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LOOKING BACK AT RUSSIAN FINANCIAL CRISIS

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Fundamental sources of the Russian financial crisis in 1998 are discussed. Focus is made on the time horizon of judgements concerning sustainability of the economic policy.

It is argued that the macroeconomic policy pursued by the monetary authorities was not robust in a medium run, but, in the absence of external shocks was far from the crisis area, and required moderate, feasible modifications to be viable in a medium run. After the sharp deterioration in the terms of trade the previously pursued policy was no more sustainable even in a short run. The implications of the crisis were aggravated by the overly optimistic expectations by the monetary authorities of the near-term recovery in the terms of trade.

A game model of the debt crisis is presented which predicts that under some circumstances (which have some common features with the situation in the Russian economy in 1998) increase in the size of reserves held by the Government may result in a further deterioration of the crisis. This may contribute to understanding of crisis occurrence immediately after disbursement of the long-awaited loan by the international institutions.

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В работе рассматриваются фундаментальные причины российского финансового кризиса в 1998 г. Особое внимание уделяется временному горизонту суждений относительно устойчивости экономической политики.

Показывается, что проводившаяся макроэкономическая политика не могла бы долгое время поддерживаться в неизменном виде, однако (при условии отсутствия внешних шоков) находилась еще достаточно далеко от кризисной зоны. Некоторые вполне реализуемые меры могли бы сделать ее жизнеспособной в среднесрочном плане. После резкого ухудшения условий торговли эта политика стала неприемлемой даже в краткосрочном плане. Последствия кризиса оказались усилены чрезмерно оптимистическим ожиданиями правительства скорого восстановления экспортных цен.

Далее описывается игровая модель долгового кризиса, предсказывающая, что в определенных условиях (имеющих общие черты с ситуацией, сложившейся в российской экономике в 1998 г.) увеличение резервов может привести к дальнейшему обострению кризиса. Это может служить одним из объяснений того, что финансовый коллапс наступил сразу после получения долгожданных кредитов от международных финансовых организаций.

ISBN

1. Causes of Russian financial crisis

The disputes on the nature and specifics of Russian crisis of 1998 have mainly passed, still fully convincing answers to many key questions are missing. We consider the same general factors as other authors [1-7], still the conclusions differ somewhat from the common views. One of our main points is to show that discussing Russian crisis one should make thorough difference between situation before and after commencement of crisis. Assertions on sustainability of macroeconomic policy which are often made without exact specification of timing an time horizon are rather misleading than explaining crisis causes.

Views on the origins of Russian crisis are lying in a broad range. Some analysts argue that Russia has experienced mainly debt crisis, which developed as a result of soft fiscal policy carried out by the government. It is often asserted that the GKO market was in fact a Ponzi scheme, and its collapse was initially inevitable, and was only slightly precipitated with the Asian crisis. According to this view, the debt crisis aroused the currency one, which otherwise would not occur, as the Central Bank (CBR) implemented tight monetary policy. The opposite view is that Russia experienced currency crisis, caused by strongly distorted targets of exchange rate policy (significantly overvalued ruble), while the debt crisis was not inevitable, and happened due to erroneous measures of the authorities. I suppose that both positions are disputable.

Before turning to analysis, let us look at economic developments on the eve of the crisis. The GKO/OFZ interest rates were rapidly falling in 1997. Yields for 6-month GKO's dropped from 45% in December 1996 down to 16-17% in July-October 1997. Ex-post real rates fell to only 8% in the Q3 1997. This decline was in a great extent explained with participation of non-resident investors.

Dvorkovich, Gurvich (1999) estimate contribution of integration of the GKO market into international capital markets as 2/3 of the total observed decline.

Lower interest rates resulted in some slowing down of the debt stock: its growth amounted to 84% in 1997, as compared to 209% in 1996. Domestic debt of the Federal Government increased in 1997 by 3 percentage points of GDP, as compared to 5 percentage points in 1996. The scale of borrowing still remained quite substantial: total GKO/OFZ's placement was equivalent in 1997, as in 1996, to 20% of GDP. Duration of domestic debt was gradually growing, still remaining quite small, not exceeding 1 year. This fact determined enormous size of current debt redemption due: GKO/OFZ's redemption due in 1998 was over 1.5 times higher than the current revenues of the Federal budget, this being one of the key causes of debt crisis.

At the same time transformation recession ceased and production recovery began. Growth rate was rather high at this period, amounting in Q2-Q4 1997 to some 4% in annual terms.

Turning now to the issue of sustainability of debt policy, we should note that despite common view on the GKO market as a Ponzi scheme, opposite arguments also can be put forward. One simple pragmatic consideration is that participants at this market were not inexperienced people who invested to the notorious 'MMM', but the largest international banks, that undoubtedly evaluated future course of events, and hardly would invest billions of dollars to a security doomed for collapse.

From the theoretical point of view prospects of the market depend on trend of debt stock in % of GDP. The latter in turn depends on combination of real interest rates r, growth rate g, ratio of debt to GDP d, and primary fiscal balance bp.

$$\Delta d = d\,(r - g) - bp.$$

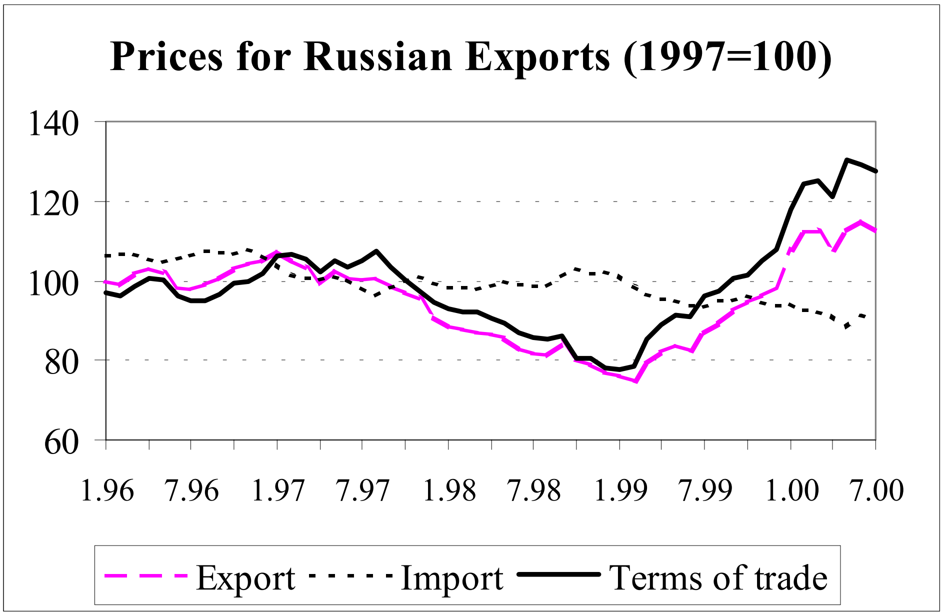
If we take actual figures as of pre-crisis period for the real interest rate (8%), growth rate (4%), and share of domestic debt in GDP (20%) we can see that if the government had primary surplus of 1% of GDP instead of primary deficit of 2% of GDP, it would stabilize debt ratio. This task does not look unfeasible. It is true, that fiscal situation was not improving before the crisis, but already in the Q2 1998, when export prices only started to grow, still being quite low, primary surplus of 2.5% of GDP was recorded. In addition, even keeping the same size of deficit would increase debt to GDP ratio by 3 percentage points a year, i.e. it would take several years to bring debt to a dangerous level. In other words, in the absence of external shocks GKO market would most probable remain stable in a short term, and had reasonable chances to stabilize also in the medium run.

Let us turn now to the second question: was ruble overvalued? First of all, UN estimates of exchange rates to PPP ratios evidence that in 1996 this ratio for ruble (43%) was roughly equal to that for Czech (43%) and Slovak (40%) currencies, and was lower than for Hungarian (48%), and Polish (51%) currencies. Hence, according to these estimates ruble was not overvalued in comparison with other transition economies. The same conclusion can be obtained from comparison of wages in dollar terms in these economies. Finally, we can examine the main test of ‘correct exchange rate’: sustainability of balance of payments. On the one hand, Russian balance of payments was supported by large-scale inflow of short-term capital: in 1997 new investment to GKO’s amounted to $11 billion, external borrowing by the government made up another $11 billion, inflows to the private sector turned to be $24 billion, of which direct foreign investment accounted for only $6 billion. The capital inflow totaled thus $45 billion, with almost 2/3 falling on short-term investment, and we admit that such huge inflows were quite unsustainable. But, on the other hand, it should not be forgotten that capital outflow from Russia (in the most broad sense, as increase in foreign assets of the private sector) was almost as large, reaching in 1997 $40 billion. Besides capital inflows and outflows if are not 'connected vessels', at least are highly correlated.

Analysis carried out by the Economic Expert Group found that sustainable in the medium term real exchange rate equals about 80% of its the pre-crisis level, that corresponds to $7.5 ruble per dollar in the H1 1998. In other words, exchange rate was overvalued, but not so much: not by 100%, as it the H2 1998, but only by 25%. Surely, capital outflow cannot be reverted as fast as short-term investments, still this proves that in a medium term only minor modification of the exchange rate policy was required. We see also that again short-term judgements differ from the medium-term, but their relationship is opposite as compared to the debt situation. The debt policy was sustained (under no shocks) in a short run, but moderately not robust in longer run. As for the exchange rate, we had, on the opposite, short-term vulnerability with sustainability (under minor corrections) in the long run.

This situation was broken abruptly with fall of the world commodity prices in the late 1997, as illustrated with the IMF data.

As a result export value has dropped by $15 billion, though its volume slightly increased. Sharp deterioration of the BOP made the then effective exchange rate no more sustainable even in a short run, and nobody could know how deep turns to be the recession and how long it would last. The monetary authorities had two options: to abandon the 'crawling peg' exchange regime and switch to floating exchange rate policy, or to defend ruble. The Central Bank and the Government chose the latter option.



It is clear that success in defending ruble depended critically on the duration of the crisis: the actual rate could be maintained only in a very short run. Hence the actual policy choice made implied **quite optimistic** expectations of rapid recovery of commodity prices. Throughout the crisis period authorities were arguing that prices would recover in some 3 or 4 months, and their actions were based on this presumption. The major measures included:

- replacing short-term domestic borrowing with long-term external borrowing,
- swap of the GKO/OFZ's falling due in 1998-99 (worth 27 RUR bn, or equivalent of around one month of redemption due) for long-term eurobonds (worth $5.9 bn),

- requesting an urgent IMF loan,

- cutting net domestic financing (it was negative since March 1998) and correspondingly cutting spending at the cost of building up arrears by the budget.

Fiscal Consolidation Program was elaborated, but faced difficulties in passing Duma, and as a result turned to be of no use.

Combination of all these circumstances resulted in development of two parallel, very fast and closely interrelated processes:

- Increased demand for hard currency,

- Falling demand for ruble-denominated government debt. Average GKO yields hiked to 37% in December 1997, 24% in March 1998, 55% in May 1998, and 81% in July 1998.

The underlying mechanism, as I see it, was the following.

•Expected depreciation raised GKO interest rates via <u>'interest parity ratio'</u>. It is important to draw attention to the fact that while yields for 6-month GKO's hiked from 16-17% in Q3 1997 to 31-32% in H1 1998, yields for comparable MinFin bond increased relatively slightly: from 8-9% to 9-12%. It should be noted, that despite common view, the change in investors sentiments towards emerging markets <u>had nothing to do with lower demand for GKO's</u>, as share of non-residents in the GKO/OFZ market (as well as non-resident's holdings in dollar terms) was growing during the crisis.

• Borrowing at such rates evidently made fiscal policy unsustained, hence the Government made efforts to cut domestic financing as noted above. Domestic public debt has increased in the first half of 1998 by only 16%.

- The free money were directed then to the currency market, depleting Central Bank international reserves (the latter fell from $23 bn in the end of October 1997 to $15 bn in the end of March 1998),

- The Central Bank, trying to defend ruble from devaluation, used to raise money market interest rates,

- High interest rates in the money market relaxed pressure on ruble for a while, but, on the other hand, suppressed production. Say, industrial output has dropped in 9 months of crisis period (from October 1997 to July 1998) by 10% on a seasonally adjusted basis.

It is clear that such process could be sustained for only very short time, and the outcome depended on how long the period of low commodity prices may last. This was a gamble: monetary authorities bet that prices will start recovering before reserves are depleted. And if this would really occur a year earlier, than it happened in effect, the crisis could well be evaded in near term, and perhaps would make the government to modify its policy and thus evade the crisis in longer run as well.

Summarizing, we can conclude, that the macroeconomic policy pursued by the monetary authorities was not robust in a medium run, but, in the absence of external shocks it was far from crisis area, and required moderate, feasible modifications to be viable in a medium run. The impetus to the crisis was given by a sharp deterioration in the terms of trade. After this shock the previously pursued policy was no more sustainable in a short run, and required serious modification. First of all, switching to the floating exchange rate was urgently needed. The authorities underestimated the scale of the deterioration in the fundamentals, and failed to make adequate adjustments of the policy. They assumed that 'bad times' would finish not even in a short, but in a very short term. As optimistic expectations did not realize, the crisis became inevitable. The debt market was not the source of crisis, but was the weakest, most vulnerable element hit by the crisis. The fundamental cause of immense yields at the GKO market was expectation of devaluation, not distrust to Russian government debt or to emerging market securities in general.

After the crisis government had to make fundamental modifications in the macroeconomic policy, but this does not prove by itself that previous policy was doomed to fail. The course of events only confirmed necessity to react adequately to serious changes in fundamentals.

The above presented developments set framework for more particular processes, that had special features a each stage. We consider below a model of the final stage of the crisis - 'End-Game'.

2. Crisis 'End Game' model[1]

The GKO market from its origin was dominated by limited number of large investors, (both Russian and international). In the course of the crisis this situation was aggravating: small investors were first to leave the market, and only the largest investors participated government bond market immediately before its collapse.

One of the most stunning point in the course of Russian financial crisis is the following fact. In July-August 1998 the IMF, the World Bank, and the

[1] The part of the paper presented in sections 2-4 was carried out with participation of Alexander Andryakov, and was supported by the grant of Economic Education and Research Consortium (Project 99-249).

Government of Japan approved new programs of financing Russian monetary authorities. These programs envisaged $22.6 billion total facility to Russia for the years 1998 and 1999, of which $5.5 billion were disbursed immediately. Despite expectations, the result was not the relief of the crisis, but its outburst, which showed itself in the collapse of the GKO market.

We consider below a simple model of 'Acute Liquidity Crisis'. Its main features can be summarized as follows.

A crisis shows itself in our model as a 'liquidity shock' due to decrease of expected budget revenues or sources of deficit financing. The deterioration of the fiscal situation is transient: everybody believes that after a while the Government restores access to capital markets and will be able to pay off its debts. But the duration and scale of the crisis are uncertain. We assume that these factors taken together are characterized by the amount of *fiscal gap*, which is a random variable. The underlying reasons include both external (like world commodity prices in case of Russia), and domestic (ability of the Government to cut spending or raise more revenues) factors.

To address the problem of fiscal gap, the Government can attract new borrowing. An important issue is the level of interest rate suggested by the Government. Normally this rate corresponds to the risk of investment. But balancing investment risks during acute crisis may require sharp raise of interest rates. This may, first, have serious adverse effect on the production, undermining thus budget revenues and further increasing thus need for financing[2], and second, make fiscal policy look unsustainable, with the same implications. As

[2] Frankel and Rose (1996) found out, that the financial crises often are concurrent with production decline, but direction of causality is uncertain.

demonstrated by Lahiri and Vegh (2000), policy of raising interest rate to defend financial system from crisis has some limitations. After interest rate has reached this ceiling, further raising the rate only precipitates the crisis.

We assume that raising interest rate above certain level may result in aggravating the crisis, and hence the Government refrains from raising the rate above this ceiling. The salient feature of our model is an assumption that, first, the interest rate is *fixed* (at the level viewed as sustainable in the medium-run), and, second, this rate does not cover the risk of investment (with account of the possibility of investment depreciation, as specified below).

Investors choose the amount they are willing to lend the Government. In addition the monetary authorities have their own resources (reserves). The sum of these initially available reserves and total investment made by investors makes *resources* that can be used to cover the fiscal gap.

After investors choose the amount of lending, the size of fiscal gap is observed. If resources held by the Government (including domestic borrowing and reserves) exceed the gap, the crisis is overcome, and the Government pays off the investment and interest. Otherwise the Government is unable to cover the gap and has to print new money or default on domestic debt. The result is depreciation of the domestic debt, i.e. losses of investors. We will call this outcome 'default', even though it does not necessarily include formal default. The share of debt face value lost in case of default is considered to be an exogenous parameter. This can make sense if inability to honor in full all commitments by the Government leads to multiple hardly predictable implications, as it was the case in Russia in 1998, when the crisis had damaged severely output, currency stability, banking system, all capital markets, budget revenues and sources of financing.

Once the interest rate does not cover the expected losses from investment, what are incentives to invest? The only reason for investors in our model is an effort to protect the portfolio of earlier made investment from default. Accordingly, only investors holding domestic debt come into the game.

The outcome of the game under consideration is random: the government and investors cannot phase out entirely the possibility of default, but probability of its occurrence depends on the decisions by investors. Additional investment diminish chances of default, but increase losses for investors if the default occurs.

The model thus defined presents rather special situation, but does not look implausible. We argue below that it may well explain partly the mechanics of Russian financial crisis.

Now we formulate more formally a game 'Acute Liquidity Crisis'. The key features of the game are as follows.

1.Participants – N investors. Investor i holds portfolio $D_i>0$ of domestic debt and has limitations H_i on new investment.

2. At the first stage all investors choose an amount x_i of lending to the government in the range 0 to H_i. The interest rate on this investment equals r. Money not invested gain zero interest (alternatively, r can be viewed as spread over the risk-free investment).

3. The size of fiscal gap G is observed at the second stage, following distribution function F(z). F(z) is assumed to be twice differentiable function.

4. If the total amount of investment $X=\Sigma x_i$ plus government reserves R (which is game parameter) happens to exceed the fiscal gap G, the Government

redeems all investment (both 'Old' and 'New') and pays interest $x_i r$ on the new investment. Otherwise real value of the debt held by investors decreases by ω percent. We can define then the payoff function of the i-th participant as a change in the real value of his assets:

$$w_i = F(X + R)\, x_i\, r + [1 - F(X + R)]\, [x_i\, r - \omega\, (D_i + x_i + x_i\, r)] \qquad (1)$$

The first term is an investor's gain in case of no default, multiplied by the probability of this outcome, and the second one corresponds to the default outcome. In the latter case investor bears losses proportional to his investment (both 'Old' and 'New'). The face value of the portfolio is not included in the payoff, as this would only change the baseline level of the payoff function.

Investor's marginal payoff from additional investment is

$$w'_i = f(X + R)\, \omega\, (D_i + x_i + x_i\, r) + \{r - \omega\, [1 - F(X + R)]\, (1+r)\} \qquad (2)$$

where *f* is a density function of the distribution *F*. The first term in the right part of (2) accounts for the indirect effect of investment: increase of the expected payoff due to less probability of default from additional investment. The second term presents the direct effect, equal to return from investment less losses in case of default. Our assumption is that the direct effect of investment is negative for any set $(x_1,\dots,x_n)$ within limitations $0<x_i<H_i$. This assumption guarantees that there is no trivial decision in the game: to invest maximum possible amount they can, as with positive real rate and large enough H_i this would provide maximum payoff to all participants.

The *real* (adjusted for risk) interest rate equals

$$\rho(X) = r - \omega\, [1 - F(X + R)]\, (1+r)$$

It is clear that $\rho(X)$ tends to *r* as X is increasing. This means there exists a point Q such that $\rho(X)>0$ for all X>Q. We assume thus that $\Sigma H_i \leq Q$. Let us denote ρ_0 supremum of $\rho(X)$ for X from 0 to Q. This means that $\rho(X) \leq \rho_0<0$.

The real interest rate $\rho(X)$ remains negative if probability of default is significant even when all participants invest all available resources, losses in case of default (characterized by ω) are large, and r is not too high. For instance, this is true if r=30%, ω=0.7, and F≤0.6. Then $\rho(X) \leq -6.4\%$.

3. Model analysis

3.1.<u>Nash Equilibria</u>

The nature of equilibria in the game can be seen from the following discussion.

It can be shown that only investors holding government debt will invest. Indeed, let w(x|Y) is the payoff of the i-th participant if his investment is x, and total amount invested by other players is Y. If i-th player has zero portfolio, his payoff under zero investment is zero, while under positive investment (x>0) it is always negative:

$$w(x|Y) = x\,r - (1-F(x+Y+R))\,\omega\,(x + x\,r) = x\,\rho < 0.$$

Hence, zero investment dominates any other decision for a participant with zero portfolio.

It can be easily seen that the same holds if the portfolio is small enough.

On the other hand, if the portfolio is large enough, a player makes positive investment regardless of the decisions by others. Indeed,

$$w(x|Y) - w(0|Y) = x\,\rho + D\,[F(x+Y+R) - F(Y+R)] = x\,\rho + D\,x\,f(z+Y+R),$$

where z is some point between 0 and x. Hence, whatever are ρ and f, the right side is positive for all large enough D. More than that, the derivative of *w* by *x* is also positive for large D, hence the player with large D will make maximum possible investment.

We come thus to a conclusion, that participant with very small portfolios always refrain from investment, and those with very large portfolios always make maximum investment. The decisions in the intermediate case require coordination: amount of investment by each participant depends on the expected investment by others, which depend in turn on their portfolios, distribution F of gap value, and reserves R.

Some general conditions on the game parameters that are necessary for the 'free rider equilibrium' (situation when nobody invests) to collapse can be formulated in relatively simple form. Consider the expected payoff of i-th investor from investing infinitely small amount of money (x) when all others refrain from investing. The investor will have the incentive to do so if her payoff will be greater then that in the free rider equilibrium:

$$w_i(x,0) - w_i(0,0) > 0.$$

Expanding $w_i(x,0)$ versus x and keeping terms up to the first order only one can easily see that the above condition is satisfied only if the following holds:

$r - \omega [1 - F(R)] (1+r) + \omega D_i f(R) > 0.$

We will focus in the further analysis primarily on internal Nash equilibria of the game ($x^*_1, \ldots, x^*_N$), where all x^*_i are positive, but less than H_i. One can easily see that **if investors are similar (i.e. all portfolios D_i are equal), all internal equilibria are symmetric: $x^*_i = x^*_j$.** Indeed, for any internal equilibria first-order conditions hold:

$$w'_i = f(X + R)\, \omega\, (D_i+x_i+x_i r) + \{r - \omega [1 - F(X + R)] (1+r)\} = 0 \qquad (3)$$

Subtracting these equations for i and for j we obtain $x_i = x_j$.

The fact that we can consider only symmetric internal solutions makes their search much easier.

The payoff of a participant depends on his investment y and the sum Y of investment made by other players: w=w(y,Y). Let us introduce function V(x) equal for each *x* derivative of *w* by *y* at a point y=x, Y=(N-1)x, i.e. when all players invest amount *x*.

$$V(x)= f(Nx + R)\, \omega\, (D_i+x+x r) + \{r - \omega [1 - F(Nx + R)] (1+r)\}$$

It is clear that if $(x^*,\ldots,x^*)$ is an internal equilibrium, it provides solution for the equation:

$$V(x) = f(Nx + R)\, \omega\, (D+x+x r) + \{r - \omega [1 - F(Nx + R)] (1+r)\} = 0 \qquad (4)$$

To find internal Nash solutions we should thus find points where $V(x^*)=0$ and then check individual optimality conditions, i.e. whether payoff of a particular player w_i really reaches maximum at x^* if all other investments are equal x^*.

We will focus on internal Nash equilibria of the game. Our analysis evidences, that Nash solutions exist and are unique for a broad range of game parameters. We can formulate some simple sufficient conditions for this.

Let A is a game of N identical participants (with equal portfolios $D_i=D$ and limitations $H_i=H$). Whatever is D, combinations of distribution F and bounds H exist, such that there is a unique internal Nash equilibrium in the game.

To prove this, let us introduce the following family of distributions (we are disregarding here differentiability aspects): $f(x)=0$ for $x<R$, $f(R)=1/NH$, $f(NH)=0$, $f(x)=f(R)-(1/N^2H^2)x$ for $x\in(0,H)$, $f(x)$ – any, meeting condition $F(\infty)=1$. Then, for any $H<D/2N(1+r)$ there exists a unique Nash equilibrium. Our conditions guarantee that:

a) $V(0)>0$,

b) $V(z)<0$ for some $z\in(0,H)$,

c) $V'(z)<0$ for all z,

d) $w''(y|x)<0$ whatever are y and x.

"a", "b", and "c" ensure that there is a unique solution x* for equation $V(x)=0$, and "d" guarantees that $(x^*,\ldots,x^*)$ is a Nash equilibrium.

The Nash equilibrium is never Pareto-optimal: coordinated actions always can improve it for all participants. Indeed, let Z(x) is a payoff function of any player in case each participant invests amount *x*. Then

$$Z'(x)=Nf(Nx+R)\,\omega\,(D_i+x+x\,r)+\{r-\omega\,[1-F(Nx+R)]\,(1+r)\}>V(x)$$

Once $V(x^*)=0$, $Z'(x^*)>0$, hence at the Nash point coordinated increase of x would result in payoff growth for all participants. The gap between Pareto optimality and Nash solution is increasing with the number of players.

Now we turn to comparative static analysis, estimating effect of the major parameters on investment and probability of default.

3.2. The effect of portfolio

Suppose $(x_1, x_2, \ldots, x_N)$ is an internal Nash equilibrium in the game A with portfolios D_i. Then investment made by different participant are linked by the following relations:

$$x_i+D_i/(1+r) = x_j + D_j/(1+r).$$

This conclusion can be obtained by subtracting first-order conditions:

$$w'(x_i) = f(\Sigma x_k + R)\, \omega\, (D_i+ x_i + x_i r) + \{r - \omega\, [1 - F(\Sigma x_k + R)]\, (1+r)\} = 0, \quad (6)$$

for participants *i* and *j*.

In other words, we obtain here rather unexpected result: though the only incentive to invest is saving portfolio from depreciation, within the same internal equilibrium the larger is the portfolio, the less is investment. The reason is that the amount of investment is defined by a balance of direct effect (interest less possible losses from devaluation) and indirect effect (gain from lower default probability) from the unit of additional investment. The former effect is identical for all investors, hence the latter effect, proportional to total ('old' and 'new') assets is also identical in the Nash equilibrium.

On the other hand, participants with small portfolios do not come into game at all, having zero new investment. This is evident from comparing payoff function of a participant *i* in the arbitrary point $x^*=(x_1, x_2, ..., x_N)$, $x_i>0$ and in the point x^0, which differs from x^* only in the i-th component, which equals zero here. Then

$$w_i^*-w_i^0 = [F(\Sigma x_k+R) - F(\Sigma x_k -x_i +R)]\, \omega\, D_i + x_i \{r - \omega\, [1-F(\Sigma x_k+R)]\, (1+r)\} < \omega\, D_i + x_i\rho_0.$$

The second term is negative, hence if D is small, $W_i^*-W_i^0 <0$, i.e. x^* is not Nash equilibrium. On the other hand, if investment $\{x_k\}$, $k\neq i$ is an equilibrium in the game with N-1 participants, then x^0 is also Nash equilibrium in the initial game of N participants.

We obtain thus, that **the participant with the smallest portfolio either does not invest at all, or makes the largest investment** (if his limitation H_i allows this).

Coming back to a game with equal initial portfolios $D_i=D$, one can easily see, that in a game A_0 with equal portfolios $D = \Sigma D_i /N$ obtained by modifying game A, the set (x, x, …, x) is a Nash equilibrium, where $x = \Sigma x_k /N$.

In the game with equal portfolios D the amount of investment in the Nash equilibrium positively depends on D. This is proved by estimating derivative of equilibrium investment *x* by D, which can be obtained by differentiating equation (4) by D. We get then

$$dx/dD=-f\omega/[(N+1)f\omega(1+r) + Nf'\omega(D+x+xr)]. \qquad (7)$$

Applying second-order conditions

$$w''(x,(N-1)x) = 2\, f((N-1)x +x + R)\, \omega\, (1+r) + f'\, ((N-1)x +x + R)\, \omega\, (D+x+x\, r) <0,$$

we obtain:

$$(N+1)f\omega(1+r) + Nf'\omega(D+x+xr) = N[2f\omega(1+r) + f'\omega(D+x+xr)] - (N-1)\, f\omega(1+r)<0.$$

As $f\geq 0$, we conclude that $dx/dD>0$.

This result is more complying the general logic of portfolio-driven investment than dependence of investment by particular participants on their portfolio.

In a game with different portfolios increase of the i-th portfolio results in decrease of investment by i-th participant, and increases investment by other participants, with positive effect on total investment.

It should be noted that this analysis implied internal equilibrium. But the positive effect of D on investment holds also for equilibria where investment made by some participants lie on the boundaries, if their marginal payoff in these points differs from zero. This is true also for other effects presented below.

3.3. Effect of reserves

More important and quite surprising is that **equilibrium amount of investment turns to be negatively dependent on the size of Government reserves**.

Indeed, by differentiating the first order conditions by R, one obtains:

$$x'_R = -[f\omega(1+r) + f'\omega\,(D+x+xr)]/[(N+1)f\omega(1+r) + Nf'\omega\,(D+x+xr)]. \qquad (8)$$

Taking into account the second-order condition (5), and $f\geq 0$, we obtain that both the numerator and denominator are negative, and hence $x'_R<0$.

Even more strong and more striking result holds: not only investment is falling, but the **probability of 'default' is rising as reserves are increasing.**

This is clear from taking derivative of F(Nx+R) by R:

$F'_R = f(N x'_R + 1) = f[f\omega(1+r)]/[(N+1)f\omega(1+r) + Nf'\omega(D+x+xr)]<0.$ (9)

This means, that not only amount of investment, but also resources held by the Government are declining as reserves are growing, i.e. the reaction on reserves growth is stronger than the growth itself. Additional reserves thus not only do not relieve the crisis, but even aggravate it!

The conclusion $x'_R<0$ is clear also from general analysis of the function V(X). One can easily see that increase in reserves from R to R* is equivalent to the shift of V(x) to the left by (R*-R)/N, and reducing D by the same amount (this is equivalent to shifting V(x) down). The effect of reserves increase on investment is then evident: it shifts the solution of equation V(x)=0 to the left.

3.4. Number of participants

Let us analyze now effect of changing number of investors. We consider two games, one (A_1) having N, and another (A_2) N+1 identical investors (holding equal portfolios), both having internal solutions. It can be shown that if V(x) is decreasing for all x between 0 and H, equilibrium investment *x** is negatively depending on the number of participants. Indeed, let $(x_1,\ldots,x_1)$, and $(x_2,\ldots, x_2)$ are solutions in the games A_1 and A_2. Then $V_N(x_1)=0$, and $V_{N+1}(x_2)=0$. Subtracting these equations we obtain:

$$[V_N(x_1) - V_N(x_2)] + [V_N(x_2) - V_{N+1}(x_2)] = [V_N(x_1) - V_N(x_2)] + [V_N(x_2) - V_N(z)] + \omega(1+r)f[(N+1)x_2+R]\,(z-x_2) = 0,$$

where $z=(N+1)/N\ x_2$.

Once $z>x_2$, both the second and the third items in the right part are positive. Hence the first item is negative, which is to say that $x_1>x_2$.

This means that **adding to the game A an investor with the same portfolio D leads to a decrease of investment made by each investor**.

Preliminary analysis based on differentiation by N (as well as findings from simulation) evidences that, even more striking, total amount of investment made by all investors also declines as their number grows (and chances for default are rising).

$(Nx)'_N = x\ (N\ x'_R + 1) < 0$ (see analysis of F'_R above).

If the new investor has portfolio less than D, then overall effect of his appearing consists of two components: 1) decrease of average portfolio, 2) increase of the number of participants. Since both are negative, we can conclude that adding a participant(s) with portfolio not exceeding average portfolio in the initial game A results in decrease of the total investment. The effect of adding a participant with portfolio larger than D is uncertain and depends on the particular value of his portfolio.

REFERENCES

1. Calvo G. //Capital Market Contagion and Recession (An Explanation of the Russian Virus), Note, October 1, 1998.

2. Calvo G. //Understanding the Russian Virus (with special reference to Latin America), Note, October 13, 1998.

3. Dvorkovich A., E.Gurvich Interest Rates and Domestic Borrowing Costs in the Medium-Term Perspective, Economics Education and Research Consortium, Moscow, 2000.

4. Financial Crisis and Public Debt (in Russian). Moscow, Institute for Financial Research, 1999.

5. Financial Crisis: Causes and Consequences. Moscow, Institute of Transitional Economy, 2000.

6. Montes M., S.Popov //The Asian Crisis Turns Global, Institute of South-East Asian Studies, 1999.

7. Review of Economic Policy in Russia, 1998. Moscow, Bureau for Economic Analysis, 1999.

8. Lahiri A., C.Vegh // Delaying the Inevitable: Optimal Interest Rate policy and BOP Crises. National Bureau for Economic Research, Working paper 7734, 2000.