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Financial Crisis in Russia

The Behavior of Non-Residents

Alexei Medvedev
Georgy Kolodyazhny

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This study focuses on the behavior of non-resident investors during the Russian financial crisis of 1997–1998. Two hypotheses that explain the destabilizing behavior of non-residents were considered and tested. First, non-residents had relatively more attractive alternative investment opportunities than residents, which explains their overreaction to changes in market fundamentals. Second, non-residents imitated the actions of a leader — the largest foreign investor (herding behavior). Results of the empirical testing of the theoretical implications suggest that the first hypothesis does not fully explain all the stylized facts. We found that the actions of the leader had a significant impact on other non-residents' actions, which supports the herding behavior hypothesis.

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Keywords: Russia, financial crisis, non-residents, herding behavior

Alexei Medvedev, Georgy Kolodyazhny

The Bank of Russia.

12 Neglinnaya ul., 103016 Moscow, Russia.

Tel./Fax: +7 (095) 929 43 35, 928 12 25

E-mail: man@cbr.ru, kolodiajnyi@grpwise.omod.cbr.ru

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The financial crisis in Russia that began in November 1997 and ended with the dramatic ruble devaluation in August – September 1998 was not as unexpected as the series of crises in East Asia. It was obvious to many economists that the policy of building up state debt coupled with slow progress in fiscal reform was bound to be unsustainable. Mostly unexpected was the scale of the devaluation of the national currency, which was not forecasted by even the most pessimistic analysts. In summer 1999, the Russian government found itself to be unable to service its debt, acquired in the form of state bonds (GKOs and OFZs) under high domestic interest rates, and simultaneously keep the exchange rate within the official band. Uncontrolled ruble devaluation and unilateral restructuring of the domestic GKO-OFZ debt undermined the stability of the Russian banking system.

The Russian crisis is considered as mainly a government debt crisis; however, alternative views also exist. In particular Montes and Popov (1999) argue that the primary cause of the crisis was overvaluation of the domestic currency. Nevertheless, all researchers agree that the timing of the crisis was largely determined by the actions of foreign investors in the domestic financial market. It is well known that Russia abolished capital controls under the pressure of the International Monetary Fund, which was widely criticized as making the domestic economy dependent on world financial markets. Already by the beginning of the crisis, the share of non-residents in the GKO-OFZ market amounted to about 40%, meaning that foreign investors might significantly influence the market balance. Understanding the role of non-residents in the development of the Russian crisis is important in order to assess the consequences of a liberal balance of payments policy in Russia and formulate policy recommendations for the future. The aim of this research is to study the behavior of non-residents during the financial crisis in November 1997 – August 1998[1] and try to explain the stylized facts. This task is rather complicated given that during the period under consideration the financial market was highly unstable and it is difficult to apply standard econometric analysis. The study was made possible by the availability of high frequency data on individual investors' behavior, which permitted application of non-parametric analysis.

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[1] The end of October 1997, when the downward trend of domestic interest rates was sharply reversed, should be considered as the beginning of the crisis.

The empirical investigation suggests that non-residents indeed destabilized the GKO-OFZ market during the period of financial turbulence. We formulated two hypotheses that can explain this fact. The first hypothesis states that non-residents, who were global investors, had more diversified alternative investment opportunities and hence were relatively more sensitive to changes in market fundamentals. In order to justify the hypothesis, we constructed a model of the financial market and investigated the effect of changes in fundamentals on the allocation of securities between different types of market participants. We showed that if investment in an economy is associated with a high degree of uncertainty, then participation of non-residents in the state bond market leads to an overreaction to the change in fundamentals. The idea underlying this result is that domestic investors consider investment in state bonds as a means of reducing portfolio risk whereas foreign investors allocate some small fraction of their assets to the state bond market in order to increase gross expected return. Changes in fundamentals, which affect expected payoff of bonds, result in a relatively bigger shift in the non-residents' demand curve.

Using an imperfect information extension of the basic model, it was shown that some stylized facts were still unexplained. In particular, the share of net buyers among non-residents during main episodes of market turbulence differed significantly from the share of net buyers among residents. In other words, the theoretical model suggests that residents and non-residents should behave differently on the aggregate level but one should not observe differences on the individual level. The second hypothesis was formulated to explain observed differences on the individual level. Based on the specific structure of non-resident participants in the GKO-OFZ market, which was distinguished by the presence of a foreign market maker (a leader), we hypothesized that non-residents imitate the market maker's actions and thus exhibit herding behavior. This hypothesis was supported by empirical tests based on daily data on investors' transactions. We found that herding behavior explained the opposing strategies of residents and non-residents during the financial turbulence of 1997–1998.

1. THE GKO-OFZ MARKET: ASSET STRUCTURE AND PARTICIPANTS

The state debt market was established for the purpose of providing domestic financing for the federal deficit. Market financing was considered a source of non-inflationary financing — an alternative to direct credits from the Central Bank (CBR). The first bonds that were issued in May 1993 represented zero coupon bonds that promised to pay a predetermined (face) value on a fixed date. These bonds were called state short-term bonds (GKO). The maturity of the first issues was three months.

In 1995 the Finance Ministry (FinMin) began issuing federal variable coupon bonds (OFZ-PK) with maturity of more than one year. During the period of circulation, the FinMin paid coupons according to the prevailing market level of interest rates. In 1996 the FinMin issued fixed coupon bonds (OFZ-PD) to restructure its debt to the CBR that had accumulated in 1992–1994. These bonds began to be quoted in the market only in June 1997. By the time of the crisis, short-term bonds (GKOs) comprised the largest share of the state bond market (see Table 1).

Table 1. Structure of GKO-OFZ market (October 31, 1997).

	Definition	Maturity	Market share*
GKO	Zero coupon bonds	No more than 1 year	81%
OFZ-PK	Variable coupon bonds	2 years	12%
OFZ-PD	Fixed coupon bonds	2–7 years	7%

* Market value, CBR not included.

The redemption of bonds and issue of new ones was carried out by the FinMin regularly on Wednesdays. The pricing of new bonds was done by means of a primary American-type auction. The participants of the auction submitted two types of orders: competitive, that included price and quantity; and non-competitive, that is an intention to buy a stated volume of securities at the average auction price. The FinMin determined the cut price and accepted orders with bidding prices higher than the cut price. The parameters of the issue were disclosed in advanced; however, the volumes of the issue were common knowledge only after the auction.

Apart from primary auctions, there existed a secondary market for state bonds in which trade was fully computerized and carried out in the Moscow Interbank Currency Exchange (MICEX). Due to the paperless nature of the securities, the only way to buy or sell securities was to participate in the secondary market, that is, in the MICEX. In this secondary market, buy/sell orders were of two types; however, there existed certain restrictions that will be mentioned below.

All the participants in the GKO-OFZ market can be divided into the following four major categories: the state (CBR and the FinMin), non-residents, dealers, and other residents. Direct participants in trading were dealers — institutions (mostly banks) that had signed a special agreement with the CBR[2] and thereby were permitted to directly participate in trading sessions. Some dealers signed another special agreement with the CBR and were called *primary dealers*. The division between primary and other dealers began in 1996. The aim of singling out primary dealers was to establish a two-level mechanism of market regulation in which the CBR controls only a relatively small number of key market participants.

Primary dealers had significant advantages over the others including the exclusive right to submit orders with lasting terms, access to additional refinancing facilities, and the right to take limited short positions. In every transaction in the secondary market, the primary dealer was one of the parties since an order placed by a market participant was matched by an order previously placed by the primary dealer.

Primary dealers had additional obligations according to their role as market regulators. Primary dealers were requested to participate in auctions buying out certain volumes of new issues and in the secondary market to maintain the liquidity of some securities or the market as a whole. Officially this took the form of an obligation to keep a certain bid/ask spread, to maintain a minimum volume of selling and buying orders, and to recover executed orders in time. In mid 1997, out of about 300 dealers in the GKO-OFZ market, 43 were primary dealers.

The state was represented in the secondary market by the CBR and the FinMin. The FinMin occasionally used the secondary market to sell additional papers and buy out previous issues if it was deemed to be optimal. The CBR took active part in secondary trading, smoothing the yield curve according to its short-term objectives. At the same time, the CBR also intervened to maintain long-term liquidity. A clear example of such a policy is the building up of the GKO-OFZ portfolio in March–June 1996, right before the presidential elections, and again in November–Decem-

[2] CBR was responsible for monitoring and regulating activity of GKO-OFZ market participants.

ber 1997 when the first external shock hit the domestic market. The CBR was not legally able to participate in primary auctions; however, this task was fulfilled by Sberbank — the largest state-owned bank. The CBR was also responsible for monitoring and regulating the activity of GKO-OFZ market participants. Open market operations departments monitored trading in real time and spotted violations of explicit or implicit norms in the trading process. Technically, the trading system allowed agreed upon non-competitive transactions, that is transactions at a price far from the market price, to be carried out. Participants responsible for such transactions were warned and in some cases were temporary banned from the trade sessions.

Non-residents were not allowed to invest in state bonds under the same conditions as residents until 1998. The first non-residents were admitted to the market in 1996 and were allowed to purchase securities only in primary auctions where they settled non-competitive orders and they had no right to participate in secondary trading. In fall 1996, non-residents were admitted to the secondary market.

Until the end of 1997, certain restrictions existed on non-residents' capital flows in and out of the market.[3] A non-resident willing to invest in the GKO had to exchange a certain fraction of invested funds directly via the CBR. If the non-resident intended to withdraw funds from the market, he was requested to inform the CBR in advance[4] and to make a forward deal with the CBR to exchange a certain share of withdrawn money at a forward exchange rate. The forward exchange rate was determined in such a way that the dollar yield on state bonds was set at a targeted level. In 1996, the share of non-residents' funds subject to forward transactions was 100%; however, it was gradually lowered, as were minimum terms. Fig. 1 shows the time path of quantitative restrictions on non-residents' capital outflows from the GKO-OFZ market.

In order to invest in state bonds, non-residents had to sign an agreement with a dealer (primary, as a rule) that offered corresponding services. An alternative way was to establish a branch institution in Russia, which according to the law could be dealer or even primary dealer. For instance, Credit Suisse First Boston had a daughter company that was a primary dealer in the GKO-OFZ market. Despite the fact that non-dealers could not directly participate in trading sessions, large clients were of-

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[3] The process of liberalization of the GKO-OFZ market is described in detail in Vavilov *et al*. (1999).

[4] The minimum term between the time of informing authorities about the intention to withdraw funds and the time of the actual withdrawal was determined by the CBR.

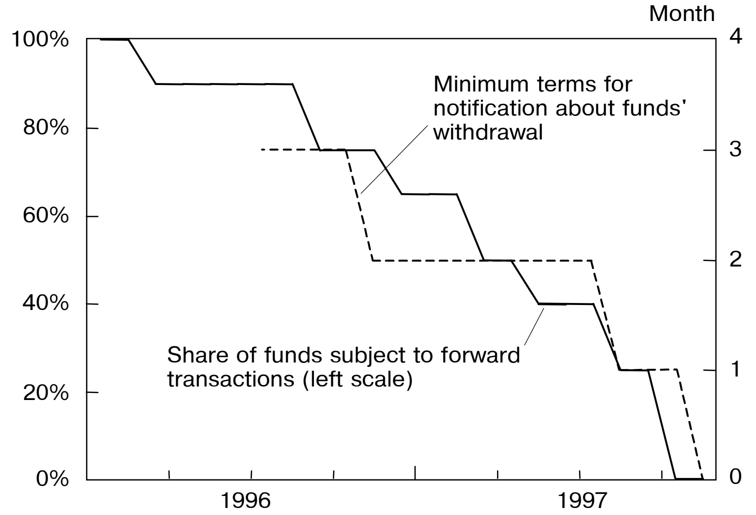

Fig. 1. Liberalization of terms of investment for non-residents.

fered terminals as a means by which they had direct access to secondary trading. By the beginning of the crisis, the share of non-residents in the GKO-OFZ market had grown to 40% (not including the CBR, see Fig. 2).

Dealers, excluding Sberbank's dealers, held 25% of the market portfolio. The market value of Sberbank's portfolio was larger than the portfolio value of all the other dealers as a whole. The share of other residents was less than 20%; however, they numbered over 40,000.

According to the official definition, non-residents were individuals having permanent residence abroad or institutions that were created in accordance with foreign legislation. However, this definition is not entirely appropriate from the economic point of view since in practice not all non-residents were 100% foreign-owned companies. Russian companies had opportunities to establish daughter companies in other countries (offshores) in order to minimize their tax burden. The problem of tax burden optimization became important after the FinMin began to tax interest income on new issues from the GKO and OFZ starting from January 1997. The tax rate was set at 15%. This measure did not affected investors that were registered in countries with which Russia had a double taxation treaty. Introduction of income tax stimulated Russian companies to register offshore.

Cyprus was the most favorable country for Russian companies establishing an offshore company due to its low taxes and the double taxation

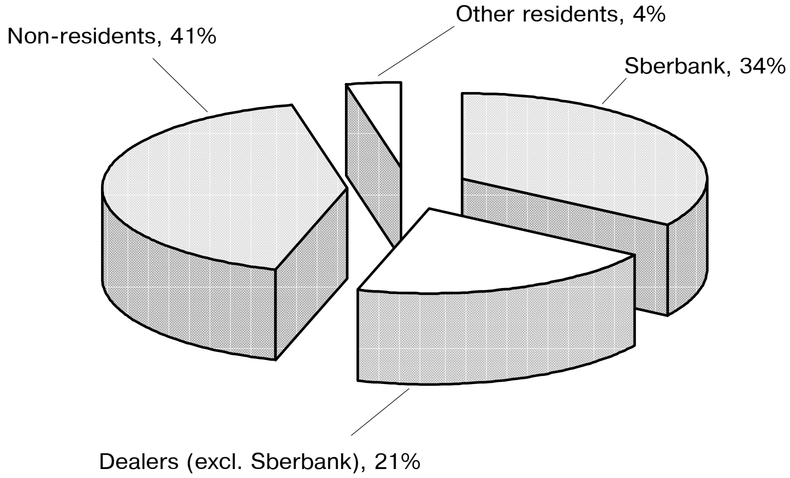

Fig. 2. Structure of the GKO–OFZ portfolio (end of October 1997). Shares were calculated based on market value.

treaty signed between Cyprus and Russia. Daughter structures of Russian companies and companies with Russian ownership existed not only in Cyprus but also in republics of the former Soviet Union. About half of all non-residents who invested in GKOs and OFZs were either residents of Cyprus or residents of republics of the former Soviet Union. It would be incorrect to consider all non-residents as a uniform group of investors, but unfortunately we have no information about the owners of the companies that participated in the GKO-OFZ market (see data description). In order to exclude the possible influence of Russian-owned companies when studying the behavior of non-residents, we did not take into consideration investors who were registered in those countries (except those companies about which we had reliable information).

Similar to Sberbank, whose portfolio was comparable with that of other residents, there was one large non-resident investor both with respect to size of portfolio and volume of market operations. Studying the behavior of this particular investor would be interesting from the perspective of his strategy. In particular, it would be interesting to know if this investor used his market power to earn abnormal returns. Unfortunately, it is impossible to study the behavior of one large non-resident alone due to the natural restriction formed by the confidentiality of information on actions of single investors. Excluding this largest investor, about 80% of the total portfolio of remaining non-residents (including Cyprus and republics of the former Soviet Union) was concentrated within a group of British investors. This can be easily explained by the fact that the headquarters of many largest investment banks whose business is spread around the world are located in London. The group of British investors was relatively small; about 30 companies covered more than 90% of the market.

2. DID NON-RESIDENTS DESTABILIZE THE GKO-OFZ MARKET?

Investors could purchase and sell state bonds in the primary (auctions) and secondary (trade) market. The secondary market was the main segment where price tendency was formed. The orders of investors in primary auctions generally contained prices that approximately corresponded to the market price of the analogous bond on the day proceeding the day of the auction. For the purpose of comparing behavior of residents and non-residents, we used daily data on investors' net position in the secondary market during the period of crisis. Since non-residents were professional investors, it is natural to compare their behavior with that of Russian professional participants, most of whom were dealers. Our first step is to check the allegation that non-residents destabilized the GKO-OFZ market during the period of crisis. This statement will be supported if we show that during most of the trading days when the market price went down, non-residents were net sellers as a group and residents were net buyers.

Let N^+R^- denote the event in which residents are net sellers as a group and non-residents are net buyers. We will consider only those daily observations in which net position of residents and non-residents differed in sign. Hence, by definition we consider only those days when one of two above-mentioned events occurred. The period of crisis contains 158 observations, of which 124 satisfy this condition. Using data on investors' transactions, it is straightforward to calculate the sample probability of event N^-R^+ based on the restricted set of observations

$$\Pr{}^{estimate}(N^-R^+) = 0.55 \pm 0.05\ .$$

The estimate and its standard deviation do not suggest that non-residents were net sellers more frequently than residents. However, this fact does not allow us to reject the hypothesis of the destabilizing behavior of non-residents. Let us show that non-residents were net sellers more frequently in periods of falling prices, that is,

$$\Pr(N^-R^+ \mid \Delta p < -\alpha) > \Pr(N^-R^+ \mid \Delta p > -\alpha)\ , \qquad (1)$$

where $\Delta p = \frac{p}{p_{-1}} - 1$ and α — some positive number.

Table 2. Test of the hypothesis of the destabilizing behavior of non-residents.

α	$N(\Delta p < -\alpha)$	$N(\Delta p > -\alpha)$	$\Pr(NR \mid \Delta p < -\alpha)$	$\Pr(NR \mid \Delta p > -\alpha)$	*Significance*
0.0%	65	59	0.63	0.47	2.86%
0.5%	52	72	0.71	0.45	0.10%
1.0%	37	86	0.78	0.45	0.01%

Note: *N*(.) denotes the number of observations that satisfy the condition in parentheses. The last column contains the significance level of the test of inequality (1).

As it follows, inequality (1) holds with good probability, which suggests that non-residents tended to sell more frequently in periods of falling prices than in periods of rising prices. As a price index we used

$$\frac{1}{1 + i_{GKO}/100},$$

where i_{GKO} stands for the GKO yield index.[5] It should be noted that the frequency of selling by non-residents grows as threshold α rises. This fact suggests that for most extreme episodes of GKO-OFZ market turbulence, non-residents were generally net-sellers and residents were net buyers. To sum up, we conclude that the hypothesis of the destabilizing behavior of non-residents is supported.

3. BEHAVIOR OF NON-RESIDENTS: HYPOTHESES

Studying the behavior of international investors has gained interest relatively recently and is related to studying the problem of financial market globalization. The last wave of financial crises in 1997–1998 that hit mainly recently growing emerging market economies is viewed as being caused by the adverse behavior of international investors. Among widely accepted facts is that a financial crisis is preceded by a period of significant capital inflow, which is then sharply reversed (Calvo, 1998). In the previous section, we established that non-residents destabilized the

[5] Use of any other yield indicator would not affect the results since prices of all issues were changing proportionally.

GKO-OFZ market during the period of crisis. Let us consider the following four hypotheses that explain this fact:

1. Destabilizing behavior is explained by non-residents' being less informed about Russian market fundamentals than residents;
2. Non-residents imitated each other actions (herding behavior);
3. Non-residents' strategy was determined not only by the information about the Russian market, but also by events taking place abroad;
4. Non-residents' reaction to worsening fundamentals was stronger due to generally more attractive alternative investment opportunities.

Calvo and Mendoza (1999), using a simple model of portfolio investment, show that with a growing number of independent markets the incentives to collect information about specific markets are diminishing. This statement is most obviously true in the extreme case when the number of independent markets is very large. Indeed, since the global portfolio is risk-free, any effort to reduce specific market risk is not rational. Brennan and Cao (1996) show that the optimal strategy of foreign investors, provided they are comparatively less informed, is to buy securities when prices are going up and sell when prices are down. This type of strategy is called positive feedback strategy since it creates positive feedback between prices and investors' actions leading to multiplication of the initial shock. Obviously, such a strategy may destabilize a financial market via overreaction of prices to a change in fundamentals. Empirically, the hypothesis of non-residents' following a positive feedback strategy was found to be supported in the case of the Korean stock market in period before and during the 1997 crisis (Kim and Wei, 1999 in contrast to Choe *et al*., 1998). In the case of the GKO-OFZ market, the assumption of non-residents' being less informed than residents does not seem to be justified. The major foreign capital flows went through a limited number of well known global investment funds with significant exposure in the Russian market, whose traders we can not consider as relatively less informed market participants.

Herding behavior is a phenomenon of a market with imperfect information and behavioral externalities. One of the most popular explanations of herding behavior in financial markets is the particular structure of incentives that are faced by managers of investment funds which give rise to payoff externalities (Scharfstein and Stein, 1990). Managers are interested in maximizing expected payoffs, which depend on the assessment of their relative rather than absolute success (principal-agent problem). This type of payoff scheme is called a benchmark-based compensation scheme. Even in the case of having positive information about the market, the manager may decide to sell its portfolio, following the actions of others, since in that way he will be at least not worse off than the others. Another possible explanation of herding behavior is the existence of a large investor — a leader whose actions produce information externalities for others. Calvo (1999) argues that a crisis may be launched by the actions of a large nonresident (informed investor). Suppose that due to losses in other markets or the need to meet margin calls such an investor sells assets in some financial market. Other investors (uninformed) who observe his actions may interpret his behavior as a signal of weakening fundamentals and follow him in selling securities. The hypothesis of herding behavior should be considered as one of many possible explanations for the difference in behavior between residents and non-residents since it can not be excluded that key non-residents had information about each others' actions. A survey of the literature on herding behavior in financial markets is given in (Bikhchandani and Sharma, 2000)

Foreign participants in the GKO-OFZ market were international investors. The portfolios of such companies were composed of financial instruments issued in different markets. Consequently, their investment in each market is the outcome of a complex optimization problem. A change in the conditions in one of the markets should necessarily result in the redistribution of their assets among all the markets. Schinasi and Smith (1999) show that if the return of a leveraged portfolio on a unit of capital is less than the costs of financing, then the optimal strategy is to reduce debt and correspondingly reduce positions in all risky markets. This result leads to the conclusion that a reduction in expected return in world markets or an increase in interest rates in industrial countries may have led to the reduction of the number of foreign investors' positions in the Russian market. Thereby, the destabilizing behavior of non-residents can be explained by the influence of external markets. This argument implies that Russian investors did not consider outflow of foreign capital as a permanent reduction in external demand for state bonds. Otherwise residents should have also reduced their demand and the final redistribution of the market supply between investors' groups should have been ambiguous.

Personen (1998) investigated the relationship between the Russian stock market and world stock markets for the period of 1997–1998. The influence of Asian markets proved to be insignificant and a significant opposite causality from the Russian stock market to East-Asia financial markets was found. At the same time, a simple Granger causality test suggests that American and Japanese stock markets significantly affected the prices of Russian stocks.

The difference in behavior between non-residents and residents can be explained by the different investment conditions. Due to a large set of financial instruments that are available across the world to large investment banks, these companies have opportunities to significantly reduce the risk of their assets. Suppose that the worsening of fundamentals, such as a fall in world energy prices, increases the probability of the state being unable to fully service its obligations under the current exchange rate regime. It seems to be reasonable to suppose that non-residents having more attractive investment opportunities would react more actively by reducing their demand for state bonds. If this intuition is correct, then in order to explain the difference in behavior between residents and non-residents it is not necessary to resort to imperfect market arguments or the influence of world financial markets. This hypothesis seems to be a good starting point in the analysis of investors' behavior during the period of the Russian crisis. The hypothesis does not have immediate implications for its empirical testing so we need to construct a formal model. This model should also formalize the argument of the overreaction of non-residents to changes in fundamentals.

4. A MODEL OF A FINANCIAL MARKET WITH TWO TYPES OF INVESTORS

Let us consider the following simple two-period model of a financial market with two types of investors, residents and non-residents. We assume for simplicity that there is one type of discount bond that is traded in the market. The bond takes the form of an obligation to pay 1 ruble after some sufficiently long time period (T). The purpose of the model is to study the effect of external shock on the allocation of bonds between investors. The period immediately prior to the shock we denote as period 0, and the period immediately after the shock we call period 1. By assumption, the duration of the shock is short enough that we can consider bonds in period 0 and 1 as identical ($T >> 1$). We assume that all the available investment opportunities are the same kind of obligations with the same maturity (T). Suppose that the dollar exchange rate is fixed one to one in both period 0 and period 1; however, it is uncertain if the exchange rate will be kept fixed at the same level until the time of the bonds' maturity. Hence, the amount of repayments in dollar value by the end of the bond circulation period is a random variable that has a normal conditional distribution in periods $t = 0, 1$ with mean and variance (q_t, δ_t^2). The pair of mean and variance we call market fundamentals, which are assumed exogenous. For the sake of simplicity, assume $q_0 = 1$.

In each period of time investors allocate their assets between two types of financial instruments. The first are discount bonds that are traded in the market, which is a common form of investment available to both groups of investors. In period t the mean and the variance of the dollar yield of the bond to the date of maturity are equal to $r_t = q_t/p_t - 1$ and $\sigma_t^2 = \delta_t^2 / p_t^2$, where p_t is the market price of the bond. The second financial instrument represents a set of all available alternative investment opportunities modeled as one security with mean and variance of return by the same date: (r_r, σ_r^2) for residents and (r_n, σ_n^2) for non-residents.

We assume that investors within each group are identical. Demand for bonds in each period is a result of utility optimization under uncertainty. Investors maximize an expected utility function of the following type:

$$U = r - \gamma_i \sigma^2 , \qquad i = r \text{ or } n. \tag{2}$$

This type of expected utility can be derived from the constant relative risk aversion utility function under an assumption of normality.

Let us introduce the following notation:

ω_{rt} — share of assets allocated by representative resident to the bond market in period t = 0, 1;

ω_{nt} — share of assets allocated by representative non-resident to the bond market in period t = 0, 1;

A_{rt} — total value of residents' assets in period t = 0, 1;

A_{nt} — total value of non-residents' assets in period t = 0, 1.

In both periods of time t = 0, 1 the market reaches equilibrium which means that price p_t takes a positive value such that excess demand for bonds by residents and non-residents sum to zero. By this statement we assume that the supply of bonds is absolutely inelastic with respect to the price. Additional assumptions are the following:

- the returns on alternative assets are independent of return on the discount bond;
- the optimization problem for residents and non-residents always has an internal solution.

The assumption about the independence of returns on alternative financial instruments available to non-residents and of returns on the bond seems to be justified. However, we can not make a similar assumption for the case of residents since a significant part of the bond risk was risk of ruble devaluation that was also part of risk associated with other ruble financial instruments. This means that the dollar yield of alternative financial instruments should correlate with the return on the bond. Nevertheless, we are still able to neglect this correlation if we keep in mind that the share of residents' assets invested in bonds and the variation of bond returns have different meanings. Let ξ and η denote random variables that are returns on alternative investment for residents and returns on the bond. Then random variables ξ and $\zeta = \alpha\xi + \eta$ are independent, where

$$\alpha = -\frac{Cov(\xi,\eta)}{Var(\xi)} < 0 .$$

Consequently, we can assume that the bond return is equal to ζ since the optimal portfolio can also be written as a linear combination of two independent factors. Let us show that its variance is less than the variance of ξ, and the actual share of residents' assets invested in bonds ω' is less than the share obtained from solving the problem of allocating assets between two independent instruments that have returns ξ and ζ (ω). Note that the last statement easily follows from $\alpha < 0$.

$$Var(\zeta) = \alpha Var(\xi) + (1+\alpha)Cov(\xi,\eta) + Var(\eta) = Cov(\xi,\eta)\alpha + Var(\eta) < Var(\eta) .$$

Hence further in the text where we discuss the theoretical implications, we will take into account that actual data on the share of residents' assets invested in GKOs underestimates the theoretical counterpart, and the actual variance of return is higher than the one considered in the model.

The next proposition characterizes the direction of allocating bonds after a very slight worsening of fundamentals $dq = q_1 - q_2 < 0$ or $d\delta^2 = \delta_1^2 - \delta_0^2 > 0$.[6] The simplifying assumption about infinite change was made for reasons that will become evident in the next section. Simulations suggest that the proposition holds also for large external shocks.

Proposition 1.

If worsening in fundamentals leads to a decrease in market price then.

1). If $\omega_r > \omega_n[1 + 4\max(\gamma_n,\gamma_r)(\sigma^2 + \sigma_n^2)]$, $dq = 0$ and $d\delta^2 > 0$, then in period 1 bonds are allocated from residents to non-residents.

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[6] We use notation dq or $d\delta^2$ to emphasize that we consider sufficiently small changes in fundamentals.

2) If

$$\omega_r >> \omega_n \frac{\gamma_n}{\gamma_r},$$

$d\delta^2 = 0$ and $dq < 0$, then provided condition

$$\sigma_r^2 < \sigma^2 \frac{1+\omega_r}{1-\omega_r}$$

holds, in period 1 bonds are allocated from residents to non-residents and in the case

$$\sigma_r^2 > \sigma^2 \frac{1+\omega_r}{1-\omega_r},$$

bonds are allocated from non-residents to residents.

Proof: see Appendix 1.

The assumption that the share of non-residents' assets invested in GKOs was rather small or at least much less than the share of residents' assets (adjusted for the coefficient of risk aversion) reflects a broader range of alternative investment opportunities available to non-residents and is justified by the actual data. Indeed, the total value of assets of foreign GKO holders was several trillion dollars and the value of non-residents' portfolios of state bonds was some 20 billion dollars. To get an idea of how realistic is the condition of the first statement in Proposition 1, assume that the share of bonds in residents' total assets is equal to 0.3, and the same share for non-residents is 0.01. Let us assume that the standard deviation of returns on bonds as well as alternative non-residents' assets is not greater than 10 percentage points. Then in order for the condition to hold, the maximum of two parameters of risk aversion should not be greater than 362. Let us consider the following example in order to obtain an estimate of the coefficient of risk aversion. Assume that the portfolio risk (standard deviation of return) increases by 1 percentage point or formally $\sigma_2 - \sigma_1 = 0.01$. At the same time the expected return also goes up to keep utility constant or $r_2 - r_1 = \gamma(\sigma_2^2 - \sigma_1^2)$. It seems justified to assume that with a probability of less than 95%, the new portfolio return will exceed the old portfolio return since otherwise it is unlikely that an investor considers the two portfolios as equivalent. Formally, this can be written as $r_2 - r_1 \le 2\sqrt{\sigma_2^2 + \sigma_1^2}$. Using the previous equality, we arrive at the following estimate of the coefficient of risk aversion:

$$\gamma \le 2\frac{\sqrt{\sigma_1^2+\sigma_2^2}}{\sigma_2^2-\sigma_1^2} \le \frac{2}{\sigma_2-\sigma_1} = 200\,.$$

As it follows from Proposition 1, in period 1 bonds are allocated from non-residents to residents only when alternative investment opportunities available to residents are risky enough. Note that with a growing share of residents' assets invested in bonds this condition becomes stronger. Indeed falling prices significantly reduce the assets of residents if the share is not very small and consequently contribute to further reduction of their demand for bonds.

The result presented in the second part of Proposition 1 can be interpreted the following way. In the case when the variance of residents' alternative investment is not large, then the small share of nonresidents assets' invested in bonds (ω_n) accounts for the relatively weaker sensitivity of their demand with respect to a change in expected payoff. However unlike the demand sensitivity to a change in risk, with ω_n going to zero, the sensitivity of non-residents' demand with respect to the expected payoff does not go to zero as well. With a sufficiently large variance in residents' alternative investment (σ_r^2), their priorities shift from maximization of expected returns to reduction of risk. Hence, sensitivity of residents' demand for bonds with respect to a change in expected payoff goes down. In particular, if $\omega_r \le 0.5$ and $1.7\sigma < \sigma_r$, then the opposite is true, that is, the effect of the presence of richer alternative investment opportunities available to non-residents dominates the effect of a small share of their assets in bonds.

It seems natural to assume that the variance of returns on non-residents' alternative investment is less than the variance of returns on bonds due to sophisticated risk diversification. Further in the text, we assume that the share of residents' assets in bonds is less than 50%. This assumption implies that the utility of investment in bonds is lower than the utility of investment in alternative instruments. In particular, from $\sigma^2 < \sigma_r^2$ it follows that $r_r > r$. According to the consolidated balance sheet of t he banking system (Sberbank excluded), the share (in book value) of state bonds of banks' assets was about 7% and the same share for Sberbank — the largest GKO-OFZ holder — was less than 30%. However, we should keep in mind that in the case of correlation of returns, the actual share is lower than the direct analog of the theoretical notion.

The condition $\sigma_r^2 > \sigma^2 \frac{1+\omega_r}{1-\omega_r}$ is justified if we assume that the economy is characterized by high investment risk. Indeed, the variance of returns on alternative investment available to residents is a measure of the risk of investment in the domestic economy. Taking this into account we can reformulate Proposition 1 in the following way. In financial markets of countries with high investment risk, non-residents will contribute to the market's reaction to worsening fundamentals if it is mainly related to a reduction in expected payoff. A clear example of this kind of shock is increased devaluation expectations.

Statement 1 provides formal ground for the intuitively accepted hypothesis that a shift in the demand curve of non-residents after worsened fundamentals is greater than that of residents. This statement, however, does not produce any implications that can be used to check if the asymmetrical effect of changes in fundamentals is responsible for the observed opposing strategies of residents and non-residents. The simple full information model that was used to prove this statement is highly stylized since it does not allow for differences in assessment of market perspectives by investors. In practice investors have different perceptions about the attractiveness of investment in bonds which, roughly speaking, means separation of the market participants between optimists and pessimists. If non-residents and residents are not different with respect to the quality of information they receive, then the ratio between optimistic and pessimistic investors should be the same for both groups. The differences among investors in assessing the market perspective, which interferes with the difference in available alternative investment opportunities, makes less obvious the conclusion drawn from the simplest model. In particular it is not clear if in a general case of heterogeneity of investors we still can expect that in some rather probable circumstances non-residents generally tend to sell and residents tend to buy bonds in the case of worsening fundamentals. It may well be the case that this conclusion is valid for the extreme case of full information. It can be easily shown that it is also true for another extreme case of highly imperfect information. Indeed, let us consider a slightly different scenario that allows for imperfect information in the model. Suppose that in period 0 all investors had full information about market fundamentals. In period 1 the financial shock hit the market. It is not known if the shock is permanent (fundamentals changed) or temporal (fundamentals unchanged). In another extreme case when investors do not have any reliable information about a change in fundamentals, they all give equal probabilities to both possibilities (fundamentals worsened and fundamentals remained unchanged) and consequently are not different with respect to received information (no information). In this case, the difference in alternative investment opportunities naturally leads to opposing strategies of residents and non-residents. Let us consider an extension of the basic model that incorporates the scenario just described.

Assume that in the case of a permanent shock, fundamentals change from $(1, \delta^2)$ to (q, δ^2) $(q < 1)$. We also assume that each investor independent of his type correctly determines the true type of shock with probability $\pi > 1/2$, which is common knowledge. The new model requires a slight change in notations. As

$$r = \frac{q}{p_1} - 1$$

we denote the mean return if shock is permanent n during, as

$$r_0 = \frac{1}{p_1} - 1$$

— the mean return if shock is temporary. situation when. We will say that an investor is optimistic if he considers the shock to be temporary.

The return on the bond expected by an optimistic investor is

$$r^+ = \pi r_0 + (1 - \pi)r. \qquad (3)$$

The return on the bond expected by a pessimistic investor is

$$r^- = \pi r + (1 - \pi)r_0. \qquad (4)$$

Similarly let us introduce the following notation for the expected value of repayments:

$$q^+ = \pi + (1 - \pi)q, \quad q^- = \pi q + (1 - \pi). \qquad (6)$$

$x^{+(-)}_{n(r)}$ — Share of non-residents (residents) that received positive (negative) signal.

Further in the text superscripts "+" and "−" will be used to show that the variable corresponds to optimists and pessimists. It is straightforward to show that optimists expect the bond payoff to be q^+, and pessimists expect q^-. As in the previous section, we consider infinitely small changes in fundamentals. Since we are interested in the case when in equilibrium non-residents are supposed to sell bonds to residents, we consider only specific types of shocks that affect only the expected payoff $dq = q - 1 < 0$, leaving its variance unchanged.

Proposition 2.

If the number of residents and non-residents is very large, worsening in fundamentals leads to a decrease in market price and the following conditions hold:

$$\omega_n \le \frac{\gamma_r}{\gamma_n}\omega_r, \quad \omega_r \le 0.5, \quad \sigma_r^2 > \sigma^2 \frac{1+\omega_r}{1-\omega_r}$$

and

$$r_r - r < \frac{(2\pi - 1)(1-\pi)}{\pi}; \tag{7}$$

then the share of buyers among residents and non-residents in period 1 is the same.

Proof: see Appendix 2.

Proposition 2 describes the comparative behavior of investors. Using a simple model it was shown that only under some conditions can selling by non-residents and buying by residents be explained using the argument of differing alternative investment opportunities. However as it was shown in Proposition 2, under some additional conditions (7) there should be no difference between the share of buyers in the two groups. The idea of this result is that non-residents and residents are different with respect to their intensities of buying and selling but not with respect to their relations between buyers and sellers.

Let us assess how realistic is condition (7). In Fig. 3 we illustrate the function

$$\frac{(2\pi - 1)(1-\pi)}{\pi}$$

in the plane $(r - r_r, \pi)$.

Since theoretical returns correspond to the period of bond circulation, the real-life analog of it is a period of one year. Indeed, more then 80% of state bonds were GKOs with a period of circulation of no more than one year (see Table 1). As it follows from the graph, if the quality of information is not extremely poor or perfect (probability is not close to 0.5 and 1), then condition (7) does not hold only when the expected return differential is significant. Indeed, for example, if $\pi = 0.7$ then the differential should be greater than 17 percentage points on an annual basis. In the reality of the Russian economic crisis, this would mean the exis-

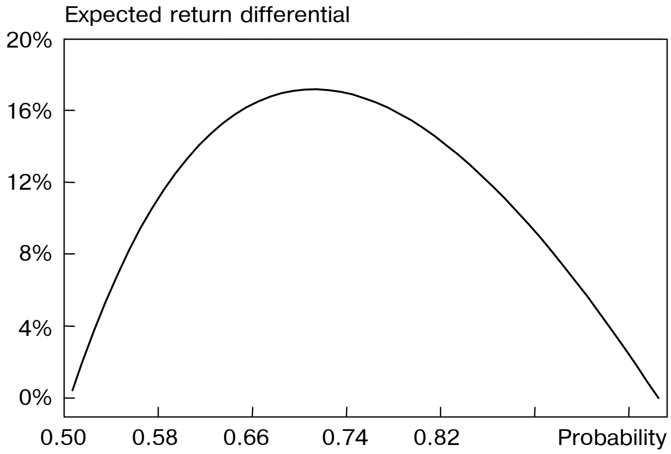

Fig. 3. Condition (7) holds below the curve.

tence of significantly more profitable (from the expected return perspective) investment opportunities. Obviously any judgements about the realness of this situation have subjective bias. However it seems highly unrealistic that under conditions of no economic growth (0.4% in 1997), investment in the economy could not have a high average (dollar) return.

The imperfect information variant of the model was simulated using some reasonable values for exogenous parameters. The most important conclusion is that a very small change in expected payoff drives the solution for pessimistic non-residents to the boundary. This result has a simple explanation. Since the share of non-residents' assets invested in bonds is very small, any slight change in expected return may drive the solution for the optimal share to the negative domain. For this reason, in the case of full information, a change of fundamentals does not affect expected return in equilibrium and all solutions remain internal. In the case of imperfect information, non-residents differ with respect to perceived fundamentals and hence the expected return can not be the same. If the change of fundamentals is very small, then the optimal solution for pessimistic non-residents is still internal, meaning that the assumption of a very small change seems to be important but at the same time unrealistic.

It is obvious that reality is much more complicated and can not be fully captured by this type of stylized model. Judging from the data, we conclude that a key group of non-residents held a non-empty GKO-OFZ portfolio throughout the period of crisis and no one fully exited the market. One possible reason is restricted market liquidity. In our stylized model prices always clear the market and each investor holds a small portion of the market portfolio. Hence one should interpret obtained results cautiously taking into account the stylized nature of assumptions. The model helps us to understand what the picture would be if liquidity was perfect. In order to derive real-life implications, we should think about how liquidity constraints could have changed the model result. The lack of market liquidity effects mostly the actions of those investors who intend to sell bonds. Hence, one can expect that this factor should diminish the intensity of selling which means that the difference between residents and non-residents with respect to the share of net buyers should be even less pronounced. This argument allows us to use model implications to test the hypothesis that the existence of different alternative investment opportunities is a sufficient explanation of the observed empirical dissimilarities in investors' behavior.

Data.

The data on transactions in the GKO-OFZ market were collected on a daily basis by the Open Market Operations Department of the Bank of Russia. This data set is rather huge having several megabytes of data per day and contains information on all transactions and orders of each investor according to his ID, including the exact time, codes of securities, etc. A separate file provides deciphered information about these IDs including information on the name of each investor and the country of residence. Unfortunately, this is the only information about investors that we have. The major problem with the data set was that it was not organized as a database but rather represented as a data archive. Several programs were written that helped organize the database.

Another difficulty that we faced when working with these data files was that one non-resident investor could enter the GKO-OFZ market via several dealers and thereby have several IDs. This problem was solved by investigating the names of investors and by grouping investors according to their names rather than IDs. In this way the database was constructed and contains daily data for November 1997 – August 1998. In order for the database to be easily processed, we decided not to include all residents but only dealers.[7] Since non-residents were professional investors, it seemed reasonable to compare their behavior with similar counterparts among resident investors, of which dealers represented the most active and professional part.

[7] Total number of residents exceeded 40,000.

The database is a Microsoft Access file of about 500 Mb in size. For each non-resident investor and dealer, the database contains information on their end-of-week portfolios (nominal and market), portfolio duration, volume of bonds sold (nominal value, market value, units), volume of bonds bought (nominal value, market value, units), duration of sold and bought bonds. When calculating daily sell and buy figures we excluded REPO transactions between dealers and the CBR. These transactions took place off market and did not affect prices. REPO was primarily a refinancing instrument and state bonds were used as collateral.

5. TESTING MODEL IMPLICATIONS

Implications of the extended model can be used for the practical testing of the hypothesis that the existence of different alternative investment opportunities is a sufficient explanation for the observed empirical dissimilarities in investors' behavior. The null hypothesis is that the difference in behavior between residents and non-residents was solely due to different alternative investment opportunities. The idea of the test is to compare shares of investors within each group that increased their portfolios (nominal value portfolio rose) during a certain period of time. Theory suggests that if the null hypothesis is correct, then we will not find a statistically significant difference between these shares. In order to satisfy model conditions we should consider periods of time that correspond to the transition of the market from one equilibrium to another. This choice, however, can not be strictly formalized. In Fig. 4 we showed five main episodes of market turbulence which we considered as relevant periods for the analysis.

We could not assume that the share of non-residents that increased their portfolios over a certain period (buying non-residents) was normally distributed since the number of non-residents was not sufficiently large (see Table 3). The appropriate methodology is a little bit more complicated than the simple t-test of mean difference. Since the number of dealers was sufficiently large (over 200), following the Central limit theorem we assumed that the share of buying dealers was a normally distributed random variable. We did not observe the underlying probability of purchase but we have its estimate by observing the share of buyers within the group of dealers. Let us denote this estimate as ς. Then $\varsigma = p + \varepsilon$, where p is the underlying probability and ε is the normally distributed random variable with zero mean and variance σ^2. Note that the variance of ε being equal to $p(1 - p)/N_r$ (N_r — number of observed dealers) can be quite accurately estimated if you substitute p with its estimate ς. In

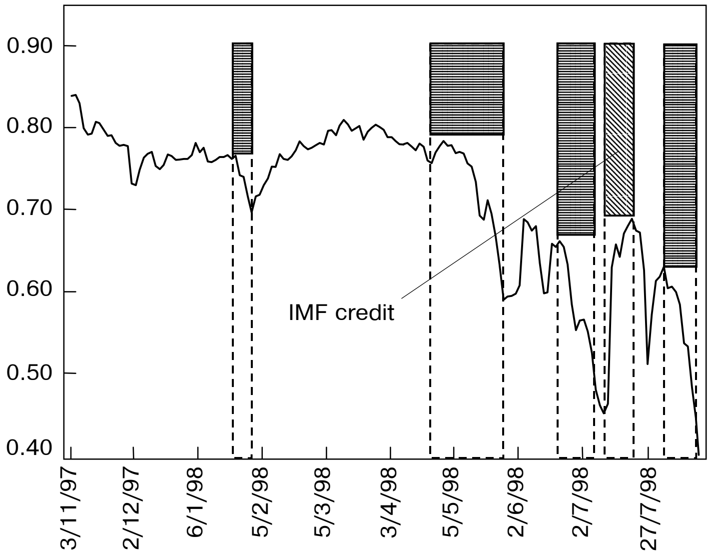

Fig. 4. Time path of GKO prices: major episodes of market turbulence.
Definition of episodes: 22.01.98–30.01.98; 5.05.98–28.05.98; 23.06.98–10.08.98; 13.07.98–21.07.98; 4.08.98–14.08.98.

this case the underlying probability can be represented as a normally distributed random variable $p = \varsigma - \varepsilon$ with known mean and variance. Let K_n be the number of buyers among N_n observed non-residents. If an episode corresponds to the fall of prices, then the relevant alternative to the null hypothesis is that the share of net buyers among non-residents was significantly less than the share of net buyers among residents. The critical probability of the test can be obtained by calculating the probability (under null hypothesis) that the share of buyers b among non-residents would be less than the observed K_n/N_n condition on known estimate ς:

$$\Pr(b \le K_n \mid \varsigma) = \int \Pr(b \le K_n \mid p = q, \varsigma) f_{\zeta\sigma}(q) dq =$$

$$= \frac{1}{\sqrt{2\pi}\sigma} \int \sum_{l=0}^{K_n} C_{N_n}^{l} q^{l} (1-q)^{1-l} e^{-\frac{(q-\varsigma)^2}{2\sigma^2}} dq . \quad (8)$$

In the case of one episode corresponding to market recovery, the relevant alternative is that the share of net buyers among non-residents would be greater than the share of net buyers among residents. Hence, we should use one minus value calculated by formula (8) to access significance of the test.

Heterogeneity of investors can potentially result in the validation of the null hypothesis using the test based on a full sample of investors, even if a difference exists between key residents and non-residents. In order to rule out any possible misleading effects of investors who had insignificant impact on the market balance, we also tested the null hypothesis using a restricted sample of investors. For each episode under consideration, we singled out those whose portfolios changed the most in absolute terms from the whole sample of non-residents and dealers. We restricted our choice to a group of investors for which the total sum of these absolute values exceeded 99% of the sum across all samples of investors. By doing this, we excluded those investors whose total effect on the market balance was relatively insignificant.

As it is evident from test results for the case of the reduced sample of investors are much more Table 3, the convincing than for the case of the full sample. The null hypothesis was rejected with good probability for each episode except the second one. Interestingly, exclusion of investors from Cyprus (for which we do not have information that they were not 100% foreign) increased the significance of the test for each episode except the first one (see the last row). This result provides evidence in favor of the hypothesis that a significant share of investors from Cyprus were Russian offshore companies.

6. DID NOT RESIDENTS HERD?

One of the hypotheses that was put forward to explain the difference in behavior between residents and non-residents was the hypothesis of herding behavior. The notion of herding behavior implies that investors rationally imitate the actions of each other or some specific agent, possibly ignoring their own private information. Imitation can take different forms and in practice it is almost impossible to statistically distinguish between two sources of group behavior: imitation and common information. The simplest case of herding behavior is the imitation of observed actions of a large investor (leader) that is supposedly better informed than others. In the case of the GKO-OFZ market we can easily single out the largest non-residents who differed from others with respect to both the size of portfolio and volume of secondary market operations (see Fig. 5). In fact, we do not know for sure that non-residents observed the behavior of the largest non-resident but this does not seem to be unrealistic provided that the group of key non-residents consisted of a relatively small number of investors. It is known that Russian traders of large foreign institutions communicated with each other and this could have been one way of spreading information between non-residents.

Table 3. Test of the hypothesis of no difference in buyers' ratio between residents and non-residents.

Episode	1		2		3	
	100%	99%	100%	99%	100%	99%
Non-res.	0.59 (33/56)	0.49 (22/45)	0.62 (72/116)	0.53 (36/68)	0.44 (54/124)	0.24 (15/63)
Dealers	0.62 (150/242)	0.61 (64/105)	0.61 (160/262)	0.61 (77/127)	0.47 (122/261)	0.37 (47/128)
Cyprus	0.58 (1/12)	...	0.71 (27/38)	...	0.56 (27/48)	...
Incl. Cyprus	0.37	0.07***	0.62	0.12	0.27	0.02**
Excl. Cyprus	0.40	...	0.31	...	0.03	...

Episode	4		5	
	100%	99%	100%	99%
Non-res.	0.44 (43/97)	0.47 (24/51)	0.49 (46/94)	0.32 (16/50)
Dealers	0.30 (73/244)	0.15 (14/95)	0.52 (127/242)	0.47 (61/129)
Cyprus	0.47 (18/38)	...	0.73 (27/37)	...
Incl. Cyprus	0.00*	0.00*	0.28	0.02**
Excl. Cyprus	0.01**	...	0.00***	...

Note: 99% corresponds to results obtained for a reduced sample of market participants. In parentheses we show the number of buyers and the total number of observed investors from the corresponding group. The estimated share is given above in parentheses. The last two rows contain probabilities calculated from (8) for four episodes of market decline and one minus this value for the one episode of market recovery. */**/*** indicates significance at 90%/95%/99%, respectively.

The idea behind testing the hypothesis is to estimate the effect of the actions of the largest non-resident on the behavior of other non-residents. This is not an easy task since we need to study the disaggregated behavior of investors. The dynamic specification of actions of investors we borrowed from Welch (1999); however, we applied it to a different type of test. Welch (1999) studies the behavior of market analysts who supposedly tend to herd by following market consensus. Our task is to explain the difference in the behavior between the two groups of investors by providing evidence that investors from one of these groups imitate the actions of the leader.

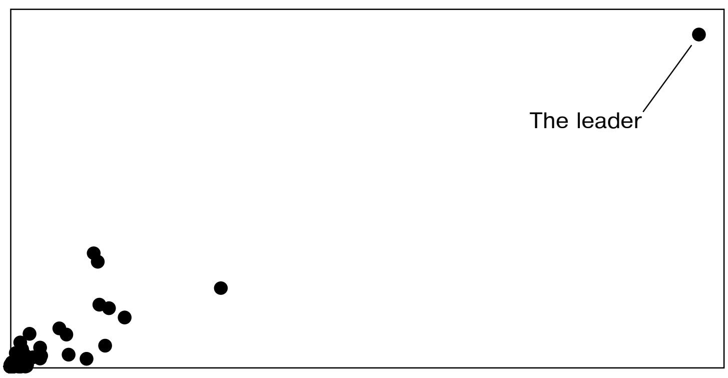

Fig. 5. Comparison of the leader with other non-residents.

Let us first describe the general form of the statistical model. The model specification assumes that investors follow discrete actions according to the Markov switching process. Suppose that in each period of time an investor can be in three states:[8] "buy", "sell", "indifferent". Each state is assigned one of three numbers: 1 (buy), 0 (indifferent), −1 (sell). There exists a matrix of unconditional transition probabilities $\{p_{ij}^0\}$ where p_{ij}^0 is the *ex ante* probability of transition from state i to state j between any two periods of time. These probabilities measure the uncertainty of individual decisions, which can not be attributed to common factors. Let $\rho_t \in [-1, 1]$ denote the time series of common factors that affect investors' choices. In any period the matrix of conditional probabilities of transition between states is a function of the matrix of unconditional probabilities and external variable ρ_t, which stands for common factors. The

[8] In Welch (1999) states are recommendations of analysts that take five values from "strong sell" to "strong buy".

functional relationship was borrowed from Welch (1999):

$$p_{i,j}^{t} =$$

$$= \frac{p_{i,j}^{0}[1+(\rho_t - j)^2]^{-\theta_t}}{p_{i,-1}^{0}\{1+[\rho_t - (-1)]^2\}^{-\theta_t} + p_{i,0}^{0}[1+(\rho_t - 0)^2]^{-\theta_t} + p_{i,1}^{0}[1+(\rho_t - 1)^2]^{-\theta_t}}, \quad (9)$$

here $i, j = -1, 0, 1$, p_{ij}^{0} — unconditional transition probabilities.

Parameter θ_t, which may be time dependent, measures the degree of influence of common factors on transition probabilities. Obviously, the bigger is θ_t, the more weight is given to the probability of the state, which is closer to the value of the external variable. There are two important problems with the practical implementation of any kind of test based on a general specification (9):

1. investors actions are not characterized by discrete variables;
2. investors are not homogeneous (for instance, they differ with respect to speculative activity).

The simplest approach to resolve the first problem is to assume that an investor is in the "sell" state if the value of securities sold during the corresponding day exceeds the value of securities bought. Similarly, the investor is considered to be in the "buy" state if the value of securities purchased exceeds the value of securities sold. If the investor does not participate in the market over the period under consideration, then he is assumed to be the "indifferent" state. This approach has a number of disadvantages that are related to non-homogeneity of market participants. One may suppose that investors were different with respect to their extent of involvement in market speculation. Some investors permanently purchased and sold securities which did not necessarily reveal their preferences with respect to increasing or reducing their portfolios. This is especially true if we consider short time intervals such as trading days. Suppose that an investor is actively involved in market speculation, selling and purchasing securities simultaneously. Most probably due to the dynamic nature of the process, the difference between value of sold and bought securities is different from zero over the trading day even if he is not inclined to change the volume of his portfolio. However, according to the above stated approach we will have to assume him to be either in the "buy" or "sell" state. Let us consider another investor who is not involved in market speculation and participates in the market only if he intends to change the volume of his portfolio. Obviously, the latter investor will be in the "indifferent" state more frequently than the former, and it would be incorrect to assume equal transition probabilities when modeling their behavior.

A straightforward modification of the approach is to assume that an investor is in the "sell" ("buy") state if the value of sold (purchased) securities "noticeably" exceeds the value of purchased (sold) ones. In order to correctly define the term "noticeably," let us consider some number $\alpha \in [0, 1]$ and define the states in the following way:

$\alpha B > S$ — an investor is in the "buy" state (1);

$\alpha S > B$ — an investor is in the "sell" state (0);

$\alpha \le S/B \le 1/\alpha$ — an investor is in the "indifferent" state (1/2).

Here B and S are values of securities bought and sold correspondingly.

Choice of parameter α, which ranges from 0 to 1, affects the results of model estimation. The parameter should be chosen in such a way that investors are reasonably homogeneous with respect to their activity in the market. Denote as a_t^k the variable that characterizes the actions of investor k in trading day t:

$a_t^k = 1,$ if $\alpha B_t^k > S_t^k$,

$a_t^k = -1,$ if $\alpha S_t^k > B_t^k$ and

$a_t^k = 0$ in other cases.

Suppose that we estimated transition probabilities by calculating their sample counterparts or by using the maximum likelihood method. Denote as p_{jt}^k the estimate of the probability of transition to state j ($j = -1, 0, 1$) in day t for k-th investor. Since the matrix of transition probabilities is invariant in time, its value is determined by the state in the previous moment of time. The probability that an investor will be in an "active" state, that is "buy" or "sell," in period t is equal to

$$p_t^k = 1 - p_{0t}^k .$$

In our notations, the following random variable has zero mean:

$$s_t^k = \left| \left| a_t^k \right| - p_t^k \right| - E \left| \left| a_t^k \right| - p_t^k \right| , \qquad (10)$$

where

$$E \left| \left| a_t^k \right| - p_t^k \right| = \left| 1 - p_t^k \right| p_t^k + \left| 0 - p_t^k \right| (1 - p_t^k) = 2 p_t^k (1 - p_t^k) .$$

Let us sort the whole sample of $2K$ market participants in descending order according to the number of days when an investor was in an active state. All market participants can be equally divided into two groups of more active and less active investors. If parameter α is close to unity, then we expect that the probability of being in an active state p_t^k will be overestimated for the group of less active investors ($E|a_t^k| < p_t^k$) and underestimated for the group of more active investors ($E|a_t^k| > p_t^k$). Let us assume that the probability of transition from any state to "indifference" state is greater then 1/2. Then for investors from the first subgroup, random variable s_t^k will have a negative bias:

$$\begin{aligned} Es_t^k &= E\left\| a_t^k \right| - p_t^k \right| - 2p_t^k(1 - p_t^k) = \\ &= \left|1 - p_t^k\right| E\left|a_t^k\right| + \left|0 - p_t^k\right| \left(1 - E\left|a_t^k\right|\right) - 2p_t^k(1 - p_t^k) = \\ &= \left(1 - p_t^k\right) E\left|a_t^k\right| + p_t^k \left(1 - E\left|a_t^k\right|\right) - 2p_t^k(1 - p_t^k) = \\ &= \left(E\left|a_t^k\right| - p_t^k\right)(1 - 2p_t^k) < 0, \end{aligned} \tag{11}$$

$k = 1, \ldots, K.$

With small values of α, the picture changes into the converse one. Indeed, under a stronger definition of active state, the frequency of sell and buy states for active investors goes sharply down which results in underestimation of the active state probability for the group of less active investors. It should be again emphasized that signs of biases depend on the assumption that the probability of transition in an active state is less than 1/2. The presence of biases can be digested in large samples. Hence, in order to test for biases we calculated the following statistics for a given value of α:

$$s_t = \frac{1}{K} \sum_{k=1}^{K} s_t^k \ . \tag{12}$$

By definition, s_t is the average of s_t^k across the sample of more active investors. If the null hypothesis about homogeneity of investors is correct, then for each period of time t we can assume s_t to be independent and normally distributed random variables according to the Central limit theorem. The null hypothesis can be tested using a simple t-test additionally assuming that s_t are realizations of single normally distributed random variables. A similar procedure is used in financial literature in order to test the hypothesis of herding behavior in stock markets (see Lakonishok *et al.*, 1992). Herding behavior is tested by calculating biases in tendencies to sell and buy individual assets.

Before we apply the methodology of choice of optimal transformation from continuous to discrete data, we need to make a preliminary analysis to construct a sample of investors. Since we expect to include all key market participants in the sample who were also the most speculatively active, then we should exclude inactive participants to ensure homogeneity of the sample. Let us consider the group of non-residents that held a non-zero GKO-OFZ portfolio throughout the crisis period. For different values of α and for each non-resident, we calculated the share of trading days when he was in one of the "active" states (active trading days).
The issue of heterogeneity of investors is related to the difference in de-

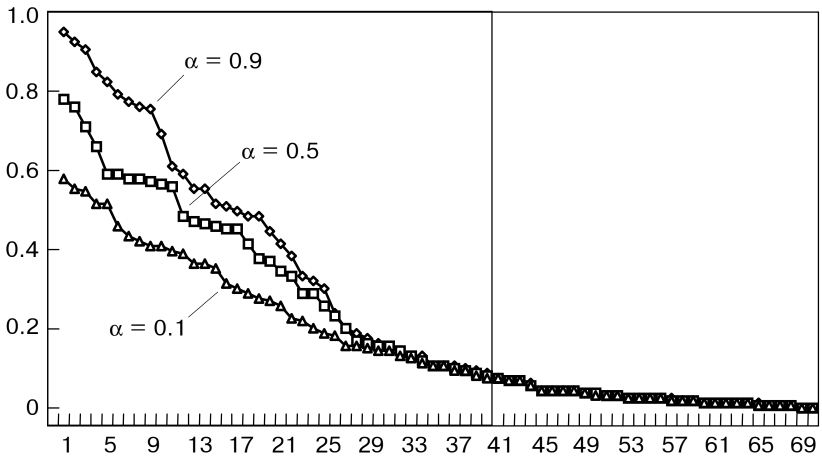

Fig. 6. Distribution of non-residents with respect to the share of active trading days.

gree of their involvement in market speculation. From Fig. 6 it can be seen that a change in value α makes a noticeable difference only for the first 30 investors. This observation gave us the justification for singling out active non-residents, which we assumed to be a group of homogeneous investors. There was still a technical problem; for different values of α, the group of the first 30 investors was not identical. Fortunately, by excluding investors from Cyprus[9] and the republics of the former Soviet

[9] Except those that are known to be 100% foreign companies.

Union, we were left with the group of 22 non-residents that were among the first 30 for all three values of α. Most of these non-residents are well-known international investment banks with headquarters in London. The fact that during the period of crisis about 90% of non-residents' GKO-OFZ portfolios were concentrated within this group of investors suggests that the sample includes key non-resident investors.

Applying the same approach to resident investors (here dealers), we have not found any observable break point between (speculatively) active and non-active investors (see Fig. 7). Hence, we decided to consider all the dealers that held non-empty GKO-OFZ portfolios throughout the period of crisis as a homogenous group of investors.

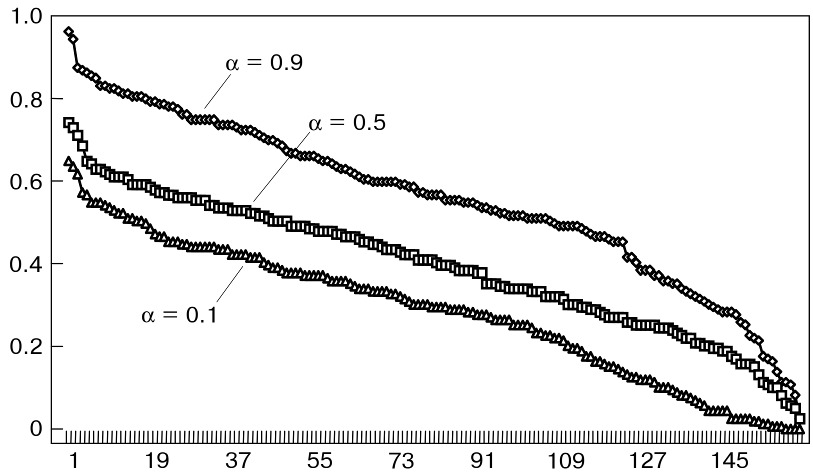

Fig. 7. Distribution of residents (dealers) with respect to share of active trading days.

Based on the sample of market participants, we tested for homogeneity using different values of α which are uniformly distributed in [0, 1] (see Table 4).

Table 4. Test for homogeneity.

α	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
t-statistic	8.66	6.10	3.72	1.31	−1.48	−3.66	−4.56	−0.33	6.34	20.43

First we estimated transition probabilities by means of the maximum likelihood method and then calculated t-statistics for the test of bias of s_t (see (12)). The minimal value of t-statistic is achieved for $\alpha = 0.8$. However, this is attributed to the probability of transition in an active state, which is close to 1/2 (see (11)). For $\alpha < 0.8$ this probability is less than 1/2, and for large values of the parameter we observe negative bias as expected. The values of t-statistics suggest that there is no significant bias for $\alpha = 0.4$ and 0.5. Hence, further we will base our conclusions on the results obtained for these two values of the parameter α.

Now we turn to the specification of the appropriate model of testing for herding behavior. We model the behavior of investors as a Markov process with the matrix of conditional transition probabilities being a function of the matrix of unconditional probabilities where the external variable that stands for common factors (see (9)). The difference in behavior between residents and non-residents can appear in different matrices of unconditional probabilities, time path of common factors and parameter θ. As it follows, we have many dimensions of possible differences. The null hypothesis of no difference in behavior implies that non-residents' behavior was not influenced by some private information which is different from the common information available to residents. Let us assume the following proxy for common factors that affected the actions of residents:[10]

$$\rho_t = \frac{1}{N_t} \sum_i \operatorname{sign}\left[\sum_{\tau=1}^{5} \left(b_{it-\tau} - s_{it-\tau} \right) \right]. \tag{13}$$

Here N_t is the number of residents that participated in secondary trading in any of five previous trading days, $b_{it-\tau}$ and $s_{it-\tau}$ are values of securities bought and sold correspondingly during trading day $t - \tau$.

Let us place a restriction on the matrices of unconditional transition probabilities for residents and non-residents by assuming them to be equal. In this case the test of the null hypothesis of no difference takes the form of testing equality $\theta_r = \theta_n$, where θ_r and θ_n are θ-coefficients in function (9) for residents and non-residents correspondingly and ρ_t is defined by (13).

Suppose, however, that non-residents were different with respect to speculative activity, which does not mean that they had different preferences. In terms of the model, this implies that the matrix of transition

[10] The number of days was chosen arbitrarily.

probabilities for non-residents is different from that of residents. Hence, θ_n estimated under the assumption of no difference in matrices can naturally deviate from θ_r. Nevertheless, we can still expect that it should not be negative. Hence if there was no difference in behavior between residents and non-residents, we expect to find that residents' common information affected the actions of non-residents in the same manner: $\theta_n > 0$. We will use the last inequality as a formal representation of the null hypothesis. One of the reasons behind adopting the assumption of equal transition probabilities was the small number of analyzed non-residents (only 21 excluding the leader), which is insufficient to produce reliable estimates of transition probabilities.[11]

Before we proceed with the statistical analysis, we need to determine the period of estimation. Statistical models of the stationary type like our model require a stationary time series. For example, in the case of simple linear regression, if the dependent variable has a significant outlier in some period of time, then estimates of regression coefficients are significant if and only if the independent variables explain this particular event. In other words, the major weight in regression is assigned to this particular moment of time; therefore, estimation results are non-informative. The same kind of phenomenon can happen in our case taking also into account that we are dealing with a crisis period. In order to restrict the period of observations by excluding sharp movements in the series, we constructed an indicator that measured the gap in trading tendencies between residents and non-residents. For the sample of non-residents we calculated the indicator of their average direction of trade the same way as it was done for residents (see (13)) and denoted it as ρ_t^n. We used series $\rho_t - \rho_t^n$ as a dynamic measure of the gap (see Fig. 8).

In the graph, we show the point of time that corresponds to the arrival of news about the agreement reached between the Russian government and the IMF on emergency credit to support the balance of payments. One can observe sharp and sizeable movements of the indicator thereafter. Based on this observation we restricted the period of estimation by excluding this time interval. Precisely, we chose the following period for estimating the model parameters: November 1997 – mid-July 1998.[12]

The results of the test are given in Table 5. Estimation was carried out using maximum likelihood methodology. The significance of coefficients

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[11] Welch (1999) does not estimate these probabilities and assumes them equal to sample frequencies. We can not use this approach again because of the insufficient number of observations.

[12] November 3, 1997 – July 14, 1998.

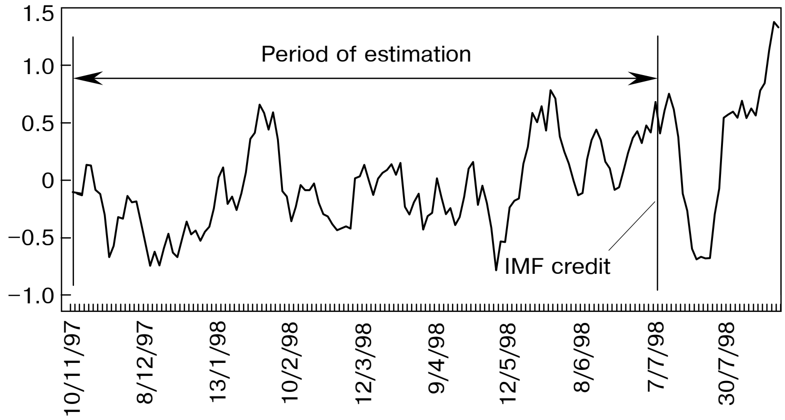

Fig. 8. Gap between average behavior of residents and non-residents.

was verified using asymptotic properties of the maximum likelihood estimator: $-2(L_R - L_{UR}) \sim \chi^2(1)$.

Table 5. Test of the difference of behavior between residents and non-residents.

α	0.3	0.4	0.5	0.6
N_r	7434	8032	8700	9436
N_n	1232	1294	1363	1439
θ_r	0.30*** (0.00%)	0.30*** (0.00%)	0.32*** (0.00%)	0.30*** (0.00%)
θ_n	−0.21*** (0.87%)	−0.18** (2.19%)	−0.14* (7.92%)	−0.12 (13.01%)

Note: N_r — total number of individual observations that correspond to active states of residents. N_n — the same for non-residents (21 investors excluding the leader). Significance is shown in parenthesis: */**/*** indicates significance at 90%/95%/99% correspondingly.

We excluded the leader from the sample of non-residents since his actions will be considered as an exogenous factor. As it follows from Table 5, the hypothesis of no difference in behavior between residents and non-residents is rejected with good probability for $\alpha = 0.4$. For all considered values of α, estimates of θ_r are significantly positive and almost identical. Therefore, the use of a proxy for residents' common information seems to be justified.

The idea of testing for herding behavior is the following. We allow coefficient θ_n to be time dependent by introducing the behavior of the leader as an external factor that might have affected the intensity and sign of influence of common information available to residents on non-residents' behavior. If there was no imitation, then we expect to find that this effect is insignificant. Let us denote as l_t the sign of the net value of state bonds purchased by the leader in the secondary market during the period of [t − 1, t − 5]. We expect that the more the action of the leader deviated from residents' behavior, the less non-residents were sensitive to residents' common factors. Formally the gap between residents' behavior and leader's actions was proxied by $(l_t - \rho_t)^2$:

$$\theta_{nt} = \theta_{n0} + \phi(l_t - \rho_t)^2 . \qquad (14)$$

The case of $\phi = 0$ corresponds to no influence of the leader on the actions of other non-residents. In the opposite case we expect it to be significantly negative.

Note that results obtained from model estimation based on (14) can be interpreted differently. One may argue that if the leader's behavior was not different from that of an average non-resident, then $(l_t - \rho_t)^2$ also measures the gap between the directions of trade of residents and non-residents. In this case, the fact that this gap negatively influences coefficient θ_{nt} only suggests that there was no convergence between the trading tendencies of residents and non-residents but does not provide evidence of imitation. To control for this possibility we included $(\rho_t - \rho_t^n)^2$ in the linear equation (14):

$$\theta_{nt} = \theta_{n0} + \phi(l_t - \rho_t)^2 + \varphi(\rho_t^n - \rho_t)^2 . \qquad (15)$$

The results of the estimation based on (15) are given in Table 6. As it follows the hypothesis of herding behavior is supported. Indeed, coefficient ϕ proved to be negative with a good degree of significance for both considered values of α. Estimates of φ are positive, however, of low significance.

The applied specification allows for testing the importance of herding behavior in explaining the lack of relationship between non-residents' behavior and residents' common factors. Strictly speaking we can not test the hypothesis that non-residents' behavior would not have been different from that of residents' behavior if there had been no imitation. Imitation is already inherent in the estimated parameters of the model, and we can not exclude it by placing restrictions on the coefficients. However, we can compare the imaginable behavior of non-residents and residents if the leader did not deviate in his behavior from the representative resident. Let us denote as i_t^* the stochastic process such that

$$\mathrm{cov}(I_t^*, I_{t-\tau}^*) = 0 , \qquad I_t^* = -1 \text{ or } 1, \text{ and } E(I_t^*) = \rho_t. \tag{16}$$

Table 6. Test for the hypothesis of herding behavior.

	0.3	0.4	0.5	0.6
N_r	7434	8032	8700	9436
N_n	1232	1294	1363	1439
N_l	58	69	80	92
θ_r	0.30*** (0.00%)	0.30*** (0.00%)	0.32*** (0.00%)	0.31*** (0.00%)
θ_{no}	0.15 (47.72%)	0.29 (16.68%)	0.40* (5.58%)	0.49** (1.97%)
ϕ	−0.36** (3.57%)	−0.44** (0.95%)	−0.50*** (0.26%)	−0.62*** (0.06%)
φ	0.37 (30.75%)	0.39 (28.44%)	0.38 (28.80%)	0.49 (17.16%)

Note: N_r — total number of individual observations that correspond to active states of residents. N_n — the same for non-residents (21 investor excluding the leader). N_l — number of observations of the leader's active states. Significance is shown in parentheses: */**/*** indicates significance at 90%/95%/99% correspondingly.

In this case coefficient θ_{nt} is also a stochastic process and is described by the following equation:

$$\theta_{nt} = \theta_{n0} + \phi(I_t^* - \rho_t)^2 , \tag{17}$$

with mean

$$E(\theta_{nt}) = \theta_{n0} + \phi(1-\rho_t)(1+\rho_t) . \tag{18}$$

Random variable θ_{nt} can take both positive and negative values even if the actions of the leader were not different from that of the average resident. Moreover, its mean can also take on negative values. Nevertheless, one can expect that "on average" θ_{nt} is positive. In other words, the following constant should be positive:

$$\theta_n^* = \frac{1}{T}\sum_t E(\theta_{nt}) = \theta_{n0} + \phi A , \quad (19)$$

where

$$A = \frac{1}{T}\sum_t (1-\rho_t)(1+\rho_t) .$$

The statistical significance of θ_n^* can be tested and is equivalent to the significance of the following restriction placed on the coefficients of equation (14):

$$\theta_{n0} + \phi A = 0 . \quad (20)$$

Hence, in order to test if herding behavior explains the lack of relationship between residents' common factors and non-residents' behavior, we estimate the coefficients of equation (14) and test restriction (20). The results of the test are presented in Table 7.

Table 7. Evaluation of the significance of herding behavior.

α	0.3	0.4	0.5	0.6
N_r	7434	8032	8700	9436
N_n	1232	1294	1363	1439
N_l	58	69	80	92
θ_n^*	−0.15* (9.64%)	−0.10 (25.33%)	−0.04 (64.37%)	−0.00 (42.89%)

Note: N_r — total number of individual observations that correspond to active states of residents. N_n — the same for non-residents (21 investor excluding the leader). N_l — number of observations of the leader's active states. Significance is shown in parentheses: */**/*** indicate significance at 90%/95%/99% correspondingly.

As it follows, exclusion of the effect of the leader leads to insignificant estimates of θ_n meaning that herding behavior at least explains the polar difference in behavior between residents and non-residents. It should be emphasized that results of this kind of analysis depend on the assumed statistical model. Indeed, we can not guarantee that if another, for example, more sophisticated model was applied that we would arrive at similar conclusions. In other words, we tested if the herding by non-residents explains the "observed" difference in behavior between residents and non-residents.

7. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper, we analyzed the behavior of non-residents during the period of the Russian financial crisis of 1997–1998. The purpose of this research was to explain the commonly accepted fact, which was also supported by data, that non-residents destabilized the state bond market during the crisis period. It is obviously impossible within one study to cover all related issues and provide a comprehensive analysis of all possible explanations of the stylized facts. Therefore we concentrated on two hypotheses that seem to be realistic for the case of the Russian financial market. The first hypothesis states that the destabilizing behavior of non-residents can be explained by their relative overreaction to fundamentals. Non-residents being global investors have highly diversified portfolios and hence have richer alternative opportunities for investment. The theoretical model developed in this paper allowed us to draw the following major conclusions:

1. in a country with high investment risk, non-residents contribute to a greater fall in prices in the bond market after adverse external internal shocks to fundamentals;
2. it is unlikely that non-residents and residents will differ with respect to the share of buyers during transition from one equilibrium to another after external shocks to fundamentals.

The first conclusion supports the initial argument that the destabilizing behavior of non-residents can be attributed to the natural differences in alternative investment opportunities. The second conclusion provides us with a clear implication that provides a means for testing the hypothesis. As it follows from the statistical analysis, non-residents and residents were significantly different with respect to their buyer ratio. This result suggests that the hypothesis does not explain all stylized facts.

The second hypothesis that was considered in the paper was whether non-residents exhibit herding behavior as a result of imitating leaders' actions. The rationale behind this hypothesis was the observation of a large foreign investor (the leader) that was noticeably different from others both with respect to the size of GKO-OFZ portfolio and volume of secondary market operations and a relatively narrow group of key non-residents. The results of the statistical testing of this hypothesis suggest that:

1. the leader's actions had significant impact on the behavior of other key foreign participants;
2. herding behavior at least explains the polar difference in behavior between residents and non-residents.

There are several policy implications that can be derived from our findings. First, non-residents should not be freely allowed to enter financial markets of unstable economies. It is likely that the presence of non-residents will lead to an overreaction of the market to changes in fundamentals. This overreaction is a benefit in good times but can be fatal in bad ones. Second, authorities should pay attention to the microstructure of market participants. In particular, there should not be "leaders" in the market that can influence the decisions of other market participants. This can be achieved by placing quantitative restrictions on investments made by individual companies. Foreign companies may overcome such barriers by investing via numerous branches; however, this measure is not absolutely ineffective. Indeed, first, it is costly for investors to establish many branches to perform one task. Another argument is that the diffusion of the portfolio of a large investor between different companies will make it less likely that the market will have reliable information about his strategy.

A high degree of concentration of foreign investment is the natural outcome of two factors that are relevant for an emerging market economy: 1) high information costs that require scaled investment to make market research profitable; 2) relatively low financial capitalization that forces a scaled investor to hold a significant portion of the market. As it follows, a large investor is also an informed investor, which is good rather than bad. This argument obviously makes sense; however, our findings suggest that the problem of possible adverse outcomes of a leader-type market should not be ignored.

APPENDICES

1. Proof of Proposition 1

Let us denote as $D_{r(n)}(p,\ q)$ the function of residents' (non-residents') demand for bonds. The equilibrium condition under the assumption of fixed supply can be formally written as

$$D_r(p,q) + D_n(p,q) = S\ . \quad (21)$$

A necessary and sufficient condition for non-residents to sell bonds and residents to buy bonds in equilibrium in the case of a small decrease in q (dq < 0) is a positive sign of the full derivative of non-residents' demand function with respect to q. According to the definition,

$$D_I = \frac{A_I \omega_i}{p} \ \ (i = r,\ n).$$

A negative change in q has its effect on demand via three channels. A fall in expected payoff results in reduction of the optimal share of assets to be invested in bonds for any given level of prices. Decease in prices have two opposite effects. Firstly, lower prices have positive effect on the demand due to substitution effect, secondly, lower prices result in loss of value of previously held portfolio, which translates into lower demand. Prior to the shock, investors held

$$\frac{A\omega}{p}$$

bonds. Hence, the change in the value of assets due to a change in price is equal to

$$\frac{A\omega}{p} dp\ .$$

A change in demand due to devaluation of assets is equal to

$$\delta D = \frac{\omega}{p} \delta A = \frac{\omega}{p} \frac{A\omega}{p} dp = \frac{D\omega}{p} dp\ .$$

The full differential of demand is the following:

$$dD = \delta D + \frac{\partial D}{\partial p} dp + \frac{\partial D}{\partial q} dq = \left(\frac{D\omega}{p} + \frac{\partial D}{\partial p} \right) dp + \frac{\partial D}{\partial q} dq\ . \quad (22)$$

By differentiating (21) using expression (22), we arrive at the following expression for the price differential:

$$dp = \frac{1}{\Delta}\left(\frac{\partial D_n}{\partial q} + \frac{\partial D_r}{\partial p}\right) dq \,,$$

where

$$\Delta = -\left(\frac{\partial D_n}{\partial p} + \frac{\partial D_r}{\partial p} + \frac{\omega_n D_n}{p} + \frac{\omega_r D_r}{p}\right).$$

By assumption of the proposition, a worsening in fundamentals leads to a decrease in prices or

$$\frac{dp}{dq} > 0 \,.$$

As it will be shown below, partial derivatives of investors' demand with respect to q are positive; hence, we are able to conclude that $\Delta > 0$. After differentiation of equality (21) and substitution of the expression for the price differential, it is straightforward to obtain the necessary and sufficient conditions for non-residents to sell and residents to buy after an adverse external shock:

$$\frac{dD_n}{dq} = \frac{1}{\Delta}\left(\frac{\partial D_n}{\partial p}\frac{\partial D_r}{\partial q} - \frac{\partial D_n}{\partial q}\frac{\partial D_r}{\partial p} + \frac{\omega_n D_n}{p}\frac{\partial D_r}{\partial q} - \frac{\omega_r D_r}{p}\frac{\partial D_n}{\partial q}\right) > 0 \,.$$

Since by assumption the denominator in the right hand side of the equality is positive, then the necessary and sufficient condition can be written as

$$\frac{\partial D_n}{\partial p}\frac{\partial D_r}{\partial q} - \frac{\partial D_n}{\partial q}\frac{\partial D_r}{\partial p} - \frac{\omega_n D_n}{p}\frac{\partial D_r}{\partial q} - \frac{\omega_r D_r}{p}\frac{\partial D_n}{\partial q} > 0 \,. \qquad (23)$$

Due to

$$\frac{\partial D_{n(r)}}{\partial q} > 0 \,,$$

(20) is equivalent to:

$$\frac{\partial D_n / \partial p}{\partial D_n / \partial q} - \frac{\partial D_r / \partial p}{\partial D_r / \partial q} + \frac{\omega_n D_n}{p\, \partial D_n / \partial q} - \frac{\omega_r D_r}{p\, \partial D_r / \partial q} > 0 \,. \qquad (24)$$

The necessary and sufficient condition for non-residents to sell bonds and residents to buy bonds in the case of an increase in δ^2 is the negative sign of the full derivative of non-residents' demand with respect to δ^2 ($d\delta^2 > 0$):

$$\frac{dD_n}{d\delta^2} = \frac{1}{\Delta}\left(\frac{\partial D_n}{\partial p}\frac{\partial D_r}{\partial \delta^2} - \frac{\partial D_n}{\partial \delta^2}\frac{\partial D_r}{\partial p}\frac{\omega_n D_n}{p}\frac{\partial D_r}{\partial q} - \frac{\omega_r D_r}{p}\frac{\partial D_n}{\partial q}\right) < 0 . \quad (25)$$

Dividing both sides of inequality (22) by the positive number

$$\frac{\partial D_r}{\partial \delta^2}\frac{\partial D_n}{\partial \delta^2},$$

we obtain the following equivalent condition:

$$\frac{\partial D_n / \partial p}{\partial D_n / \partial \delta^2} - \frac{\partial D_r / \partial p}{\partial D_r / \partial \delta^2} + \frac{\omega_n D_n}{p\, \partial D_n / \partial \delta^2} - \frac{\omega_r D_r}{p\, \partial D_r / \partial \delta^2} < 0 . \quad (26)$$

From the first order condition of the maximization of expected utility (2), it is easy to get the following internal solutions for optimal shares of assets invested in bonds:

$$\omega_n = \frac{r - r_n + 2\gamma\sigma_n^2}{2\gamma(\sigma_n^2 + \sigma^2)},$$
$$\omega_r = \frac{r - r_r + 2\gamma\sigma_r^2}{2\gamma(\sigma_r^2 + \sigma^2)}. \quad (27)$$

Here ω_n and ω_r are shares of assets of non-residents and residents invested in bonds. After substitution of $r = q/p - 1$ and $\sigma^2 = \delta^2/p^2$, (27) is transformed into

$$D_i = A_i \frac{\omega_i}{p} = A_i \frac{q - p - pr_i + 2\gamma\sigma_i^2 p}{2\gamma(\delta^2 + p^2\sigma_i^2)}, \qquad i = n, r. \quad (28)$$

Differentiating (28) with respect to p, q and δ^2 we obtain

$$\frac{\partial D_i}{\partial p} = \frac{A_i}{2\gamma(\delta^2 + p^2\sigma_i^2)}\left[2\gamma(\sigma^2 - \sigma_i^2)\omega_i - r - 1\right], \quad i = n, r, \quad (29)$$

$$\frac{\partial D_i}{\partial q} = \frac{A_i}{2\gamma(\delta^2 + p^2\sigma_i^2)}, \quad i = n, r, \quad (30)$$

$$\frac{\partial D_i}{\partial \delta^2} = -\frac{A_i\omega_i}{p(\delta^2 + p^2\sigma_i^2)}, \quad i = n, r. \quad (31)$$

Let us prove the first statement of the proposition.

$$\frac{\partial D_n/\partial p}{\partial D_n/\partial \delta^2}-\frac{\partial D_r/\partial p}{\partial D_r/\partial \delta^2}\frac{\omega_n D_n}{p\,\partial D_n/\partial \delta^2}-\frac{\omega_r D_r}{p\,\partial D_r/\partial \delta^2}=$$
$$=\frac{2\gamma_n(\sigma^2-\sigma_n^2)\omega_n-1-r}{-\omega_n}p-\frac{2\gamma_r(\sigma^2-\sigma_r^2)\omega_r-1-r}{-\omega_r}p-$$
$$-2\gamma_n\omega_n(\sigma^2+\sigma_n^2)+2\gamma_r\omega_r(\sigma^2+\sigma_r^2)=$$
$$=p\begin{Bmatrix}(1+r)\left(\frac{1}{\omega_n}-\frac{1}{\omega_r}\right)+2\gamma_n[\sigma^2-\sigma_n^2-\omega_n(\sigma^2+\sigma_n^2)]+\\+2\gamma_r[\sigma_r^2-\sigma^2+\omega_r(\sigma^2+\sigma_r^2)]\end{Bmatrix}\geq$$
$$\geq p\omega_n\omega_r\left\{(\omega_r-\omega_n)-2\gamma_n\omega_n\omega_r[\sigma_n^2+\omega_n(\sigma^2+\sigma_n^2)]-2\gamma_r\omega_n\omega_r\sigma^2\right\}\geq$$
$$\geq p\omega_n\omega_r[(\omega_r-\omega_n)-4\max(\gamma_n,\gamma_r)\omega_n\omega_r(\sigma_n^2+\sigma^2)]\geq$$
$$\geq p\omega_n\omega_r[(\omega_r-\omega_n)-4\max(\gamma_n,\gamma_r)\omega_n(\sigma_n^2+\sigma^2)]\,.$$

Using assumption $\omega_r>\omega_n[1+4\max(\gamma_n,\gamma_r)(\sigma^2+\sigma_n^2)]$, we conclude that inequality (26) does not hold.

Let us prove the second statement of the proposition.

Using (29) and (30) we can rewrite the left-hand side of inequality (21) in the following way:

$$\frac{\partial D_n/\partial p}{\partial D_n/\partial q}-\frac{\partial D_r/\partial p}{\partial D_r/\partial q}\frac{\omega_n D_n}{p\,\partial D_n/\partial q}-\frac{\omega_r D_r}{p\,\partial D_r/\partial q}=$$
$$=2\gamma_n\omega_n[\sigma^2-\sigma_n^2+\omega_n(\sigma^2+\sigma_n^2)]+2\gamma_r\omega_r[\sigma_r^2-\sigma^2-\omega_r(\sigma^2+\sigma_r^2)].\qquad(32)$$

If we skip the first term in the sum due to its small value, following the assumption of the proposition, then inequality (21) holds if and only if the expression in the parentheses is positive. Hence, if the variance of residents' alternative investment is not large enough, then non-residents buy bonds in equilibrium. In the opposite case non-residents sell bonds to resident investors.

2. Proof of Proposition 2

In period 1, there exist four types of investors that differ with respect to type and information received. For convenience, we can assume that the separation of optimists and pessimists occurred in period 0. Hence, we can consider q as a parameter and the demand for bonds by each type of investors as a function of this parameter. Further in the proof, we will abstract from the wealth effect since it works against the difference between residents and residents and assume A_i (i = n, r) to be constant. In other words, condition (7) is also sufficient if we take into account the wealth effect.

Similar to what has been done in the proof of Proposition 1, it easy to establish that the necessary and sufficient condition for pessimistic non-residents to sell is

$$\left(\frac{\partial D_n^-}{\partial p}\frac{\partial D_n^+}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_n^+}{\partial p}\right)+\left(\frac{\partial D_n^-}{\partial p}\frac{\partial D_r^+}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_r^+}{\partial p}\right)+ \\ +\left(\frac{\partial D_n^-}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_r^-}{\partial p}\right)>0. \quad (33)$$

If we note that

$$\frac{\partial q^+}{\partial q}=1-\pi, \quad \frac{\partial q^-}{\partial q}=\pi ,$$

then it is straightforward to obtain the following expressions for the partial derivative (similar to (29) and (30)):

$$\frac{\partial D_n^{+(-)}}{\partial p}=\frac{A_n^{+(-)}}{2\gamma(\delta^2+p^2\sigma_n^2)}[2\gamma(\sigma^2-\sigma_n^2)\omega_n-r-1]<0 ;$$

$$\frac{\partial D_r^{+(-)}}{\partial p}=\frac{A_r^{+(-)}}{2\gamma(\delta^2+p^2\sigma_r^2)}[2\gamma(\sigma^2-\sigma_r^2)\omega_r-r-1]<0 ;$$

$$\frac{\partial D_n^+}{\partial q}=\frac{(1-\pi)A_n^+}{2\gamma(\delta^2+p^2\sigma_n^2)}>0; \quad \frac{\partial D_n^-}{\partial q}=\frac{\pi A_n^+}{2\gamma(\delta^2+p^2\sigma_n^2)}>0 ;$$

$$\frac{\partial D_r^+}{\partial q}=\frac{(1-\pi)A_r^+}{2\gamma(\delta^2+p^2\sigma_r^2)}>0; \quad \frac{\partial D_r^-}{\partial q}=\frac{\pi A_r^+}{2\gamma(\delta^2+p^2\sigma_r^2)}>0 .$$

Let us prove that pessimistic non-residents reduce their portfolio in equilibrium given the specified external shock to fundamentals. It suffices to show that each term in the sum in the left-hand side of (33) is positive:

$$\frac{\partial D_n^-}{\partial p}\frac{\partial D_n^+}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_n^+}{\partial p}=\frac{(2\pi-1)A_n^+A_n^-}{(2\gamma)^2(\delta^2+p^2\sigma_n^2)^2}[1+r-2\gamma(\sigma^2-\sigma_n^2)\omega_n]>0 .$$

This inequality follows from the assumption that the partial derivative of demand for bonds is negative with respect to the price.

$$\frac{\partial D_n^-}{\partial p}\frac{\partial D_r^+}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_r^+}{\partial p}=\frac{A_n^- A_r^+}{(2\gamma)^2(\delta^2+p^2\sigma_n^2)(\delta^2+p^2\sigma_r^2)}\times$$
$$\times[2\gamma(1-\pi)(\sigma^2-\sigma_n^2)\omega_n+2\gamma\pi(\sigma_r^2-\sigma^2)\omega_r+(2\pi-1)(1+r)]>0,$$

$$\frac{\partial D_n^-}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_n^-}{\partial q}\frac{\partial D_r^-}{\partial p}=\frac{A_n^- A_r^-\pi}{(2\gamma)^2(\delta^2+p^2\sigma_n^2)(\delta^2+p^2\sigma_r^2)}\times$$
$$\times[2\gamma(\sigma^2-\sigma_n^2)\omega_n+2\gamma(\sigma_r^2-\sigma^2)\omega_r]>0.$$

Similarly we arrive at the necessary and sufficient condition that optimistic residents buy bonds in equilibrium.

$$\left(\frac{\partial D_r^+}{\partial p}\frac{\partial D_n^-}{\partial q}-\frac{\partial D_r^+}{\partial q}\frac{\partial D_n^-}{\partial p}\right)+\left(\frac{\partial D_r^+}{\partial p}\frac{\partial D_n^+}{\partial q}-\frac{\partial D_r^+}{\partial q}\frac{\partial D_n^+}{\partial p}\right)+$$
$$+\left(\frac{\partial D_r^+}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_r^+}{\partial q}\frac{\partial D_r^-}{\partial p}\right)<0.$$

Let us show that each term in the sum is negative. It was already proven that the first one is negative.

$$\frac{\partial D_r^+}{\partial p}\frac{\partial D_n^+}{\partial q}-\frac{\partial D_r^+}{\partial q}\frac{\partial D_n^+}{\partial p}=$$
$$=\frac{-2\gamma A_n^+ A_r^+(1-\pi)}{4\gamma_n\gamma_r(\delta^2+p^2\sigma_n^2)(\delta^2+p^2\sigma_r^2)}[\gamma_n\omega_n(\sigma^2-\sigma_n^2)+\gamma_r\omega_r(\sigma_r^2-\sigma^2)]<0,$$

$$\frac{\partial D_r^+}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_r^+}{\partial q}\frac{\partial D_r^-}{\partial p}=$$
$$=\frac{-A_r^+ A_r^-(2\pi-1)}{(2\gamma_r)^2(\delta^2+p^2\sigma_r^2)}[1+r+2\gamma_r(\sigma_r^2-\sigma^2)\omega_r]<0.$$

The necessary and sufficient condition for optimistic non-residents to buy is

$$\left(\frac{\partial D_n^+}{\partial p}\frac{\partial D_n^-}{\partial q}-\frac{\partial D_n^+}{\partial q}\frac{\partial D_n^-}{\partial p}\right)+\left(\frac{\partial D_n^+}{\partial p}\frac{\partial D_r^+}{\partial q}-\frac{\partial D_n^+}{\partial q}\frac{\partial D_r^+}{\partial p}\right)+$$
$$+\left(\frac{\partial D_n^+}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_n^+}{\partial q}\frac{\partial D_r^-}{\partial p}\right)<0.$$

The first term is less than zero as was proven above. Let us show that under the conditions stated in Proposition 2, the sum of the last two terms on the left hand side of the inequality is also less than zero.

$$\left(\frac{\partial D_n^+}{\partial p}\frac{\partial D_r^+}{\partial q}-\frac{\partial D_n^+}{\partial q}\frac{\partial D_r^+}{\partial p}\right)+\left(\frac{\partial D_n^+}{\partial p}\frac{\partial D_r^-}{\partial q}-\frac{\partial D_n^+}{\partial q}\frac{\partial D_r^-}{\partial p}\right)=$$

$$=\frac{2A_n^+A_r^+(1-\pi)}{4\gamma_n\gamma_r(\delta^2+p^2\sigma_r^2)(\delta^2+p^2\sigma_n^2)}[\gamma_n\omega_n(\sigma^2-\sigma_n^2)+\gamma_r\omega_r(\sigma_r^2-\sigma^2)]+$$

$$+\frac{A_n^+A_r^-}{4\gamma_n\gamma_r(\delta^2+p^2\sigma_r^2)(\delta^2+p^2\sigma_n^2)}\times$$

$$\times[2\gamma_n\pi(\sigma^2-\sigma_n^2)\omega_n+2\gamma_r(1-\pi)(\sigma_r^2-\sigma^2)\omega_r-(2\pi-1)(1+r)]\ .$$

After reduction by a common multiplier, we get the following equivalent condition:

$$A_r^+(1-\pi)[(\sigma^2-\sigma_n^2)\gamma_n\omega_n+(\sigma_r^2-\sigma^2)\gamma_r\omega_r]+$$

$$+A_r^-[\pi(\sigma^2-\sigma_n^2)\gamma_n\omega_n+(1-\pi)(\sigma_r^2-\sigma^2)\gamma_r\omega_r]<\frac{2\pi-1}{2}(1+r)A_r^-.$$

Rearranging terms, we have

$$(\sigma^2-\sigma_n^2)[A_r^+(1-\pi)+A_r^-\pi]\ \gamma_n\omega_n+(\sigma_r^2-\sigma^2)\,A_n\gamma_r\omega_r(1-\pi)<\frac{2\pi-1}{2}(1+r)A_r^-.$$

Dividing both sides by $A_r=A_r^-+A_r^+$ and substituting

$$x_r^{-(+)}=\frac{A_r^{-(+)}}{A_r^-+A_r^+}\ ,$$

$$\omega_r=\frac{\omega_r^+A_r^++\omega_r^-A_r^-}{A_r^++A_r^-}\ ,$$

$$x_r^+(1-\pi)+x_r^-\pi<\pi\ .$$

we arrive at the following inequality:

$$(\sigma^2-\sigma_n^2)\,\pi\gamma_n\omega_n+(\sigma_r^2-\sigma^2)\,\gamma_r\omega_r(1-\pi)<\frac{2\pi-1}{2}(1+r)\chi_r^-\ .$$

Making use of assumption $\gamma_n\omega_n \ll \gamma_r\omega_r$, $r\geq 0$ and the fact that due to an infinite number of investors, χ_r^- can take only two possible values:

π or $1 - \pi$ or at least not less than $1 - \pi$. We get the following sufficient condition:

$$\gamma_r(\sigma_r^2 - \sigma^2)\omega_r < \frac{2\pi - 1}{2}.$$

Now if we use assumption $\omega_r \le 0.5$, which implies that

$$\gamma_r(\sigma_r^2 - \sigma^2) \le r_r - r\ ,$$

we arrive at a weaker sufficient condition than (7):

$$r_r - r < 2\pi - 1. \tag{34}$$

Let us show that pessimistic residents sell bonds if condition (7) of the proposition holds. It suffices to show that

$$\left(\frac{\partial D_r^-}{\partial p}\frac{\partial D_n^-}{\partial q} - \frac{\partial D_r^-}{\partial q}\frac{\partial D_n^-}{\partial p}\right) + \left(\frac{\partial D_r^-}{\partial p}\frac{\partial D_r^+}{\partial q} - \frac{\partial D_r^-}{\partial q}\frac{\partial D_r^+}{\partial p}\right) + \\ + \left(\frac{\partial D_r^-}{\partial p}\frac{\partial D_n^+}{\partial q} - \frac{\partial D_r^-}{\partial q}\frac{\partial D_n^+}{\partial p}\right) > 0.$$

Since the second term was shown to be positive, we show that the sum of the other two is also positive.

$$\left(\frac{\partial D_r^-}{\partial p}\frac{\partial D_n^-}{\partial q} - \frac{\partial D_r^-}{\partial q}\frac{\partial D_n^-}{\partial p}\right) + \left(\frac{\partial D_r^-}{\partial p}\frac{\partial D_n^+}{\partial q} - \frac{\partial D_r^-}{\partial q}\frac{\partial D_n^+}{\partial p}\right) =$$

$$= \frac{2A_r^- A_n^- \pi}{4\gamma_n\gamma_r(\delta^2 + p^2\sigma_n^2)(\delta^2 + p^2\sigma_r^2)}[-(\sigma^2 - \sigma_n^2)\gamma_n\omega_n - (\sigma_r^2 - \sigma^2)\gamma_r\omega_r] +$$

$$+ \frac{A_r^- A_n^+}{4\gamma_n\gamma_r(\delta^2 + p^2\sigma_n^2)(\delta^2 + p^2\sigma_n^2)} \times$$

$$\times [(2\pi - 1)(1 + r_0) - 2\gamma_r(1 - \pi)(\sigma_r^2 - \sigma^2)\omega_r - 2\gamma_n\pi(\sigma^2 - \sigma_n^2)\omega_n].$$

Similar to the previous case, reduction by the common multiplier and re-arranging terms gives the following equivalent condition:

$$(\sigma^2 - \sigma_n^2)A_n\gamma_n\omega_n\pi + (\sigma_r^2 - \sigma^2)[A_n^-\pi + A_n^+(1 - \pi)]\ \gamma_r\omega_r < \frac{2\pi - 1}{2}(1 + r)A_r^-.$$

Using similar substitution, we arrive at

$$(\sigma^2 - \sigma_n^2)\pi\gamma_n\omega_n + (\sigma_r^2 - \sigma^2)\omega_r\gamma_r\pi < \frac{2\pi - 1}{2}(1 + r)\chi_n^+.$$

Taking into account that $\gamma_n \omega_n << \gamma_r \omega_r$, $\chi_n^+ > 1 - \pi$, we obtain the following sufficient condition:

$$\gamma_r (\sigma_r^2 - \sigma^2) \omega_r < \frac{(2\pi - 1)(1 - \pi)}{2\pi}. \tag{35}$$

Assumption $\omega_r \leq 0.5$ and its implication (see above) allows us to conclude that (35) follows from inequality (7).

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