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Analysis of the Russian Stock Market Performance at the Pre-Crisis Period October 1997- August 1998

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The subject of this study is analysis of the Russian financial market (short-term treasure bills – GKO, and stock market – RTS) during the one-year pre-crisis period. We analyze the relations between one-day return for the two segments of the Russian financial market and world financial market (Dow Jones index).

It was shown that Russian stock market return cause the GKO market, and changes in DJ returns cause the changes in RTS returns. A model for the GKO daily returns was designed. Lagged values of RTS and DJ returns are included into the model. The analysis of the model shows that there was a structural break at the Russian financial market at the mid-June. This could be interpreted as a signal of the future market crush on August 18, 1998.

Гробман И.З., Пересецкий А.А. Российский фондовый рынок в предкризисный период октябрь 1997 – август 1998. / Препринт # 99/011. – М.: Российская экономическая школа, 1999. – 26с. (Англ.)

Целью работы является анализ российского финансового рынка (ГКО, фондовый ры-нок–РТС) в предкризисный период. Анализируется связь однодневных доходностей сегментов Российского финансового рынка и международного финансового рынка (индекс Доу-Джонса).

Показано, что рынок корпоративных ценных бумаг в значительной степени влиял на рынок ГКО. С другой стороны, международный финансовый рынок оказывал влияние на рынок корпоративных ценных бумаг. Из анализа модели однодневных доходностей рынка ГКО в зависимости от рынка рынок корпоративных ценных бумаг и индекса Доу-Джонса показано, что в середине июня 1998 г. произошла структурная перестройка рынка, что можно интерпретировать, как сигнал будущего кризиса 18 августа 1998 г.

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1. Introduction

There exist a significant number of studies devoted to the nature and origins of stock market crashes. This literature mainly investigates the crash of fall 1987 when on October 19, 1987 the Standard & Poor's composite portfolio fell from 282.70 to 224.84 (20.4 percent) and the Dow Jones Industrial Average fell from 2246 to 1738 (23 percent).

The first stream in this literature is the studies of behavior of small experimental groups of traders in the controlled environment. The paper of Smith, Shushanek, and Williams (1988) represents this approach. The main results of this study are that the probability of the speculative bubbles is reducing but not eliminating with the growth of the traders’ experience.

Another view on the sources of crashes is represented by the paper of Black (1998). According to it the main source of the crisis was the dynamic strategy of the part of investors and so-called noise trading which is trade on noise as if it were news. An example here would be buying stock on news that has already been discounted in the price, assuming the unfamiliarity of the fact of discount to the buyer.

A further development of this research can be met in Genotte and Leland (1990). The authors show that information differences among market participants can cause financial markets to be relatively illiquid. A small unobserved supply shock can create a large fall in prices. This happens because the fall in prices affects investors' expectations as well as their budgets. The authors also demonstrates that traditional models which do not recognize that many investors are poorly informed will grossly overestimate the liquidity of stock markets.

The similar problems but in a more rigorous mathematical way are treated in Bulow and Klemperer (1994) where the proof of the extreme sensitiveness of financial markets to new information is provided and the consequences of such sensitiveness, in the form of both «frenzies» in which demand feeds on itself, and «crashes» in which price drops discontinuously, are treated.

According to the article *Stock Market Crashes* by A. Kleidon (1995) in R. Jarrow, V. Maksimovic and W. Ziemba, (1995), eds. *Handbooks in Operations Research and Management Science,* vol.9, *Finance.1995*

There exist three potential explanations of stock market crashes:

1. Prices are the present value of the future cash flows. Therefore, crash corresponds to new information about either future cash flows (earning or dividends) or discount rate.
2. Prices tend to converge to the predictions of rational expectations models but natural changes in the trading environment can lead to periods during which the conditions for aggregating diverse information and achieving the fully revealing REE (rational expectations equilibrium) are violated. This can be illustrated by the example when the investors no longer have common knowledge about other traders' beliefs or preferences. This initially results in deviations from the REE that would obtain in the presence of common beliefs, which lead to an abrupt change in stock price.
3. Another view is that stock market crashes can only be explained in term of capricious changes on worldview at the individual level. (So, irrational or non-rational assumption)

As it can be seen further in the paper, the most appropriate way of explanation of the Russian stock market crash is some combination of all these interpretations.

The main purpose of this work is to study the general characteristics of the Russian stock market in the one-year period before the crisis as well as to identify factors which influenced on the main market indicators and to verify the quantitative measure of this influence and the degree of interaction between different segments of the stock market The first part of this paper is devoted to the political and economical background of changes in the GKO returns behavior. Then the determination of order of integration of explanatory variables and variables to be explained is provided and the appropriate autoregressive distributed lag models are constructed. Finally, the new indexes are derived from the existing ones and the volatility examination as well as the rolling regression analysis is provided to prove the hypotheses of market efficiency and market participants' rationality.

1.1. Data

The data to be analyzed are presented by the Economic Expert Group of Ministry of Finance of Russian Federation and Alexander Ivanter, (Expert weekly).

The data are:

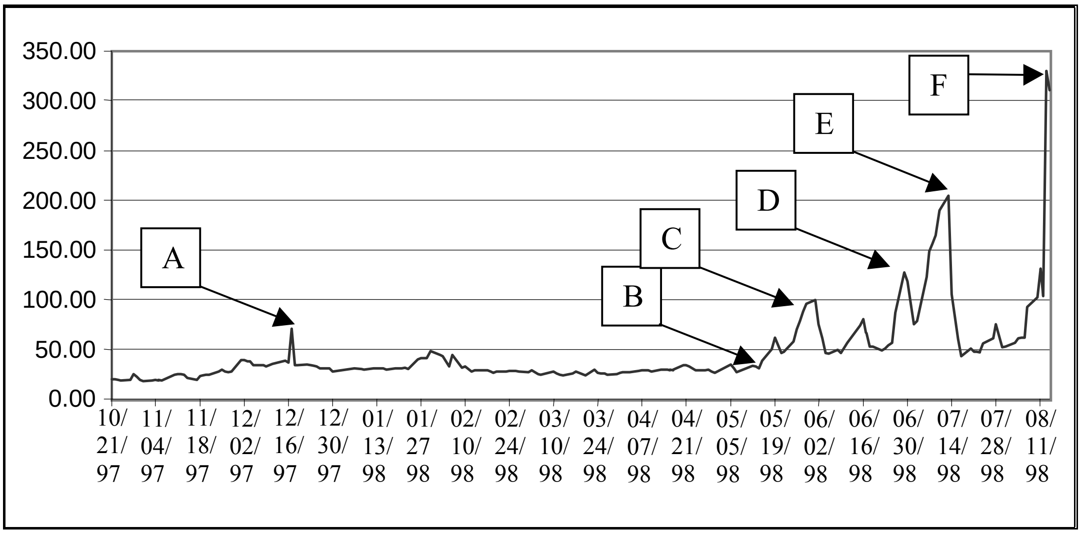
1. GKO rates.
2. RTS index.
3. DJ Industrial 30.
4. FTSE index.
5. DAX index.

The index of most interest for this study is GKO rates because of their importance as the mean of interest rate control via open market operations and, especially, as the main source of financing the budget deficit. The importance of such non-inflationary source of budget deficit financing as domestic and foreign borrowing increased gradually since 1993 and till the August 1998.

2. Data analysis

Annualized GKO returns to maturity in October 1997 - August 1998, calculated by Expert weekly, are presented at the Fig.1.

Fig 1. Annualized GKO returns in October 1997 – August 1998



The graph shows two periods of rather different behavior- before May 15, 1998 (point B on the graph) with comparatively low returns and low volatility and after this date with relatively large returns and high fluctuations. As it can be seen, the period of high instability, which was finished by the crash, lasted exactly 3 months and some explanations for this will be given further.

The following background takes place for the crucial points highlighted on the graph and the periods delimited by them:

The first stage of the Russian crisis, which began in November 1997, had moderate form and was due to financial crushes in SouthEastern Asia and aspirations of some part of investors to fix profit in the emerging markets. Pike A on the graph can be explained as an indicator of the end of year when managers close positions in order to confirm the expediency of investment limits.

Point C on the graph with annualized GKO return equal to 99.9% corresponds to June 1, 1998. At this time rating agency Moody’s downgraded Russia's long-term foreign debt rating from Ba3 to B1, and the country ceiling for foreign currency bank deposits from B1 to B2. The agency said it had also assigned a rating of B2 to medium-term ruble-denominated bonds and a rating of Not Prime to short-term Russian government debt, including GKO T-bills. Moody's, after reducing Russia's credit rating, has downgraded ratings for nine Russian commercial banks. A report from the agency says that the changes were made to reflect the downgrade in the sovereign rating. Long-term ratings have been cut from B1 to B2 for Alfa-Bank, Alba-Alyans, Avtobank, Menatep, The National Reserve Bank, Rossiisky Credit, SBS-Agro, Unexim Bank and Vneshtorgbank. Moody's also announced plans to downgrade a number of other bank ratings. The agency planed to look at bank financial strength ratings held by Alfa-Bank (at that time, D), Alba-Alyans (D), Avtobank (D), Menatep (D), The National Reserve Bank (E+), Unexim Bank (D) and Vneshtorgbank (D), as well as debt ratings for a number of companies on debts guaranteed by these banks.

The tendency of GKO T-bills for the further returns growth was reversed after the promise of the U.S. President Bill Clinton to help Russia in receiving additional financial aid from supranational financial organizations, as it was reported by Bloomberg by citing a statement from Clinton. The statement was issued as a continuation of the telephone conversation between Clinton and Russian President Boris Yeltsin. They discussed the chances for emergency aid for Russia, comparable in size to the support given by the International Monetary Fund at the end of 1997 to Thailand, Indonesia and South Korea. At the end of 1997, the IMF undertook to offer the three countries a total of $114.2 billion: of which $14.5 billion for Thailand, $40 billion for Indonesia and $57 billion for South Korea.

The next point, which is D, June 26, 1998, refers to the rate of 127% annualized GKO returns. The Central Bank of Russia has decided to raise the refinancing rate from 60% to 80% annualized starting on June 29, 1998, the bank's department for public relations said in a press release. The rate on existing agreements remained the same. The refinancing rate was last changed on June 5, 1998 when it was slashed from 150% to 60% annualized. (During the second stage of the crisis, the Central Bank of Russia began the correction of the situation in the financial markets on May 19, 1998, when the refinancing rate was raised from 30% to 50%. The next correction took place on May 28, 1998 - the refinancing rate was raised from 50% to 150% (it was the highest jump since 1992) but the situation remained untreated.)

On Monday, June 29, 1998 blue chips posted heavy losses on the Russian corporate securities market. The main decline in quotations came at the start of the trading session and was a reaction by the market to the rise in the Central Bank of Russia's refinancing rate since June 29, 1998. During the day, Russian share prices continued to fall, although at an insignificant rate. Market players said that the main reason for the decline was still the lack of confidence on the part of investors in the ability of the Russian government to implement the measures necessary to recover from crisis. Many investors were passive, awaiting the end of talks between the IMF and the Russian government regarding the provision of a stabilization loan. Trade volume was low at less than $26.7 million on the Russian Trading System.

The point E corresponds to the rate of annualized returns 205% and took place on July 13, 1998. Standard & Poor's has lowered the issuer credit ratings of six Russian banks. The agency said in a press release the ratings for Inkombank, Vozrozhdeniye and SBS-Agro fell from B+/Negative to B/Negative, those for Alba-Alliance and Rossiysky Credit from B/Negative to B-/Negative, and that for Alfa Bank from B/CWNeg to B-/Negative. It revised Eurobond ratings for three Dutch-registered Russian bank subsidiaries: SBS-Agro Finance B.V. from "B+" to B, Rossiyskii Credit Securities B.V. from B to B-, and AlfaFinance B.V. from B/CW to B-.

2.1. Determination of the order of integration.

Checking the GKO returns to maturity annualized for the unit roots we have the following results (calculations are provided in PcGive package):

Critical values: 5%=-1.941 1%=-2.576

	t-adf	σ	*lag*	*t-lag*	*t-prob*
GKO	.71146	19.863	2	1.7607	0.0798
GKO	.98678	19.968	1	-1.3338	0.1838
GKO	.49373	20.008	0		

For the first differences the unit root test gives the following results:

Critical values: 5%=-1.941 1%=-2.576

	t-adf	σ	*lag*	*t-lag*	*t-prob*
DGKO	-5.4864**	19.905	2	0.8157	0.4157
DGKO	-6.0325**	19.888	1	-1.889	0.0604
DGKO	-15.064**	20.018	0		

From the results above one can see that GKO returns followed the I(1) process. Augmented Dickey-Fuller test for unit roots show that levels of RTS, DJIA, FTSE, DAX indexes follow the I(1) processes and returns on RTS, DJIA, FTSE, DAX indexes defined according the formula of M. Rockinger and G. Urga (1997):

$$Return\_on\_index(t) = 100 * \log\left(\frac{index(t)}{index(t-1)}\right) \tag{1}$$

are stationary processes. Test statistics can be seen in Attachment 4.

2.2. AR representation.

Consider the autoregressive model for GKO returns to maturity annualized:

$$GKO_t = \beta_0 + \sum_{k=1}^{L} \beta_k GKO_{t-k} + \varepsilon_t \tag{2}$$

The general form, which includes L=20 lags was constructed and tested. Only lags 1 and 2 are significant at 5% level and test statistics were the following:

R-sq. = 0.783704 F(20, 161) = 29.168 [0.0000] = 20.7698 DW = 2.01
RSS = 69452.62565 for 21 variables and 182 observations
AR 1- 2 F(2,159) = 0.90339 [0.4073]
ARCH 1 F(1,159) = 0.0022629 [0.9621]
Normality Chi^2 = 727.8 [0.0000] **
χ^2 F(40,120) = 0.7937 [0.7970]
RESET F(1,160) = 0.0088916 [0.9250]

Tests show relatively good form of this model, but the model is not parsimonious and has poor explanatory power. Consequently eliminating insignificant regressors we can finish by the reduced form (L=2):

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-pro*	*PartR-sq.*
Constant	1.5776	2.8087	0.562	0.5750	0.0018
GKO (-1)	0.9203	0.0747	12.320	0.0000	0.4589
GKO (-2)	0.0824	0.0898	0.918	0.3597	0.0047

R^2 = 0.756177 F(2, 179) = 277.57 [0.0000] σ= 20.9137 DW = 1.99
RSS = 78291.61465 for 3 variables and 182 observations.
AR 1- 2F(2,177) = 1.6299 [0.1989]
ARCH 1 F(1,177) = 0.0169 [0.8967]
Normality Chi^2 = 445.84 [0.0000] **

χ^2 F(4,174) = 4.8944 [0.0009] **
Xi*Xj F(5,173) = 3.9442 [0.0021] **
RESET F(1,178) = 4.6412 [0.0326] *

which is obviously misspecified. The splitting into two or more series and considering them as well as considering differences do not help to solve the problem. The possible way to treat this problem is to use asymmetric GARCH (1,1) estimates as in M. Rockinger and G. Urga (1997).

Modeling the GKO returns via lagged GKO and lagged daily continuously compounded return on an stock index we have the following results (here the R_RTS is daily return on the RTS (Russian Trade System) index, defined according to the formula (1) above):

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob.*	*Part. R-sq.*
Constant	10.198	8.9744	1.136	0.2607	0.0225
GKO (-1)	0.9019	0.0924	9.753	0.0000	0.6295
R_RTS (-2)	-1.8797	0.84714	-2.219	0.0306	0.0808

R^2 = 0.645418 F(2, 56) = 50.966 [0.0000] σ = 34.608 DW = 2.18
RSS = 67072.08619 for 3 variables and 59 observations
AR 1- 2 F(2, 54) = 0.47329 [0.6255]
ARCH 1 F(1, 54) = 0.0037278 [0.9515]
Normality Chi^2 = 76.137 [0.0000] **
χ^2 F(4, 51) = 1.6513 [0.1758]
Xi*Xj F(5, 50) = 1.3052 [0.2769]
RESET F(1, 55) = 0.098795 [0.7545]

which show the greater appropriateness of this model (model is well specified and residuals can be assumed as a white noise). Returns on the Dow Jones indexes are insignificant up to the 5-th lag (in the initial model all the variables were considered up to 5-th lag, and elimination of insignificant regressors led to the parsimonious form above).

We analyzed the volatility of the Russian financial market in the framework of the following model:

$$GKO_t = \beta_0 + \sum_{k=1}^{K} \beta_k GKO_{t-k} + \sum_{l=1}^{L} \gamma_l R\_RTS_{t-l} + \varepsilon_t \qquad (3)$$

Consideration of volatility (i.e. conditional standard deviation (CSD) of error term in (3)) gives another, more powerful way of visual analysis. Optimal model of this type (3) contains lagged GKO returns, and the second lags of the returns on RTS and the first lag of DJIA indexes (R_RTS is the return on the RTS index, R_DJIA is the return on the DJIA index defined according to the formula (1) above):

(Estimation of the equation (3) with GARCH(1,1) model for the error term gave the following results (here and further regression analysis is provided in Econometric Views).

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	3.456783	0.156420	22.09936	0.0000
GKO(-1)	0.874828	0.003398	257.4571	0.0000
R_RTS(-2)	-0.26772	0.019605	-13.65599	0.0000
R_DJIAJ(-1)	0.186973	0.064820	2.884477	0.0044

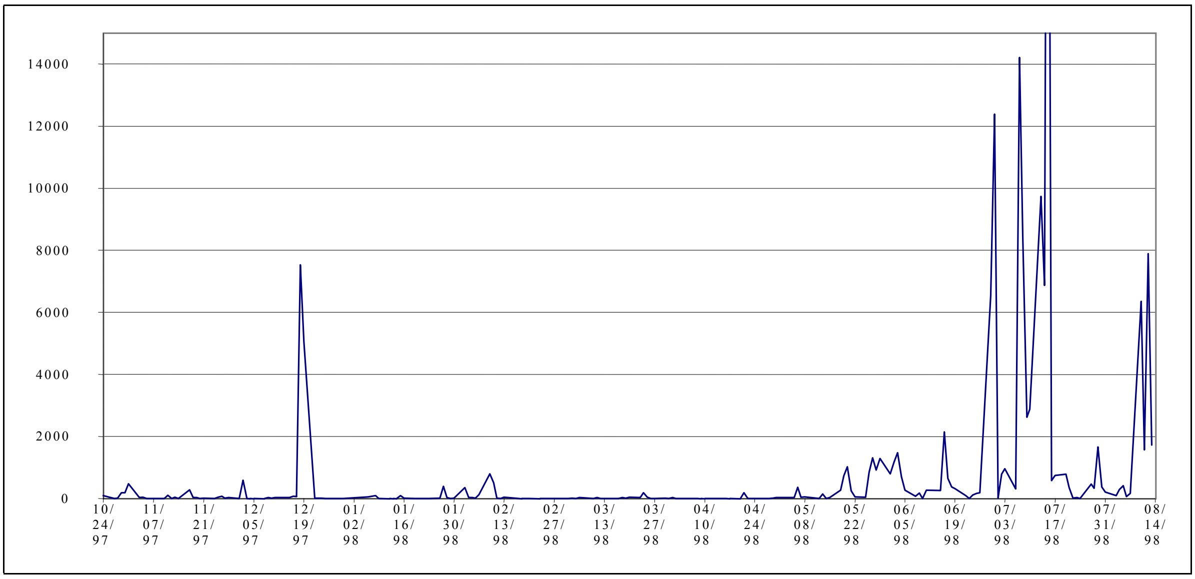
Variance Equation

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	2.33206	0.479952	4.858954	0.0000
ARCH(1)	5.52508	0.346207	15.95892	0.0000

R-squared	0.68843	F-statistic	84.84809
Durbin-Watson stat	1.265133	Prob(F-statistic)	0.000000

The graph of conditional standard deviation in this GARCH(1,1) regression (see Fig.2) shows precise correspondence of periods of high volatility to the points considered on Fig 1.

Fig. 2. Conditional standard deviation.



From the equation above one can see that one day lagged GKO and DJIA returns and two days lagged RTS returns have statistically significant predictive power for the GKO returns. Due to the difference in time zones, one-day lag in DJIA corresponds approximately to 1.5 days lag in RTS. At the period under consideration volume of operation volume of trading at the RTS market was higher than at GKO market, so it seems natural, that the biggest in volume market leaded.

For more detailed study of causality relations for the markets indices, it is possible to consider the Granger causality tests.

2.3 Granger causality tests and returns convergence.

Considering interactions of the daily returns on GKO index of Rinaco and daily returns on main world stock indexes and applying pairwise Granger Causality Tests, we have got the following results:

(Return on *index* is denoted as *R_index*)

Pairwise Granger Causality Tests

Null Hypothesis	*Obs*	*F-Statistic*	*Probability*
R_RTS does not Granger Cause R_GKO	198	7.05369	0.00111
R_GKO does not Granger Cause R_RTS		1.27231	0.28252
R_DJIA does not Granger Cause R_GKO	198	0.49460	0.61058
R_GKO does not Granger Cause R_DJIA		0.95040	0.38839
R_FTSE does not Granger Cause R_GKO	190	1.07814	0.34235
R_GKO does not Granger Cause R_FTSE		0.58254	0.55950
R_DAX does not Granger Cause R_GKO	190	0.36021	0.69802
R_GKO does not Granger Cause R_DAX		0.41812	0.65891
R_DJIA does not Granger Cause R_RTS	198	10.2539	5.9E-05
R_RTS does not Granger Cause R_DJIA		1.18777	0.30712
R_FTSE does not Granger Cause R_RTS	190	0.42281	0.65583
R_RTS does not Granger Cause R_FTSE		0.46774	0.62715
R_DAX does not Granger Cause R_RTS	190	2.35082	0.09813
R_RTS does not Granger Cause R_DAX		0.54793	0.57908

It worth to note that Granger causality test applied to the levels of indexes considered demonstrates the lower degree of interaction between the variables taken into account (see Attachment 5). The possible conclusion here is that the hypotheses of no influence of R_RTS on R_GKO and R_DJIA on R_RTS should be rejected. At the same time, tests do not indicate direct influence of R_DJIA on R_GKO – only via Russian Trade System. Another appropriate way to consider the possible influence of R_DJIA on returns on GKO index is to examine arbitrage condition. According to Peresetsky and Ivanter (1998), the rate of returns convergence can be defined as the parameter μ in equation

$$\Delta X(t) = const + \mu X(t-1) + u(t), \quad \text{where}$$

$$X(t) = (R\_index1 - R\_index2) \tag{4}$$

OLS-estimation for this equation in the case when *X(t) = R_GKO – R_DJIA* gives the following results:

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.108529	0.143333	-0.757180	0.4498
X(-1)	-0.885809	0.075374	-11.75224	0.0000

R-squared	0.412142	F-statistic	138.1152
Durbin-Watson stat	1.891898	Prob(F-statistic)	0.000000

and it can be inferred that R_DJIA affects returns on GKO index.

The value $\mu \approx 0.89$ is close to the values of the parameter obtained by Peresetsky and Ivanter (1998) for the pair of long and short GKO markets and for the pair of interbank and over-the-counter currency markets. Both estimations are made for the relatively stable period October 1996 – October 1997 of the Russian financial market. The values 0.75–0.8 corresponds at that period to the markets which are not highly related each other.

The same procedure for the case $X(t) = R\_RTS - R\_DJIA$ leads to the following estimation:

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.139193	0.428181	-0.325079	0.7455
X(-1)	-1.313808	0.225165	-5.834858	0.0000

R-squared	0.147354	F-statistic	34.04557
Durbin-Watson stat	2.984010	Prob(F-statistic)	0.000000

The absolute value of μ in the second case is statistically higher. It is possible to figure out that GKO market shows less degree of integration with main world stock markets then Russian corporate stock market, but indirect influence could serve as an appropriate indicator of structural changes in the behavior of index to be examined.

GARCH(1,1) estimations and the graphs of conditional heteroscedasticity can be seen in Attachments 6 and 7 correspondingly. Because of less degree of regulating authority intervention in the Russian Trade System than on the GKO market, the former market showed the higher rapidity of reaction on the external shocks, the latter market demonstrated the greater sluggishness.

2.4 Structural changes.

Considering the most parsimonious and appropriate GARCH(1,1) representation for the R_GKO obtained, that is

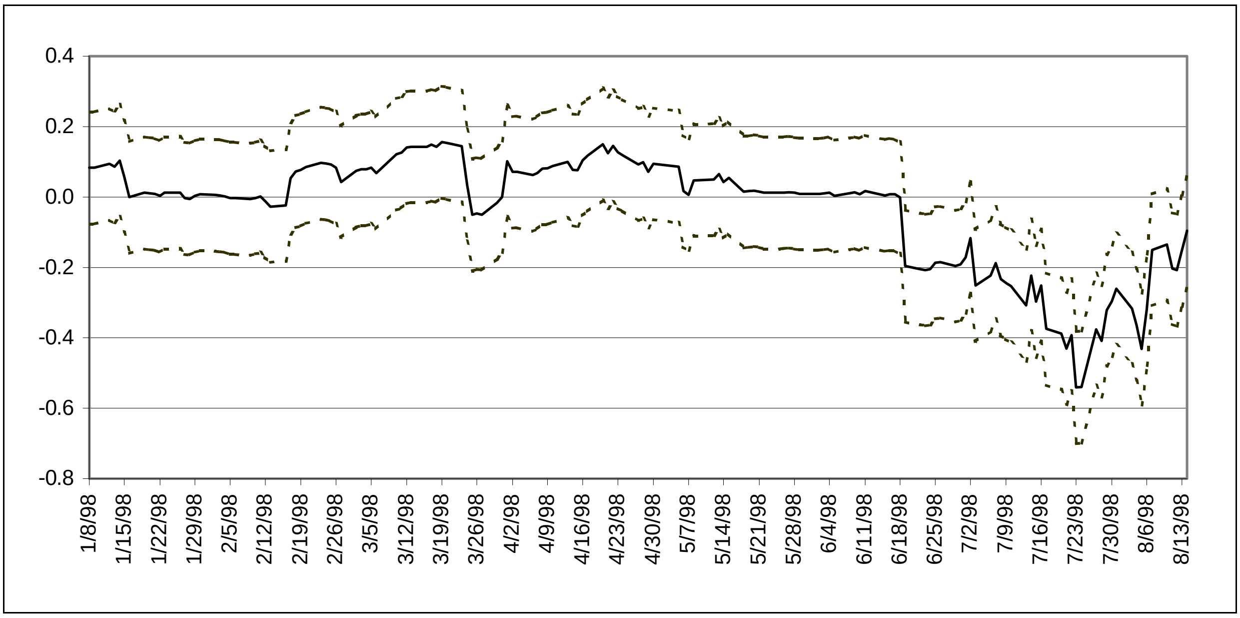
$$R\_GKO(t) = const + \alpha R\_RTS(t-1) + \beta R\_RTS(t-2) + \chi R\_DJIA(t-1) + \varepsilon(t) \tag{5}$$

with the corresponding estimation output

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Const	0.067953	0.049982	1.359569	0.1756
R_RTS(-1)	0.039649	0.010626	3.731291	0.0003
R_RTS(-2)	0.035683	0.011600	3.076091	0.0024
R_DJIA(-1)	0.108884	0.036863	2.953717	0.0035
Variance Equation				
C	-0.000107	0.004661	-0.022888	0.9818
ARCH(1)	0.321701	0.064846	4.960977	0.0000
GARCH(1)	0.825718	0.031535	26.18451	0.0000

it is possible to study the behavior of the coefficient at R_DJIA(-1) over time in the rolling GARCH(1,1) regression. Procedure, created in Econometric Views, allowed this kind of estimation and the outcome is the following (window size of rolling regression is 50):

Fig. 3. Evolution of the coefficient at R_DJIA(-1) over time in the rolling GARCH for the R_GKO.



The structural break takes place approximately two months before crash. Before the break the coefficient χ is insignificant (the dotted lines represent 95% confidence boundaries for χ) and at the period before the crash χ became significantly negative. Negative influence of R_DJIA as a regressor at the latter stage can be explained as a consequence of self-fulfilling nature of expanding crash – the “better” are the news outside, the “worse” is the situation. It worth to note that time trend included is insignificant for the both periods, so the explanation of negative influence of R_DJIA as a consequence of its spuriousity is inappropriate. The situation when the positive shocks on the Western markets (on the example of UK) are related to negative ones in Russia (on the example of CS First Boston index for Russia, which is capitalization weighted, 30 most liquid stocks are included) was investigated by M. Rockinger and G. Urga (1998). Their findings indicated the decreasing absolute value of the coefficient, represented this negative dependence on the period December 1993 – July 1997. M. Rockinger and G. Urga found that since 1994 when the Russian market appeared to live a life on its own, as this market had been opened, it started to evolve toward a situation of no correlation rather than negative correlation and as can be seen in this work the situation reversed at the beginning of the second stage of the crisis.

To study the process in detail we apply the equivalent procedure for the returns on GKO index for the bills with time to maturity 7–30 days. The result of the rolling GARCH(1,1) regression is presented at the Fig.4.

Results for the same model for returns on GKO with time to maturity greater then 90 days are presented at the Fig.5. The last graph (Fig.5) is comparable to the one at Fig. 3 due to the greater weight of long- term GKO in all issues.

Fig. 4. Evolution of the coefficient at R_DJIA(-1) over time in the rolling GARCH for the R_GKO for the bills with time to maturity 7–30 days.

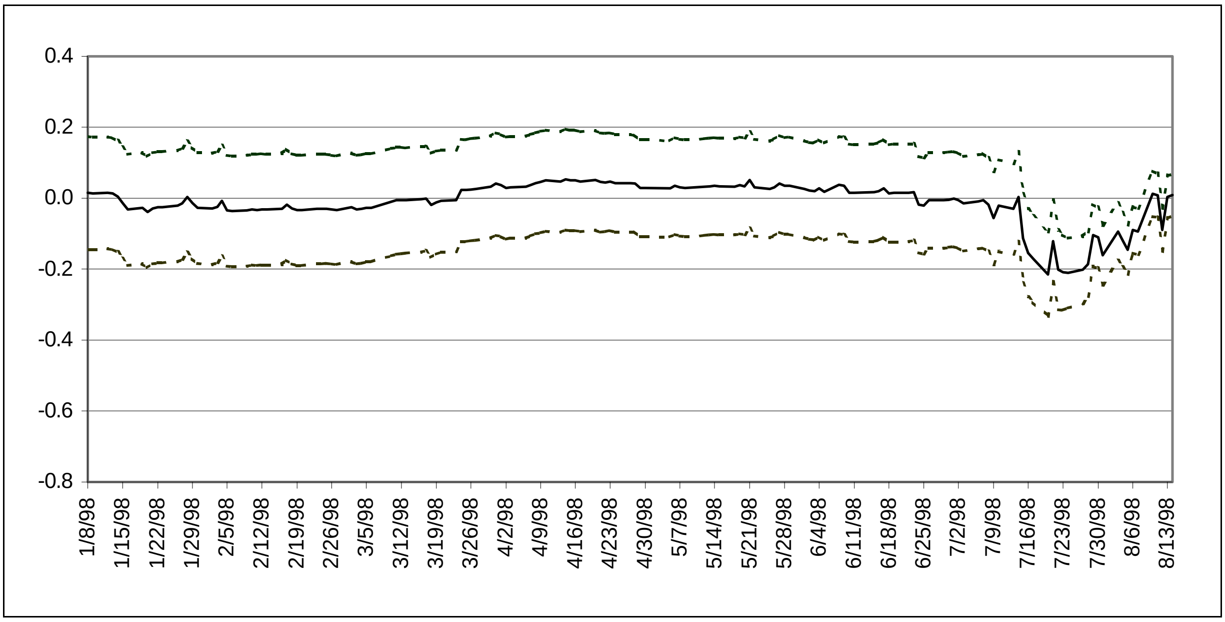
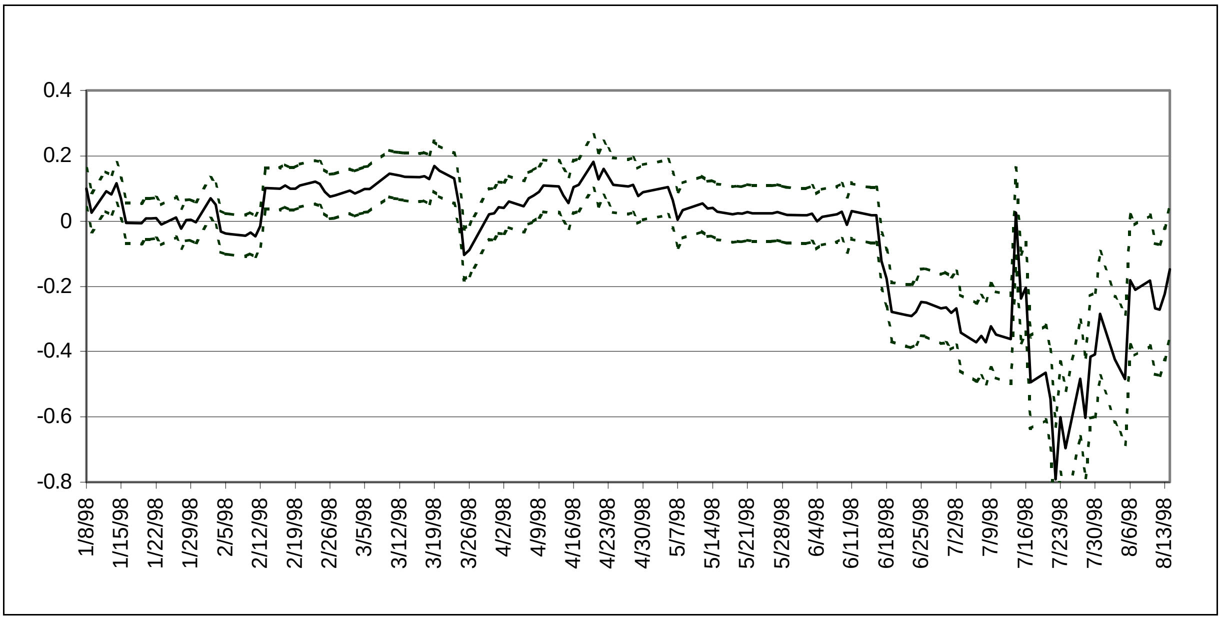


Fig. 5. Behavior of the coefficient at R_DJIA(-1) over time in the rolling GARCH for the R_GKO for the bills with time to maturity more then 90 days.



From the model (5) estimation one can see, that two months before the August 18, 1999 crisis, the structural change in the GKO market was observed. Structure of relations between GKO market on one side and RTS and world stock market on the other side changed significantly. This could be interpreted as following: in the middle of the June 1998, two months before the crisis, market participants could observe some signal about the future crisis.

3. Conclusions.

1. There exists direct influence of returns on DJIA on returns on RTS index and indirect influence of returns on DJIA on returns on GKO index. This effect can be assumed as determination of the returns on the smaller market by the returns on the greater one, therefore the problem of returns management by the regulating authority should be treated in a complex way.
2. The degree of returns convergence (which, according to Peresetsky and Ivanter (1998), is measured by the absolute value of μ coefficient) is higher for the pair R_DJIA – R_RTS than for the pair R_DJIA – R_GKO. This effect can be treated as an evidence for the higher degree of regulation on the GKO market then in Russian Trade System, but the regulation can be assumed effective only in the short-run (until the indirect effect takes place).
3. We should reject the extreme possibility that new information about future cash flows or discount rates reached the market as a whole, thus accounting for the drop in terms of external information about the fundamentals. Furthermore, we should reject another extreme view that the drop has been caused by fads or other irrational behavior. According to the structural changes in influence of R_DJIA in the rolling GARCH regression the participants forecasted perfectly the crash on

the GKO T-bills security market in the short-run (during one month) and less precisely in the long-run (three months). The possible picture of expanding crash is more adequately can be represented as convergence to rational expectation equilibrium.

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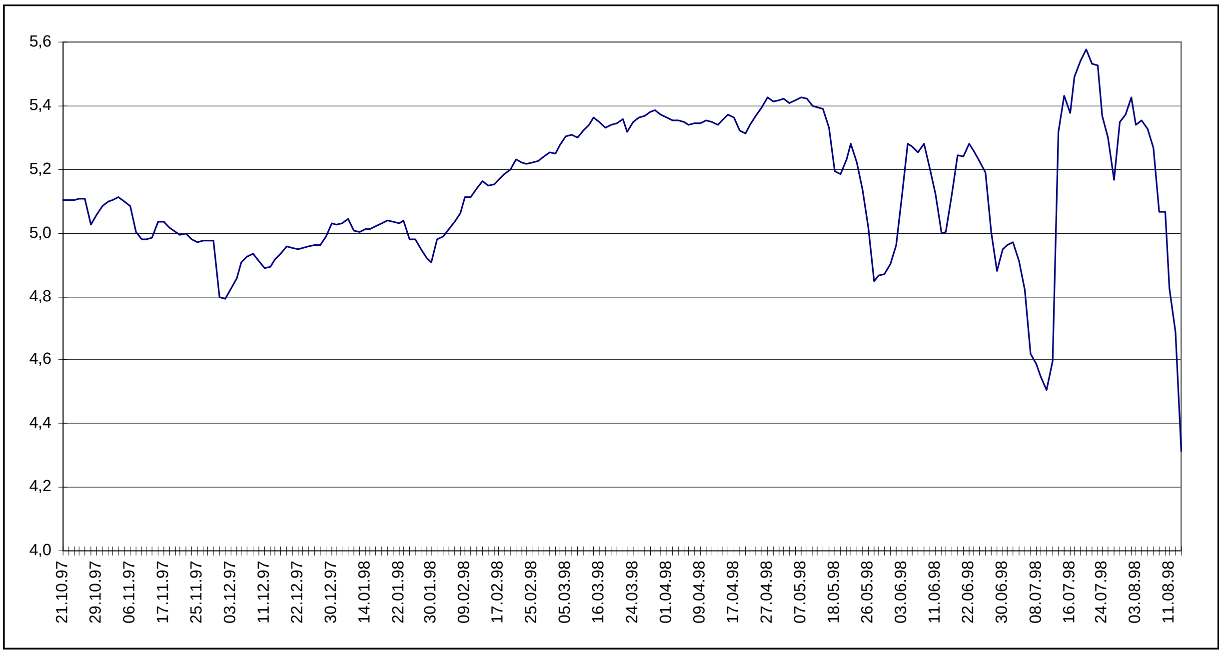
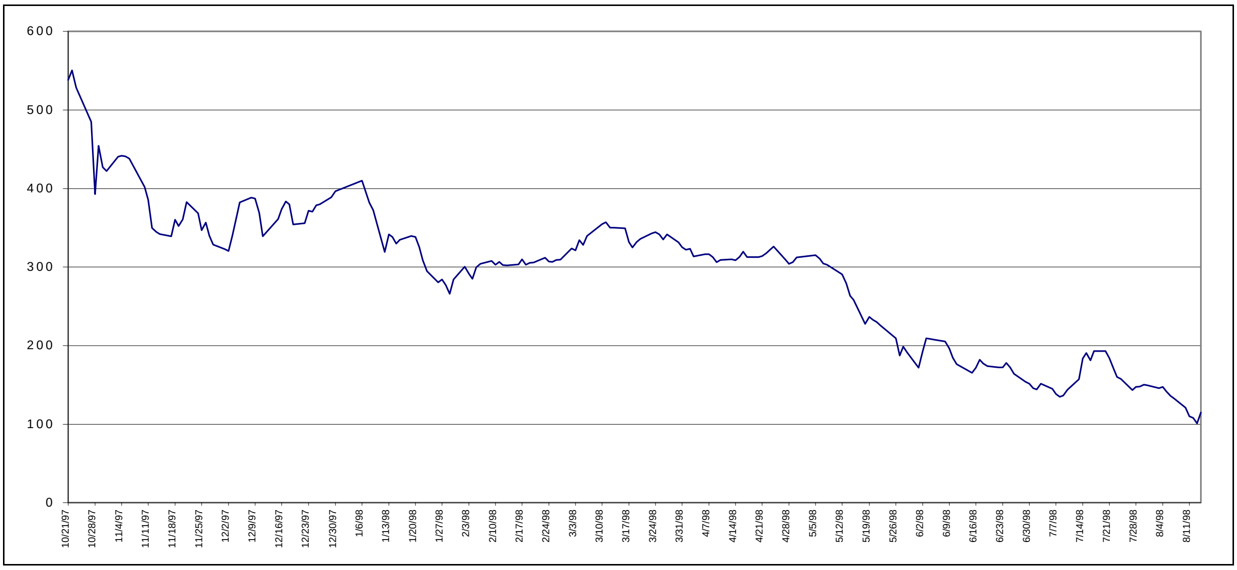
Attachment 1

Fig. 6. GKO index of Rinaco



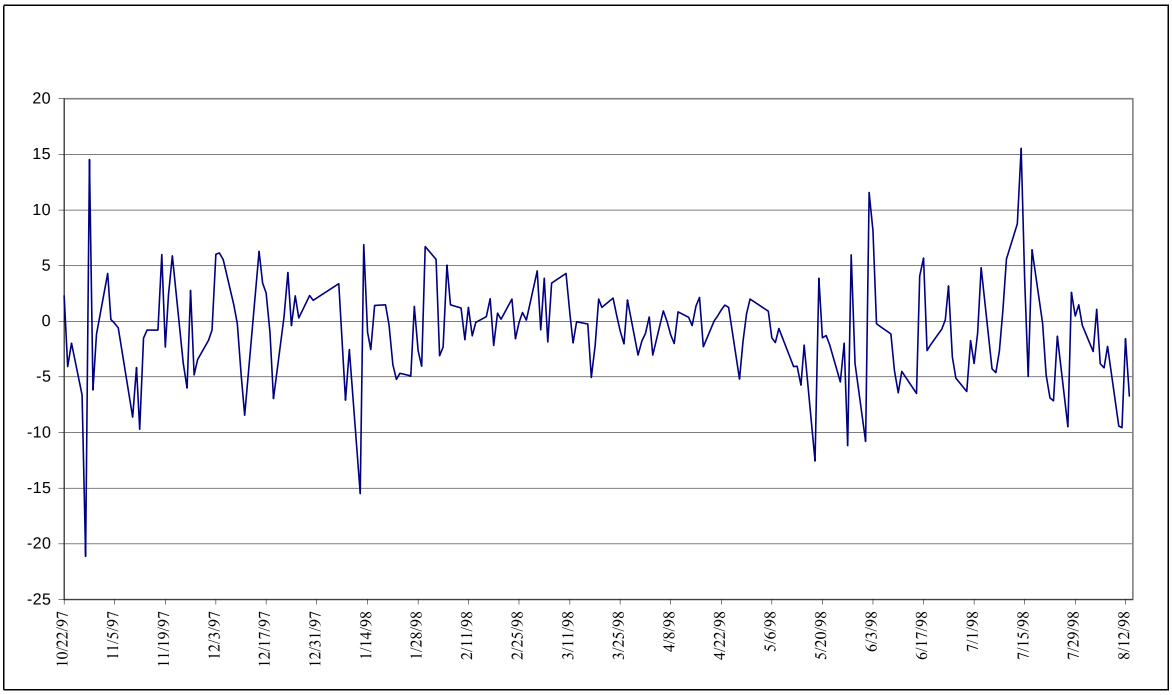
Attachment 2

Fig.7. RTS index



Attachment 3

Fig. 8. Returns on RTS index



Attachment 4

RTS index Augmented Dickey-Fuller test statistics

Rinaco index

ADF Test Statistic	-2.715220	1% Critical Value*	-3.4646
		5% Critical Value	-2.8761
		10% Critical Value	-2.5745

*MacKinnon critical values for rejection of hypothesis of a unit root

Returns on Rinaco index

ADF Test Statistic	-5.9407	1% Critical Value*	3.4651
		5% Critical Value	2.8764
		10% Critical Value	2.5746

DJIA index

ADF Test Statistic	-2.030600	1% Critical Value*	-3.4650
		5% Critical Value	-2.8763
		10% Critical Value	-2.5746

Return on DJIA index

ADF Test Statistic	-9.4121	1% Critical Value*	-3.4648
		5% Critical Value	-2.8762
		10% Critical Value	-2.5745

FTSE index

ADF Test Statistic	-1.326306	1% Critical Value*	-3.4671
		5% Critical Value	-2.8772
		10% Critical Value	-2.5750

Return on FTSE index

ADF Test Statistic	-7.611763	1% Critical Value*	-3.4676
		5% Critical Value	-2.8775
		10% Critical Value	-2.5752

DAX index

ADF Test Statistic	-1.109694	1% Critical Value*	-3.4671
		5% Critical Value	-2.8772
		10% Critical Value	-2.5750

Return on DAX index

ADF Test Statistic	-7.64267	1% Critical Value*	-3.4676
		5% Critical Value	-2.8775
		10% Critical Value	-2.5752

Attachment 5

RTS index Granger causality test (indexes' levels)

Pairwise Granger Causality Tests
Lags: 2

Null Hypothesis:	F-Statistic	Probability
RTS does not Granger Cause GKO	1.77112	0.17288
GKO does not Granger Cause RTS	2.82485	0.06176
DJIA does not Granger Cause GKO	1.41983	0.24426
GKO does not Granger Cause DJIA	1.08789	0.33897
FTSE does not Granger Cause GKO	1.96901	0.14246
GKO does not Granger Cause FTSE	1.89830	0.15268
DAX does not Granger Cause GKO	0.35210	0.70367
GKO does not Granger Cause DAX	0.46257	0.63038
DJIA does not Granger Cause RTS	17.5410	9.9E-08
RTS does not Granger Cause DJIA	1.88229	0.15501
FTSE does not Granger Cause RTS	2.07257	0.12873
RTS does not Granger Cause FTSE	1.13194	0.32460
DAX does not Granger Cause RTS	3.58296	0.02971
RTS does not Granger Cause DAX	2.55544	0.08035
FTSE does not Granger Cause DJIA	11.8158	1.5E-05
DJIA does not Granger Cause FTSE	0.71287	0.49156
DAX does not Granger Cause DJIA	2.30882	0.10219
DJIA does not Granger Cause DAX	7.86926	0.00052
DAX does not Granger Cause FTSE	1.69190	0.18696
FTSE does not Granger Cause DAX	9.7686	9.2E-05

Attachment 6.

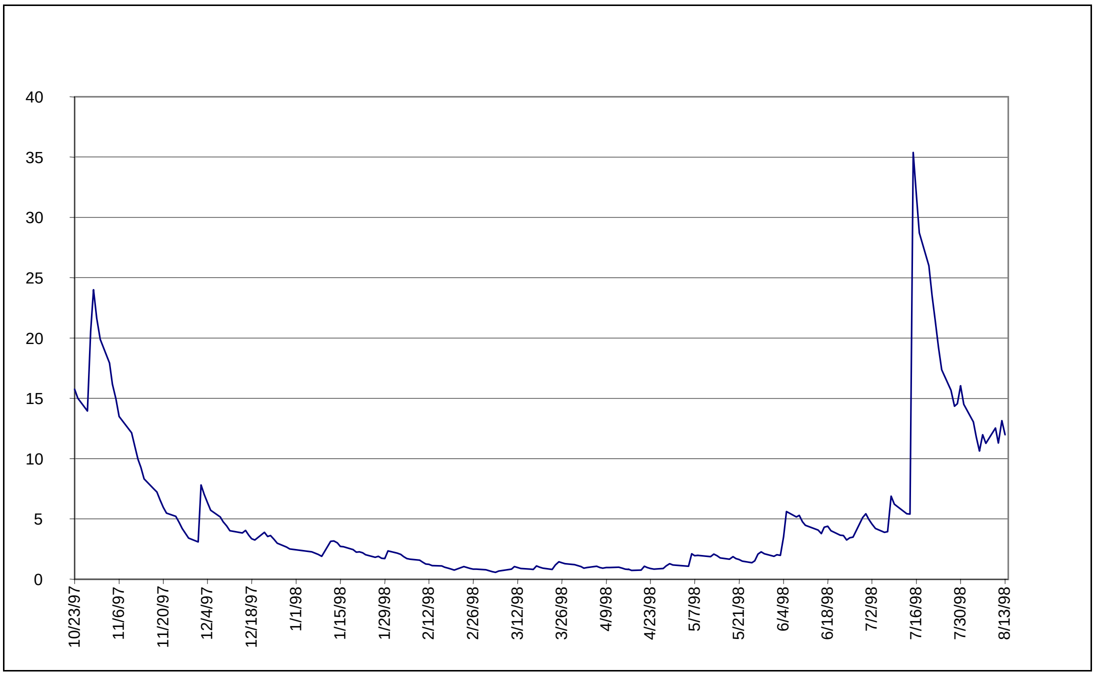
GARCH estimation of arbitrage parameter μ in equation

$$\Delta X(t) = const + \mu X(t-1) + u(t), \quad \text{where} \quad X(t) = R\_GKO(t) - R\_DJIA(t) \qquad (6)$$

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.064843	0.096256	-0.673649	0.5013
X(-1)	-0.990273	0.097992	-10.10568	0.0000
Variance Equation				
C	-0.002335	0.023702	-0.098523	0.9216
ARCH (1)	0.140822	0.024276	5.800824	0.0000
GARCH (1)	0.899278	0.012036	74.71773	0.0000

R-squared	0.406041	Mean dependent var	-0.051253
Adjusted R-squared	0.393794	S.D. dependent var	2.628967
S.E. of regression	2.046893	Akaike info criterion	1.457451
Sum squared resid	812.8159	Schwarz criterion	1.540197
Log likelihood	-390.9127	F-statistic	33.15541
Durbin-Watson stat.	1.694062	Prob(F-statistic)	0.000000

Fig. 9. Conditional standard deviation for the model (6).



Attachment 7

GARCH estimation of arbitrage parameter μ in equation

$$\Delta X(t) = const + \mu X(t-1) + u(t), \quad where \quad X(t) = R\_RTS(t) - R\_DJIA(t) \qquad (7)$$

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-0.252304	0.247370	-1.019949	0.3090
X(-1)	-0.903596	0.105417	-8.571641	0.0000
Variance Equation				
C	14.60446	3.118523	4.683134	0.0000
ARCH(1)	0.591183	0.174265	3.392444	0.0008
GARCH(1)	0.071244	0.118300	0.602234	0.5477

R-squared	0.132528	Mean dependent var	-0.054243
Adjusted R-squared	0.114642	S.D. dependent var	6.521072
S.E. of regression	6.135902	Akaike info criterion	3.653119
Sum squared resid	7303.962	Schwarz criterion	3.735865
Log likelihood	-611.8820	F-statistic	7.409599
Durbin-Watson stat	3.055713	Prob(F-statistic)	0.000014

Fig. 10. Conditional standard deviation for the model (7)