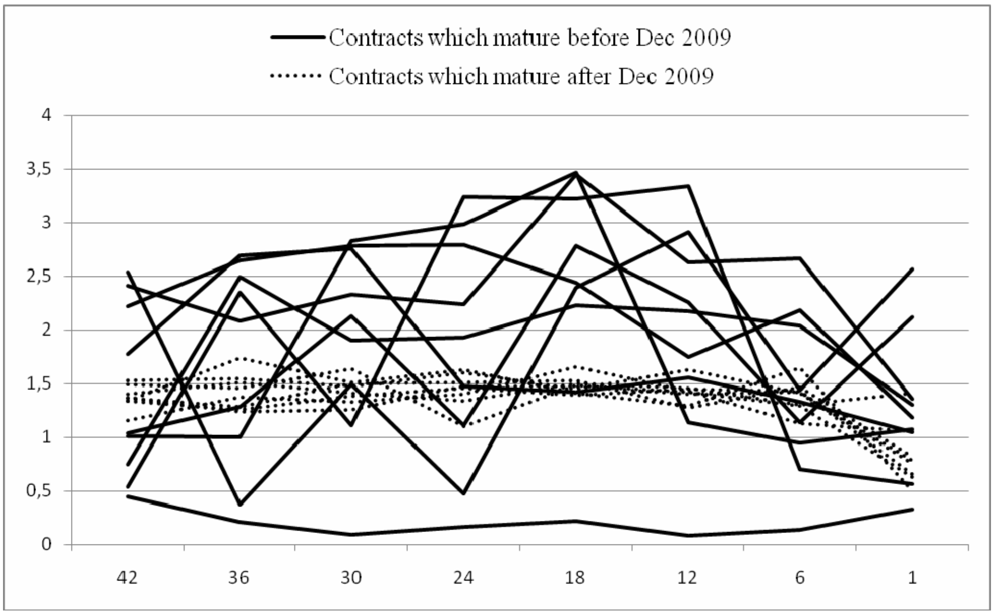


Figure 5: value of c_0 across all futures contracts. Time to maturity in day is on the Ox axis

This erratic behavior can be attributed to the absence of evening trading session. Before introduction of the evening trading session the RTS index was influenced by two streams of news: one that appear when Russian markets are open and another which were from previous trading day from US and UK markets. As a result we can see that the strength of influence index on futures change dramatically. After the introduction of evening trading session we can observe that size of the effect stabilized.

Finally, we will discuss the behavior of the RTS-12.11, RTS-9.11, RTS-6.11 and RTS-3.11 futures contracts and how they affect index and how index affect this contracts. This particular contract are of interest because two of them (RTS-12.11, RTS-9.11) where traded during the turbulent period on the financial markets whereas two others (RTS-6.11, RTS-3.11) where traded during relatively calm markets. Figures 6 and Figure 7 show this affects.

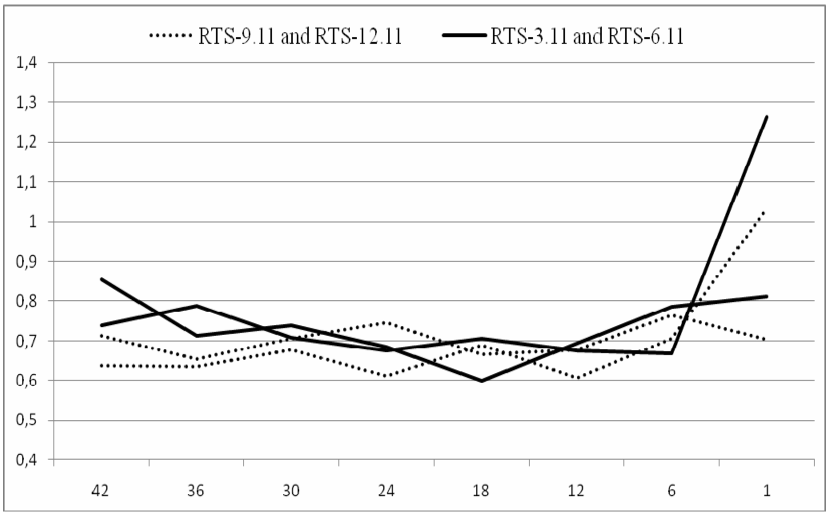


Figure 6: value of b_0 across four contracts traded in 2011. Time to maturity in day is on the Ox axis

Data doesn't suggest that there is any difference in that way how futures affect index during calm and turbulent markets. Also, there is no evidence that current values of index affect futures differently in different market environment.

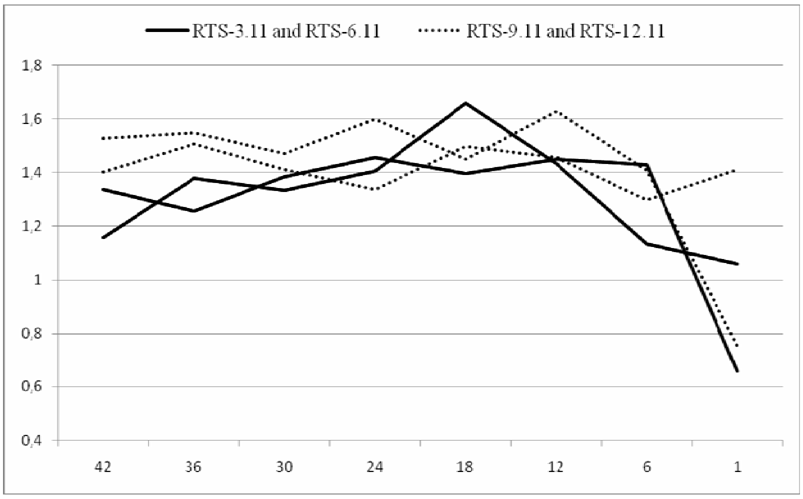
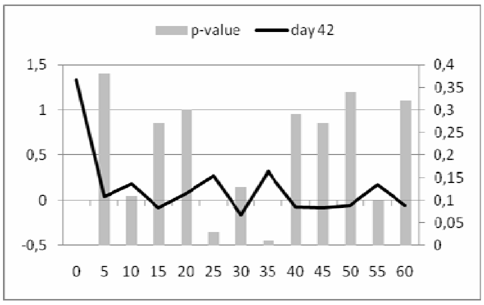


Figure 7: value of c_0 across all futures contracts. Time to maturity in day is on the Ox axis

Now, when we have a firm understanding of how current value of futures affect spot and vice versa it is time to look at other coefficients of the polynomials B(L) and C(L). This will provide as with information about the nature of the relation between spot and futures. For the sake of brevity only RTS-6.11 results are included and discussed here. Table 8-11 reveal the dynamics of the lead-lag relation.



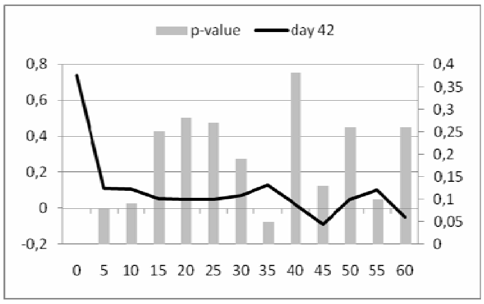


Figure 8: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 42 day prior to expiration. Time in minutes is on the Ox axis.

We can observe that current values of the futures and index are significant whereas other coefficients and insignificant and the size of the effect drops after first lag and erratically jumps around zero.

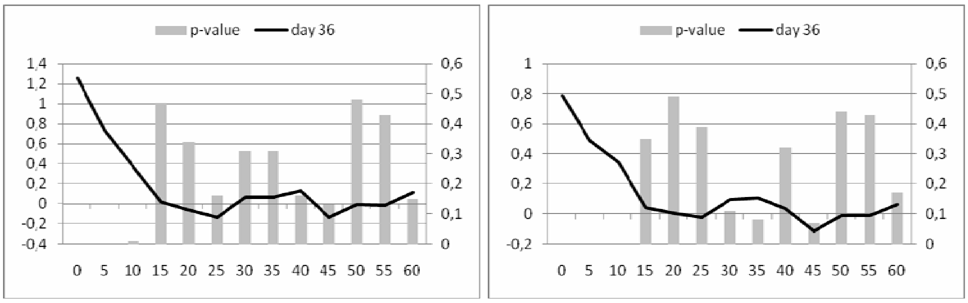


Figure 9: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 36 day prior to expiration. Time in minutes is on the Ox axis.

Value of the index and futures up to 10 minutes in the past are important in determination of future movements of the corresponding instrument. Coefficients decline steadily for 2 lags (10 minutes) and then become insignificant and the size of the effect erratically jumps around zero.

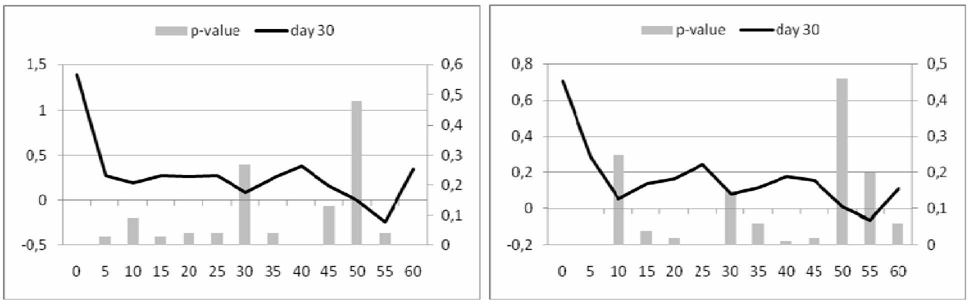


Figure 10: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 30 day prior to expiration. Time in minutes is on the Ox axis.

We can observe how the strength of the effect decay for 2 lags (10 minutes) and then become relatively constant. Also we observe that lags from futures to index are longer (6 lags, or 30 minutes) whereas lags from index to futures become insignificant after lag 2 (10 minutes).

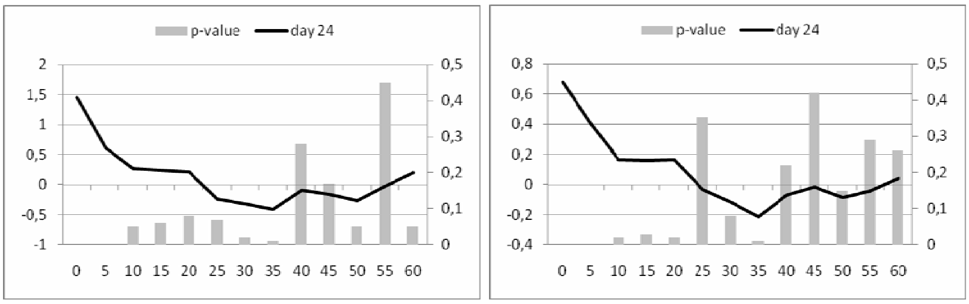


Figure 11: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 24 day prior to expiration. Time in minutes is on the Ox axis.

For 24 days before expiration we observe similar pattern. Distributed lags from futures to index are longer and significant up to lag 7 (35 minutes) whereas distributed lags from index to futures are shorter (up to 4 lag, 20 minutes). Effect of one market on the other decay with time and becomes insignificant after 8 lags for futures and 5 lags for index.

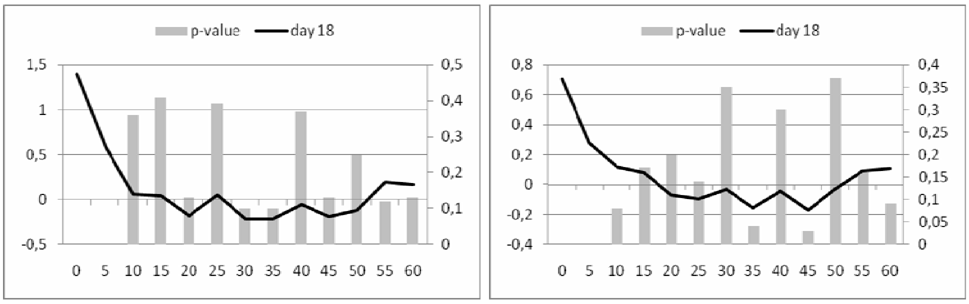


Figure 12: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 18 day prior to expiration. Time in minutes is on the Ox axis.

We can observe similar pattern 18 day prior to expiration. Strength of the effect decays for 2 lags (10 minutes) for both futures and index and then become insignificant.

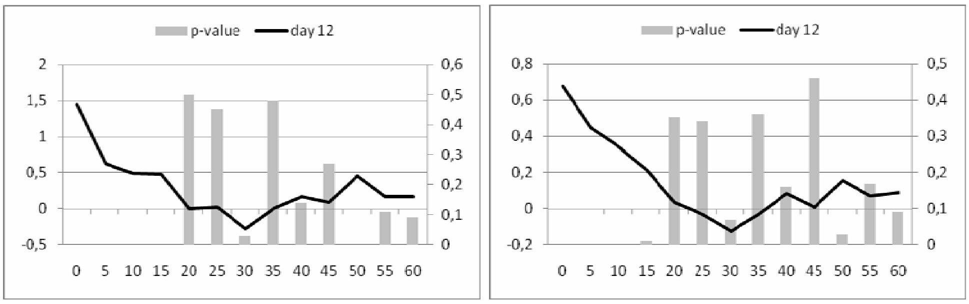


Figure 13: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 12 day prior to expiration. Time in minutes is on the Ox axis.

Pattern is similar to the previous day. Decline in the strength of the effect for 3 lags (15minutes) afterwards coefficients become insignificant.

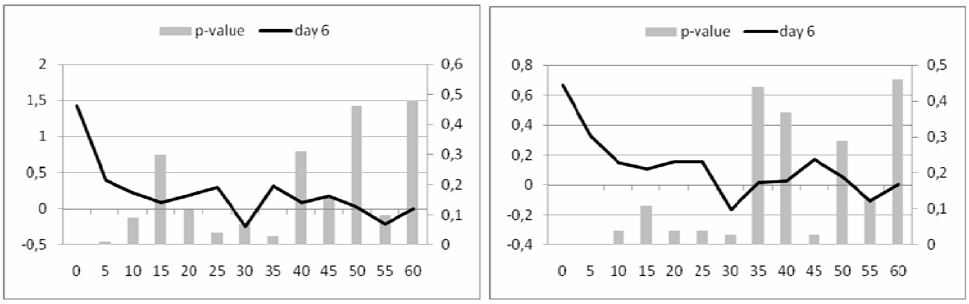


Figure 14: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract 6 day prior to expiration. Time in minutes is on the Ox axis.

Here we observe steep decline in values of the coefficients up to third lag. After third lag values stabilize and become insignificant after 8 lag (40 minutes).

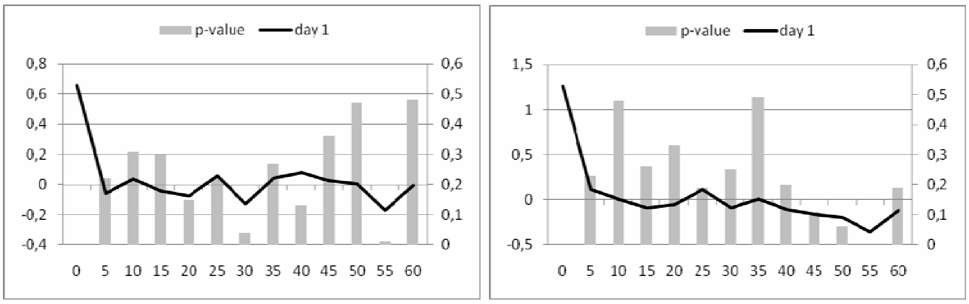


Figure 15: coefficients of B(L) (right) and C(L) (left) for RTS 6.11 contract on expiration day. Time in minutes is on the Ox axis.

On the expiation day only current values of futures and index are important. Coefficients for lag variables are insignificant.

On average effect of futures on index and index of futures last for 20 minutes during this time strength of the effect decay. After 20 minutes coefficients for lag variables becomes statistically insignificant. Common feature among all contracts it the fact the closet to maturity only most recent movement matter (up to 5 minutes) in determining the direction of the other market.

C h a p t e r 5

CONCLUSIONS

In this paper we investigate the lead-lag relation between Russian futures and spot market. Results indicate that contrary to developed market Russian market exhibit bi-directional relation between spot and futures. Same finds was discovered by Floros (2009) for South African market. Also, it was discover that strength of the relation decay when futures contract approaches maturity date and only very recent history (up to 5 minutes) meters for determining the direction of the move. Coefficitient of lag polinomials B(L) and C(L) exibit similar pattern (i.e. decay for first 4 lags, on average, and then became insignifican). This study shows that for Russian financial market RTS index (RTS futures) containe valuabe information about future development of the price of RTS futures (RTS index).

Result of the study are of interest for different groups of market participant: market makers, speculators and regulatory athority.

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Table 1: Average daily volume of RTS futures contracts by year

Year	Avg. daily volume (in contracts)
2008	316 277
2009	505 560
2010	758 247
2011	1 294 834

Table 2: Descriptive statistics for data set

	# obs.	#trading days	min	max	st.d	mean
RTS-12.07	5 220	60	193 670	237 895	8 430	218 577
RTS-3.08	4 872	56	185 000	237 500	14 668	211 506
RTS-6.08	5 481	63	115 650	150 940	8 866	135 207
RTS-9.08	5 742	66	78 130	120 190	8 560	100 492
RTS-12.08	4 350	50	61 100	121 930	16 095	85 451
RTS-3.09	4 785	55	46 510	71 675	6 171	57 417
RTS-6.09	5 481	63	56 050	141 035	25 792	85 682
RTS-9.09	5 829	67	78 130	120 190	8 560	100 492
RTS-12.09	6 336	64	115 650	150 940	8 866	135 207
RTS-3.10	5 544	56	135 445	160 290	6 042	146 018
RTS-6.10	6 351	63	120 905	165 600	11 076	148 193
RTS-9.10	6 930	66	127 405	153 130	5 583	142 505
RTS-12.10	6 615	63	145 670	176 615	7 321	159 291
RTS-3.11	5 775	55	173 150	203 080	7 350	187 043
RTS-6.11	6 615	63	174 370	208 820	7 913	192 727
RTS-9.11	6 930	66	143 880	200 670	15 717	177 373
RTS-12.11	6 720	64	118 120	162 745	9 181	143 919
RTSI	98 664	1 030	493	2 498	470	1 554

Table 3: Values of coefficients b_0 and c_0 and corresponding t-statistics, 42 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.222	4.42	1.040	4.42
RTS-3.08	0.332	10.28	2.216	10.28
RTS-6.08	0.100	2.4	0.748	2.4
RTS-9.08	0.254	8.51	2.406	8.51
RTS-12.08	0.141	5.75	2.540	5.75
RTS-3.09	1.293	8.09	0.446	8.09
RTS-6.09	0.035	1.19	0.542	1.19
RTS-9.09	0.072	2.37	1.008	2.37
RTS-12.09	0.148	5.13	1.781	5.13
RTS-3.10	0.739	26.88	1.335	26.88
RTS-6.10	0.715	24.54	1.370	24.54
RTS-9.10	0.717	24.59	1.364	24.59
RTS-12.10	0.658	25.75	1.491	25.75
RTS-3.11	0.855	31.13	1.159	31.13
RTS-6.11	0.739	28.84	1.337	28.84
RTS-9.11	0.636	23.08	1.528	23.08
RTS-12.11	0.713	-213.45	1.402	-213.45

Table 4: Values of coefficients b_0 and c_0 and corresponding t-statistics, 36 days to expiration

Contract	b0	t-stat	c0	t-stat
RTS-12.07	0.057	2.36	1.281	2.36
RTS-3.08	0.253	9.33	2.653	9.33
RTS-6.08	0.297	10.39	2.496	10.39
RTS-9.08	0.147	5.21	2.085	5.21
RTS-12.08	0.049	1.18	0.379	1.18
RTS-3.09	2.820	8.39	0.213	8.39
RTS-6.09	0.105	4.59	2.352	4.59
RTS-9.09	0.047	1.8	1.001	1.8
RTS-12.09	0.135	6.25	2.692	6.25
RTS-3.10	0.571	29.88	1.736	29.88
RTS-6.10	0.757	21.87	1.281	21.87
RTS-9.10	0.788	24.18	1.239	24.18
RTS-12.10	0.671	23.89	1.454	23.89
RTS-3.11	0.712	25.95	1.379	25.95
RTS-6.11	0.788	29.49	1.256	29.49
RTS-9.11	0.635	26.57	1.549	26.57
RTS-12.11	0.653	-26.86	1.508	-26.86

Table 5: Values of coefficients b_0 and c_0 and corresponding t-statistics, 30 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.266	7.99	2.133	7.99
RTS-3.08	0.255	9.9	2.788	9.9
RTS-6.08	0.442	12.54	1.908	12.54
RTS-9.08	0.421	23.16	2.331	23.16
RTS-12.08	0.255	5.99	1.496	5.99
RTS-3.09	0.952	2.54	0.0878	2.54
RTS-6.09	0.12	3.26	1.118	3.26
RTS-9.09	0.0593	3.69	2.829	3.69
RTS-12.09	0.219	9.08	2.758	9.08
RTS-3.10	0.653	27.6	1.513	27.6
RTS-6.10	0.657	28.4	1.504	28.4
RTS-9.10	0.793	40.11	1.257	40.11
RTS-12.10	0.591	22.44	1.639	22.44
RTS-3.11	0.738	26.72	1.334	26.72
RTS-6.11	0.709	26.06	1.386	26.06
RTS-9.11	0.677	38.16	1.471	38.16
RTS-12.11	0.705	-38.34	1.412	-38.34

Table 6: Values of coefficients b_0 and c_0 and corresponding t-statistics, 24 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.052	2.1	1.113	2.1
RTS-3.08	0.287	11.53	2.795	11.53
RTS-6.08	0.384	10.4	1.932	10.4
RTS-9.08	0.382	12.89	2.236	12.89
RTS-12.08	0.275	3.23	0.477	3.23
RTS-3.09	0.957	3.58	0.166	3.58
RTS-6.09	0.096	5.25	3.238	5.25
RTS-9.09	0.115	5.58	2.982	5.58
RTS-12.09	0.670	29.34	1.478	29.34
RTS-3.10	0.605	27.14	1.63	27.14
RTS-6.10	0.653	26.98	1.512	26.98
RTS-9.10	0.671	28.88	1.472	28.88
RTS-12.10	0.774	14.24	1.099	14.24
RTS-3.11	0.684	21.42	1.407	21.42
RTS-6.11	0.677	27.32	1.456	27.32
RTS-9.11	0.610	24.35	1.601	24.35
RTS-12.11	0.745	-38.84	1.338	-38.84

Table 7: Values of coefficients b_0 and c_0 and corresponding t-statistics, 18 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.239	9.21	2.785	9.21
RTS-3.08	0.247	8.41	2.443	8.41
RTS-6.08	0.292	9.04	2.234	9.04
RTS-9.08	0.264	15.03	3.449	15.03
RTS-12.08	0.164	6.1	2.394	6.1
RTS-3.09	2.403	7.58	0.221	7.58
RTS-6.09	0.202	9.02	3.218	9.02
RTS-9.09	0.131	6.73	3.463	6.73
RTS-12.09	0.702	37.18	1.419	37.18
RTS-3.10	0.696	24.32	1.407	24.32
RTS-6.10	0.646	30.1	1.532	30.1
RTS-9.10	0.672	29.36	1.471	29.36
RTS-12.10	0.665	27.43	1.482	27.43
RTS-3.11	0.599	33.81	1.66	33.81
RTS-6.11	0.706	26.98	1.395	26.98
RTS-9.11	0.688	46.8	1.451	46.8
RTS-12.11	0.664	-36.19	1.498	-36.19

Table 8: Values of coefficients b_0 and c_0 and corresponding t-statistics, 12 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.208	6.91	2.262	6.91
RTS-3.08	0.212	5.87	1.743	5.87
RTS-6.08	0.431	16.61	2.175	16.61
RTS-9.08	0.328	13.04	2.625	13.04
RTS-12.08	0.111	5.4	2.913	5.4
RTS-3.09	6.940	8	0.082	8
RTS-6.09	0.137	6.78	3.339	6.78
RTS-9.09	0.065	2.39	1.135	2.39
RTS-12.09	0.637	36.95	1.563	36.95
RTS-3.10	0.770	34.76	1.292	34.76
RTS-6.10	0.770	25.88	1.275	25.88
RTS-9.10	0.709	34.62	1.403	34.62
RTS-12.10	0.696	27.28	1.416	27.28
RTS-3.11	0.693	33.84	1.434	33.84
RTS-6.11	0.677	26.2	1.450	26.2
RTS-9.11	0.606	28.82	1.630	28.82
RTS-12.11	0.677	-27.77	1.457	-27.77

Table 9: Values of coefficients b_0 and c_0 and corresponding t-statistics, 6 days to expiration

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.087	2.77	1.139	2.77
RTS-3.08	0.284	8.63	2.186	8.63
RTS-6.08	0.437	14.16	2.039	14.16
RTS-9.08	0.341	14.93	2.668	14.93
RTS-12.08	0.267	6.02	1.438	6.02
RTS-3.09	2.771	6.06	0.140	6.06
RTS-6.09	0.079	2.05	0.704	2.05
RTS-9.09	0.330	5.28	0.946	5.28
RTS-12.09	0.737	24.33	1.329	24.33
RTS-3.10	0.592	23.34	1.648	23.34
RTS-6.10	0.644	19.44	1.470	19.44
RTS-9.10	0.695	26.6	1.416	26.6
RTS-12.10	0.771	35.64	1.290	35.64
RTS-3.11	0.787	15.8	1.134	15.8
RTS-6.11	0.669	20.46	1.429	20.46
RTS-9.11	0.706	35.57	1.408	35.57
RTS-12.11	0.764	-32.44	1.298	-32.44

Table 10: Values of coefficients b_0 and c_0 and corresponding t-statistics, on expiration day

Contract	b_0	t-stat	c_0	t-stat
RTS-12.07	0.289	8.53	2.120	8.53
RTS-3.08	0.751	13.92	1.180	13.92
RTS-6.08	0.255	5.49	1.304	5.49
RTS-9.08	0.204	4.9	1.353	4.9
RTS-12.08	0.192	7.14	2.565	7.14
RTS-3.09	0.518	3.71	0.328	3.71
RTS-6.09	0.321	3.87	0.569	3.87
RTS-9.09	0.547	8.21	1.070	8.21
RTS-12.09	0.644	10.12	1.051	10.12
RTS-3.10	1.387	10.52	0.506	10.52
RTS-6.10	0.876	11.12	0.817	11.12
RTS-9.10	0.870	10.54	0.784	10.54
RTS-12.10	1.139	11.06	0.626	11.06
RTS-3.11	0.813	14.55	1.059	14.55
RTS-6.11	1.263	13.65	0.658	13.65
RTS-9.11	1.034	12.34	0.753	12.34
RTS-12.11	0.703	-33.36	1.412	-33.36