EXCHANGE-RATE AND MONETARY POLICIES IN RUSSIA

Editor's Introduction

BEN SLAY

More than two years have passed since Viktor Gerashchenko's resignation in March 2002 as chairman of the Central Bank of Russia (CBR) and his replacement by Sergei Ignatiev. Many observers have argued that this changing of the guard represented a watershed for Russian macroeconomic policy in general, and for monetary and exchange-rate policies in particular. Gerashchenko, once described by Jeffrey Sachs as "the world's worst central banker," enjoys the dubious distinctions of having served as the last head of the Soviet Union's state bank, and having presided over the post-Soviet hyperinflation of 1992–93 that devastated economic prospects for a newly independent Russia and other members of the Commonwealth of Independent States. Under Gerashchenko's stewardship Russia experienced wild fluctuations in real exchange and interest rates, monetary growth rates, banking and financial crises, and episodes of demonetization. Ignatiev, by contrast, is seen by many as a modem central banker. During his tenure, exchange rates and interest rates—especially on government debt—have acquired more significance. The CBR has "moved toward a policy regime that increasingly resembles those pursued by the leading transition economies, which coordinate interest and exchange-rate policies within an inflation targeting framework. The CBR under Ignatiev has also moved to reform the banking system and shore up investor confidence in the Russian financial system. The recovery of Russia's banking and financial

systems has helped to deepen the financial system and improve the effectiveness of the CBR's instruments for open market operations and sterilized interventions on the foreign exchange market.

But however stark the contrasts between Gerashchenko and Ignatiev may seem, and despite the controversies of Gerashchenko's record at the CBR during the first half of the 1990s, it cannot be denied that Gerashchenko's second round as CBR chairman—from September 1998 to March 2002—was much more successful than his first round. It was during this time that Russia's strong economic recovery began, its financial system remonetized. the banks began to recover, and the reclaiming of the country's creditworthiness began. It was also a time in which the key contemporary challenge of Russian monetary and exchange-rate policies—the management of the ruble's real appreciation after the August 1998-financial crisis—asserted itself. The massive net foreign exchange inflows generated by the large current account surpluses Russia has experienced since 1999 have made such a real appreciation inevitable, particularly in the absence of a well-functioning government bond market that could be used to sterilize these inflows. Observers contemplating Russia's future monetary and exchange-rate policies under Ignatiev would do well to examine their evolution during 1999-2002.

The present issue *of Problems of Economic Transition* does exactly this. P. Kadochnikov's "External Determinants of the Russian Federation's Monetary Policy" provides a thorough theoretical and empirical grounding in the literature of central bank intervention on foreign exchange markets and its impact on monetary and exchange-rate policies. This is then contrasted with an empirical analysis of the CBR's interventions on the foreign exchange market during the 1999–2002 period. Kadochnikov finds that, despite the absence of a well-functioning government debt market, the CBR and the Russian government together were able to sterilize significant amounts of the foreign exchange inflows Russia received during this time. This happened primarily through

the coordinated management of the large budget surpluses man-
aged by the Ministry of Finance, under which large amounts of
budget receipts were kept idle in treasury accounts. This can help
to explain how Russia's surging growth in official reserves was
accompanied by significant progress in reducing inflation dur-
ing the 1999–2002 period.

P. KADOCHNIKOV

External Determinants of the Russian Federation's Monetary Policy

ABSTRACT: *This study analyzes potential options for intervention policy, checks certain hypotheses about foreign-trade trends and parameters of exchange-rate and monetary policy, and assesses possibilities for sterilizing money supply growth. It surveys the literature devoted to central bank intervention on foreign exchange markets and related transmission mechanisms in the economy.*

The following factors presently impose certain restrictions on exchange-rate and monetary policy in Russia. High oil prices are responsible for the current balance of payments surplus, owing to a significant excess of exports over imports. In the absence of tools for open market intervention, the mandatory sale of part of exporters' foreign exchange earnings leads to money supply growth that puts upward pressure on inflation and the real exchange rate. At the same time, the federal and consolidated budgets of the Russian Federation (RF) have recorded surpluses. These

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funds accumulate in the Federal Treasury, and either are used to repay foreign debt or they sterilize the growth in the monetary base associated with purchases of foreign exchange by the RF Central Bank.

This study analyzes potential options for intervention policy, checks certain hypotheses about the trend of foreign-trade indexes and parameters of exchange-rate and monetary policy, and assesses the possibilities for using the accumulated balance in the Federal Treasury's accounts at the RF Central Bank to sterilize money supply growth.

Survey of theoretical and empirical studies devoted to central bank intervention

This section surveys several studies that we think are interesting concerning central bank intervention in foreign exchange markets and its influences on the exchange rate and monetary policy.

The phrase "central bank interventions in the foreign exchange market" (hereinafter, interventions) refers to the purchase or sale of foreign currency by the central bank. These can take the form of partially sterilized, completely sterilized[1] or nonsterilized interventions,[2] that is, interventions that are or are not accompanied by central bank activities aimed at offsetting the change in the monetary base resulting from the sale or purchase of foreign exchange.

In the general case, the sale of foreign exchange by a central bank affects the exchange rate, monetary policy, and the real sector in two ways. First,- when the demand for foreign exchange exceeds supply, the sale of foreign exchange puts downward pressure on the exchange rate. This may have no influence on the long-term equilibrium; if excess demand persists, continued sales of foreign exchange deplete the central bank's reserves and lead to a currency crisis (see below). Second, interventions may affect the long-term equilibrium conditions in the economy. Such interventions can occur as a result of redistribution of assets between economic agents (a change in the stock of foreign exchange,

the monetary base, or securities in investors' portfolios) as well as shifts in monetary and exchange-rate policy or signals of such shifts, information about which is made public through interventions. Accordingly, the studies devoted to this subject (see, for example, Frankel, 1979; Backus and Kehoe, 1989; Dominguez and Frankel, 1993; Kaminsky and Lewis, 1993; and others, or the survey in Sarno and Taylor, 2001) distinguish two transmission mechanisms through which interventions influence equilibrium conditions in the economy; the portfolio-balance effect and the information (or signaling) effect.

The main effect of a nonsterilized intervention, besides the short-term impact on the exchange rate, is through changes in the money supply, which themselves lead to a change in equilibrium conditions. If an intervention is sterilized and there is no increase in the monetary base, then the effect of interventions on the equilibrium is not obvious and requires additional theoretical and empirical analysis.

Portfolio-balance   effects of sterilized   interventions

The "effect of interventions on the economy's equilibrium via the portfolio-balance effect can be described as follows. When the central bank sells foreign exchange and sterilizes the intervention through purchases of securities on domestic financial markets, domestic and foreign assets are redistributed among the portfolios of economic agents. If the domestic and foreign assets are not fully interchangeable, the change in their ratio leads to a shift in the equilibrium. Sterilizing an intervention through open market operations leaves the money supply and interest rates unchanged. The change in the ratio of domestic and foreign assets in the portfolios of economic agents may require an additional portfolio adjustment, which, accordingly, may bring about an additional redistribution of the portions of domestic and foreign assets and a change in the exchange rate.

This problem can be theoretically analyzed, for example, within

the framework of the classical portfolio-balance model (PBM; for more details, see Kenen, 1982; Branson and Henderson, 1985; and others), a dynamic model of exchange rate determination that describes the interactions of international capital markets, current account trends, and the exchange rate (see, for example, Evans and Lyons, 2001). Analysis of the effects of interventions within the framework of the PBM model consists largely of checking the effect of a central bank purchase or sale of foreign exchange on the ratio of domestic and foreign assets in the portfolios of economic agents, as well as on the risk premium for investing in national assets. The effect on the exchange rate will be reduced to zero if the domestic and foreign assets are perfect substitutes. In that case, an intervention only changes the ratio of assets in the portfolio. If the assets are not perfect substitutes (for example, allowing for Ricardian equivalence, an increase in domestic debt may subsequently lead to an increase in the tax burden, etc.), then a sterilized intervention may have a significant effect on the exchange rate through the portfolio-balance effect (see Frankel, 1979; Obstfeld, 1982; Backus and Kehoe, 1989; and others).

An analysis by Dominguez and Frankel (1993) of the efficiency of central bank interventions on the foreign exchange market in terms of their influence on the exchange rate through the portfolio-balance effect pointed out that sterilized interventions do not have a significant effect on the exchange rate for the following reasons:

1. The size of the intervention is usually small in comparison to turnover in the foreign exchange market.

2. Ricardian equivalence (if financing of domestic debt will entail a future increase in the tax burden, assets in the form of domestic securities are set apart as a separate type of assets, which are seen not only as profit-making investments, but also as future claims on the budget. In this case a redistribution of such assets among agents in the economy does not lead to a change in the relative demand for domestic and foreign assets and, consequently, does not influence the exchange rate).

3. High interchangeability of assets on international capital markets (in this case, sterilized intervention redistributes assets in portfolios of market participants without affecting the exchange rate).

Effect of interventions via information or signaling

The hypothesis that central bank intervention also influences equilibrium conditions in the economy via signaling assumes that intervention on the foreign exchange market give an idea of future monetary and exchange-rate policy. The effect of the interventions through this mechanism depends on how openly the interventions are carried out and what information they contain (see Mussa, 1981; Sarno and Taylor, 2001). In this case central bank intervention influences the exchange rate by providing the market with new, up-to-date, and reliable information about monetary and exchange-rate policies that can be expected from government agencies. Intervention can affect the exchange rate insofar as economic agents change their expectations about monetary and exchange-rate policies. If an intervention does not achieve its stated objective (for example, if it does not have the expected effect on the exchange rate), then we can talk about the costs of conducting a discretionary exchange-rate policy. Under certain conditions, in order to avoid these costs it may be helpful for the central bank to clearly state the objectives of its exchange-rate policy (see Kenen, 1988), thereby helping to strengthen the signaling effect.

Choice of the optimal intervention policy

Additional difficulties may arise from the need to coordinate exchange-rate with monetary policy and macroeconomic policy as a whole. In addition to adjusting the exchange rate via intervention on the foreign exchange market, the central bank (government agencies) may also target other macroeconomic indicators.

This can create a situation of asymmetrically distributed information in the economy, when economic agents are not fully informed about the policy objectives of different government agencies. Consequently, the information that becomes available to the market through interventions leads to a reduction in such asymmetry. It has been pointed out in a number of studies (see the survey in Sarno and Taylor, 2001) that making information freely available helps to achieve the stated objectives more efficiently.

It is also possible that target values of macroeconomic indicators (exchange rate, inflation, etc.) may not be achieved if they are publicly announced, due to speculative transactions by market participants. In such conditions, it is helpful to carry out shadow interventions, which diminish the speculative use of additional information about future policy. If information is not freely available, then intervention has a greater chance of changing expectations concerning future exchange-rate and monetary policies, which in turn changes expectations about inflation and the future exchange rate, thereby influencing interest rates and demand for real cash balances. If these consequences are not intended, their occurrence makes the interventions less effective.

As an example of a combination of objectives of a policy that is being pursued, Sarno and Taylor (2001) cite a model in which the following quadratic loss function including simultaneous targeting of the monetary base and the exchange rate is minimized (for more examples, see Blinder, 1997, and others):

$$L_t = (m_t - m_t^T)^2 + \overline{\omega}(s_t - s_t^T)^2 , \tag{1}$$

where

m_t and m_t^T —monetary base, actual and theoretical values;

s_t and s_t^T —exchange rate, actual and theoretical values;

ω—coefficient of the loss function *(a)* > 0).

When function (1) is minimized, it is easy to see that if one of the parameters deviates from the target values, problems may arise in conducting nonsterilized interventions because, along

with a shift of equilibrium in the foreign exchange market, such interventions lead to a change in the monetary base. In order to use sterilized interventions properly within the framework of this model, their effect on the exchange rate through the portfolio-balance and signaling mechanisms also has to be taken into account.

Boyer (1978) also discusses the problem of optimal intervention on the foreign exchange market in his article, in which a theoretical model of a small open economy is used to determine the optimal size of interventions. The model's key equation is a hypothesis about a loss function that includes deviations of output from the target value. Output, in turn, depends on the budget deficit and the money supply, which are influenced by the exchange rate and intervention. On the basis of theoretical analysis of the model constructed, Boyer determines the optimal type of linear function of government agencies' reaction to exchange rate movements. This study is a typical example of analysis of optimal intervention policy via cost functions. It argues, as do other studies, that the optimal type of intervention function depends on the type of loss function, as well as on the mechanisms by which expectations are formed.

Game theory models that allow for nonrational expectations of economic agents and infeasible, noncredible values of the macroeconomic variables (monetary aggregates, exchange rate, inflation, aggregate output, etc.) are another area of theoretical analysis concerning the influence of signaling associated with sterilized interventions. Such analysis (see, for example, Reeves, 1997 and 1998) shows that in order to achieve their stated commitments, intervention on the foreign exchange market have to be coordinated with changes in the money supply. Since intervention on the foreign exchange market depends on monetary policy, they must be coordinated, even in the case of conflicting objectives, as, for example, with the use of a target function such as (1).

Based on an analysis of exchange-rate regimes, exchange-rate behavior, the history of international foreign exchange markets,

and central bank interventions, Kenen (1987) makes a number of recommendations for interventions to pursue exchange-rate policy and manage the exchange rate. The analysis points out the following three objectives to be pursued in conducting interventions.

1. Interventions can be used to keep the exchange rate on an assigned trajectory or to change its trajectory. In this case, the central bank must fully meet excess demand for foreign currency or buy up excess supply, and the trajectory must be feasible and correspond to the long-term equilibrium. Here we are talking about nonsterilized interventions (as is noted in the article, excess demand can be modeled by examining the flow of interventions to keep market participants from deviating from the equilibrium).

2. Sterilized interventions can be used to change the relative supply of domestic and foreign currency in order to alter the equilibrium of distribution of domestic and foreign assets in the portfolios of economic agents (the portfolio-balance effect of interventions).

3. Interventions can be used to support announced exchange-rate and monetary policies, as well as to signal future policy changes (the signaling effect of interventions).

The article's suggestions for using the signaling effect presuppose that when any exchange-rate policy is announced the central bank should follow through on it, flexibly using the intervention mechanism without putting it off until the last minute, when it is inevitable or the policy has to be abandoned, losing the confidence of market participants.

Frankel (1996) analyzes the conduct of exchange-rate policies and develops proposals for making it more effective. The proposals for central bank intervention on the foreign exchange market include the following options:

1. Creating a multipurpose intervention fund, which can be jointly administered with international financial institutions.

2. Creating target zones, like those used in the European Union (EU) in the early 1990s (keeping in mind that a fixed exchange rate, free international capital movements, and an independent

monetary policy cannot all he maintained at the same time), as well as those that allow for possible changes in the parameters of the policy being pursued, taking into account fluctuations of macroeconomic variables, to avoid a crisis (see also Williamson, 1987).

Another direction of theoretical analysis of interventions concerns the search for optimal combinations of economic policy tools to achieve the optimal reaction to internal and external shocks in an open economy. For example, Devereux (1988) sought the optimal mix of wage indexation as a tool for smoothing out deviations in production from equilibrium trends through the use of long-term labor contracts and intervention on the foreign exchange market as a tool for regulating the money supply. Analysis of linear intervention rules and calibration of the model (using U.S. data) allow for the optimal combination of these two tools to protect against several types of shocks (see also Turnovsky, 1983; Aizenman and Frenkel, 1985 and 1986; and others).

Theoretical analysis of the impact of foreign exchange market intervention is part of a broader problem—optimal exchange-rate policy. A large number of studies have been devoted to this subject (see, for example, Bhandari, 1985; Turnovsky, 1987; Kenen, 1988; Sarno and Taylor, 2001; and others). This optimal exchange-rate policy literature is typically concerned with minimizing fluctuations of aggregate output around a natural growth trajectory (stated in this way, the problem deals mostly with unsterilized interventions). The following equation is the fundamental constraint of such a model (see Black, 1985):

$$INT_t = CA_t + \Delta K_t, \qquad (2)$$

where

CA_t—current account balance;

ΔK_t—flow of demand for the national currency through the capital account balance;

INT_t—intervention by the central bank.

Here it is assumed that the current account depends on the comparative advantages of production in the country under consideration (relative prices for resources, productivity, the real exchange rate, terms of trade). The impact of capital flows on the demand for the national currency can be derived, for example, from dynamic speculative models (see, for example, Stein, 1987; De Long, Shleifer, Summers, and Waldmann, 1990), from which it follows that ΔK_t depends on factors such as the deviation of interest rates from parity, investors' risk-taking propensity, the conditional variance of expected fluctuations in the exchange rate. The key component of such models is usually an assumption about the type of central bank loss function from which the optimal intervention function is determined. A relative weakness of models using equation (2) is that the optimal intervention function is determined largely by the type of cost function to be minimized; therefore, econometric methods are often used to estimate it (see below).

Other theoretical analyses of exchange-rate policies include game theory and asymmetric information models (the target value of the exchange rate is known only to the central bank, but not to economic agents; see, for example, Vitale, 1999). Game theory models are used to investigate the optimal speculation strategies. If interventions are not very large relative to daily trading volumes, then it is not beneficial for the central bank to intervene openly, and the transactions should be done through its agents, without informing the market participants. Prior announcement of the intervention may increase its requisite size due to speculative pressure from market participants. The key variables affecting the results of game theoretic models (the reaction function) are typically the type of loss function (utility function) and the degree of central bank independence.

Coordination of interventions

Sarno and Taylor (2001) note that in the case of the similar monetary and exchange-rate policies that are often used in economic

unions or in neighboring countries, exchange-rate and therefore intervention policies should be coordinated. Here it must be noted that coordination of unsterilized interventions leads to coordination of monetary policy, along with proper targeting of coordinated exchange rates (see Dominguez and Frankel, 1993).

Sterilized interventions affect the foreign exchange market through the two transmission mechanisms discussed above, portfolio balance and signaling. In this case, the portfolio-balance effect is more likely to be determined by the openness of capital markets than by the extent of monetary policy coordination. Signaling effects may be amplified if the interventions are coordinated because joint actions by several central banks are taken by economic agents as a more reliable signal of the policy being pursued. In particular, this can be used to improve the reputation of central banks that do not enjoy a high level of trust among economic agents.

Trend of international reserves and currency crises

Trends in international reserves and the exchange rate play large roles in the theory of currency crises. The first models of currency crises described the consequences of conducting inconsistent monetary and fiscal policies while trying to maintain a fixed exchange rate. Krugman (1979) showed that increasing domestic credit at a pace exceeding the rate of devaluation of an exchange being held at a certain level rate leads to a gradual decrease in reserves. When the level of reserves reaches a certain point, a speculative attack occurs, which leads to rapid depletion of the reserves and a switch from a fixed exchange rate to a floating one (first-generation currency crisis models).

A more detailed model (see also Flood and Garber, 1984) shows that when the future policies of the government and the central bank are reliably known, devaluation occurs in three stages: gradual reductions in official reserves, an abrupt attack, and a post-crisis period in which the exchange rate stabilizes at a new

level. If economic agents foresee that a speculative attack may lead to devaluation and the abandonment of the fixed rate, they will act so as to reduce reserves to the minimum level, leaving the central bank unable to defend the overvalued currency.

In practice, policies of governments and central banks cannot be reliably known, therefore the assumption about perfect information is not entirely correct in such situations. Stochastic variables—such as uncertainty about the minimum acceptable levels of official reserves—can be added to the model analyze a currency crisis in conditions of uncertainty. When the reserves drop below this level, the central bank abandons its support for a fixed exchange rate. As a result, the national currency is devalued or the behavior of fundamental variables becomes uncertain.

Uncertainty about the amount of reserves that the central bank will use to defend the exchange rate was introduced in the article by Krugman (1979). This makes speculative behavior sensitive to specification of the process that determines the minimum acceptable level of international reserves. If this amount is random, then devaluation results from speculative attacks that continue for some time. If the amount of minimum acceptable reserves is fixed, but unknown to currency speculators, then (as in the classical model) devaluation results from a sudden sharp attack (see Willman, 1989).

Uncertainty about domestic credit trends can lead to uncertainty about trends in the equilibrium exchange rate, and, consequently, to random occurrence of a currency crisis (see Flood and Garber, 1984). In order to calculate the probability of a currency crisis under such conditions, assumptions have to be made about the nature of random processes.

A number of models focusing on the behavior of the exchange rate within a certain range (target zone), which is enforced by central bank interventions on the foreign exchange market, have been developed to analyze the system of exchange rates established in the EU countries in the 1980s (before fixed exchange rates and introduction of the euro). These studies show that, with

large enough reserves, the exchange rate can be kept within set boundaries. In this case, exchange-rate movements near the upper or lower boundary of the range depend mainly on central bank interventions, not on the behavior of fundamental variables (the honeymoon effect; see, for example, Krugman, 1991). Limited reserves and the possibility of a successful speculative attack on the currency weaken this effect (see Krugman and Rotemberg, 1990), and a change in the exchange rate as a result of a speculative attack is smaller than it is with a floating exchange rate, due to expectations that the exchange rate will return from the edge of the corridor to its center sometime later (Flood and Garber, 1991).

Analysis of how central banks conduct sterilized interventions (see, for example, Flood and Marion, 1998) show that an additional increase in domestic credit with sterilization by an amount equal to the size of the intervention in the national currency diminishes the possibility of supporting the exchange rate and increases the probability of a currency crisis. Within the framework of the first-generation model, if interventions are sterilized it may -turn out that the equilibrium exchange rate is always higher than the fixed one. This means that, under conditions of complete certainty, sterilization of currency interventions is incompatible with maintaining a fixed exchange rate in this model.

In practice, countries with fixed exchange rates can be found in which interventions are sterilized at the same time as a speculative attack is being carried out, and this may go on for a fairly long time. To allow for this, it is often assumed that domestic and foreign assets are not perfect substitutes, and that the domestic interest rate includes a risk premium. This premium depends on the portion of national assets in the portfolio of investors inside and outside the country (see Flood, Garber, and Kramer, 1996), as in models analyzing the effect of interventions on the exchange rate through the portfolio-balance mechanisms. In certain conditions sterilized interventions can be compatible with maintaining a fixed exchange rate.

The use of a risk premium in the interest-rate parity equation introduces nonlinearity into the model through the behavior of economic agents (the private sector), which may lead to the existence of multiple equilibria. In addition to the crisis that occurs in the classical model as a result of inconsistent monetary and fiscal policies, a situation is possible in the model in which a crisis occurs as a result of self-fulfilling expectations (a different equilibrium). There may be a sudden transition from one equilibrium to another, in which it is profitable to carry out a speculative attack. Such an approach allows for the existence of a regime with a fixed exchange rate and sterilized interventions, if reserves are large enough. In addition, the study assumes that only a certain portion of the drop in reserves as a result of a speculative attack leading to a crisis has to be sterilized. There may also be several equilibria in the case of a floating exchange-rate policy, when the exchange rate deviates from its equilibrium value under speculative pressure but can be returned to it through interventions that satisfy the speculative demand.

As in the choice of the optimal exchange-rate policy, we can expect the central bank to choose between devaluation and its consequences (effect on unemployment, real output, etc.) by minimizing a cost function and a second-generation currency crisis:

$$\theta\delta^2 + (6 - E\delta - u - k)^2 \to \min, \qquad (3)$$

where
  δ—rate of devaluation ($E\delta$—mathematical expectation);
  u—random fluctuations with zero mathematical distortion and assigned variance;
  k—effect of devaluation (for example, the rate of change in macroindicators).

Given certain relationships between these parameters, a devaluation may be necessary even if it is possible to keep the exchange rate at its former lever In this case, a comparison of the values of the parameters at which a devaluation must occur with

their actual values in various countries makes it possible to evaluate the costs of movement to another equilibrium.

Two strategies of government behavior are often considered in minimizing the cost function: assigned rules of response and discretion. In both cases, solving the minimization problem allows us to draw the following conclusion: if the random factor does not play an important role (if it has low variance), the economy as a whole benefits when the government's action is predetermined. If the shocks have high variance, then costs are minimized if the government's actions are flexible, depending on the events that occur.

A second-generation model of a currency crisis, which includes self-fulfilling expectations, is used by Sachs, Tornell, and Velasco (1996). The model they suggest for describing the currency crisis in Mexico in 1994 includes the minimization of a cost function that includes the rate of devaluation and the tax rate. If a fixed exchange rate is to be maintained, the latter must be increased (instead of increasing domestic credit) in order to finance domestic debt service. As a result of solving the optimization problem in one- and two-period models of a currency crisis in which the government minimizes the social costs, the model allows us to draw the following conclusion: self-fulfilling expectations (transition from one equilibrium to another) influence the devaluation decision, but only if official reserves are small and the domestic debt is large. Added to the conclusions from previous studies of currency crises, this confirms the incompatibility of simultaneously maintaining a fixed exchange rate and increasing debt.

Obstfeld and Rogoff (1995) analyze the stability of fixed exchange-rate regimes in practice. They point out some basic problems connected with fixing a nominal exchange rate, including the impossibility of controlling the monetary base, the effectiveness of sterilized interventions, currency crises (based on the example of the crisis in Mexico in 1994), the inefficiency of using the exchange rate as a nominal anchor, and so on (see also Fischer, 2001; and others).

Interventions and information

Bossaerts and Hillion (1991) analyzed the microstructure of the foreign exchange market and the effects of asymmetric information. It must be noted that the general result of a fairly large number of studies (see, for example, Fama, 1984) has been that prices for forward contracts are biased estimates of the exchange rate in future time periods. To explain this, Bossaerts and Hillion (1991) use the hypothesis that the biasing of forward estimates when the market participants are risk-neutral may be due to asymmetric information about central bank interventions. On the basis of French franc exchange-rate data, they suggest that biased spreads are determined by asymmetric information among market participants. On the basis of separate empirical estimates for different days of the week, they point out that on the last trading day of the week the spreads are more volatile and biased than on other days. Bossaerts and Hillion (1991) also indicate that market participants are not neutral in relation to risk, as is assumed in the theoretical model, which introduces an additional factor biasing forward spreads (see also Sybrahmanyam, 1991).

Analysis of the microstructure of foreign exchange markets is also investigated by Peiers (1997), who concludes, on the basis of intraday data for Germany, that information about official interventions is asymmetrical across market participants. According to the hypothesis formulated in Goodhart (1988), asymmetrical information across market participants can lead, in the short run, to the appearance of price leaders who have more information than the rest of the participants. Peiers (1997) showed that Deutsche Bank usually acted as such a price leader for a certain time (up to sixty minutes) before the announcement of an official intervention by the Bundesbank. The study concluded that information about future interventions becomes available gradually—first to a few agents who are better informed, then to direct market participants, and only afterward to everyone else.

The microstructure of the foreign exchange market is also ana-

lyzed in Evans and Lyons (1999), which tests the hypothesis that the flow of orders on the foreign exchange market can have an factor influence on the exchange rate. The calculations here use daily data on the exchange rate of the deutsche mark in relation to the dollar. The results given in this study indicate that adding factors that take into account the microstructure of the foreign exchange market in empirical models of determination of the exchange rate can enhance their explanatory capability.

On the basis of a dynamic stochastic model of general equilibrium that includes a model of portfolio selection, Kumhof and Nieuwerburgh (2002) analyzed factors that determine the risk premium for investment in domestic assets and the effect of sterilized interventions on the equilibrium, including asset distribution and prices in the economy. They showed that under certain assumptions interest rate parity may not be fulfilled, and there may be risk premiums for investment in national securities. Independent management of interest rates and the monetary base turns out to be possible within the framework of the model. In this case, sterilized interventions or simply open market operations have an effect on interest rates, the exchange rate, its growth rate and volatility. Within the framework of the model, interest rate management proves effective for regulating demand, even when prices are absolutely flexible, and the exchange rate can be regulated by controlling the money supply.

Empirical verifications

The above hypotheses concerning central bank intervention are often checked by estimating the equations of the model on which the theoretical analysis is based. This raises a number of problems connected with the data needed for correct estimations, as well as proper specification of the equations to be estimated.

Sterilized interventions redistribute domestic and foreign assets among the portfolios of economic agents which, under certain conditions, may lead to bias in the economic equilibrium.

Two basic approaches are used to estimate the portfolio-balance model: direct estimation of the demand for assets, and estimation of the equation for the risk premium for investing in domestic and foreign assets (if the assets are perfect substitutes, the risk premium should not depend on the ratio of domestic and foreign assets in the portfolio). It is fairly hard to verify the influence of interventions through the portfolio-balance effect, due to difficulties that arise in econometrically specifying the equation on which the theoretical model is based; nevertheless, some results have been obtained. On the basis of data from the United States and Germany, Dominguez and Frankel (1993) show empirically that interventions have a (statistically significant) effect on the risk premium for investing in the assets of these countries. To check the operation of the portfolio-balance effect of sterilized interventions on the exchange rate, they use the hypothesis that the portion of assets in the portfolio depends on the risk premium for investing in them:

$$x_t \cdot a + b \cdot rp_t, \tag{4}$$

where

x_t — portion of an asset in the portfolio during period t;

a, b — coefficients of the dependence;

rp_t — risk premium of investment, determined according to the formula

$$rp_t = i_{t,k}^{DM} - i_{t,k}^{S} + \Delta s_{t,k}^{e}, \tag{5}$$

where

$i_{t,k}^{DM}$ — interest rate of assets in deutsche marks (for k periods forward);

$i_{t,k}^{S}$ — interest rate of assets in U.S. dollars (for k periods forward);

$\Delta s_{t,k}^{e}$ — expected change in the exchange rate (for k periods forward).

The corresponding econometric equation estimated in the same

study looks like this (the estimations use data on the deutsche mark—dollar exchange rate and corresponding interest rates for periods from September 1982 through October 1984, and also from January 1987 through December 1989):

$$i_{t,k}^{DM} - i_{t,k}^{\$} + \Delta s_{t,k}^{e} = \beta_0 + \beta_1 v_t x_t + u_{t,k}, \tag{6}$$

where
v_t — variance in the exchange rate;
$u_{t,k}$ — stochastic error of the regression equation;
β_0, β_1 — coefficients of the regression equation.

On the basis of estimations of this equation in the two subperiods, Dominguez and Frankel (1993) showed that interventions have an effect on the exchange rate through their influence on the risk premium. On the whole, this agrees with the results of other studies (see the survey in Edison, 1993) showing that a sterilized intervention does influence the exchange rate through the portfolio-balance effect, although the effect is relatively small.

The extent of the signaling effect of central bank intervention on the exchange rate, and also of the effectiveness of coordinated and uncoordinated interventions, can be empirically verified by estimating the effect of interventions on the expectations of economic agents. On the basis of a system of equations with weekly data, Dominguez and Frankel (1993) used the portfolio-balance equation (relating the risk premium for investing in national assets to the ratio of assets in the portfolio), with an additional equation modeling expectations, to obtain firm evidence supporting the idea that the signaling effect also influences the exchange rate, in addition to the portfolio-balance effect.

Empirical verification of the signaling effect on the exchange rate done by Kaminsky and Lewis (1993) tested for a correlation between interventions the U.S. Federal Reserve system and future changes in monetary policy. This study suggests the following explanation of the influence of signaling. Within the framework of the classical model of exchange-rate determination, the equilibrium

value depends on the supplies of domestic and foreign currency. If market participants form expectations concerning future exchange rates, then changes in the money supply expected in the future affect the exchange rate today. The signaling hypothesis assumes that interventions today will be accompanied by changes in monetary policy in the future, which influences the exchange rate today. The authors also note that the signals may be consistent with classical signaling theory (when purchase of foreign currency corresponds to future monetary expansion) or inconsistent with it (sale of foreign currency with subsequent expansion).

In their study, Kaminsky and Lewis checked for a correlation between interventions and future changes in monetary policy on the basis of monthly data on interventions by the U.S. Federal Reserve System from September 1985 through February 1990. As the variables reflecting changes in monetary policy they used the monetary aggregates M1 and M2 and the refinancing rate. In the first step of the estimations, they modeled changes in the monetary aggregates in the form of an autoregression process with regime switching (during the period under consideration, the money supply in the United States sometimes expanded and sometimes contracted; this was modeled with Markov switching). In the second step, they assessed how regime switching in the future conforms to interventions in the present. This study firmly rejected the hypothesis that interventions do not signal future changes in monetary policy.

Interventions can be used to stabilize the exchange rate. To check the link between exchange rate volatility and intervention, Neal and Tanner (1996) used ex ante volatility based on data on option quotes to show that interventions do not make the dollar exchange rate less volatile. On the basis of intraday data for the foreign exchange market in Japan, using the autoregressive conditional heteroskedasticity (ARCH) model, Chang and Taylor (1998) showed that volatility differed significantly before and after an intervention: the mast stable relationship was between an intervention and volatility thirty to forty-five minutes prior to its announcement.

Empirical research has also concentrated on estimating the intervention function, that is, the central bank's reaction function vis-a-vis changes in macroeconomic indicators. This type of function is most often judged on the basis of econometric estimations of fairly simple equations such as the following one (see Sarno and Taylor, 2001):

$$INT_r = \beta_0 + \beta_1(s_t - s_t^T) + \beta_2 \Delta s_t + \zeta X_t + v_t \tag{7}$$

where

INT_t—size of the central bank's interventions during period t;

s_t—actual value of the exchange rate;

s_t^T—target value of the exchange rate;

Δs_t—change in the actual value of the exchange rate during period t;

X— vector of additional exogenous macroeconomic variables;

v_t—stochastic error of the regrexssion equation;

$\beta_0, \beta_1, \beta_2, \zeta$—coefficients of the regression equation.

In the estimation, it is assumed that the intervention is stabilizing, that is, the coefficient β_1 must be negative. Estimations of equation (7) done for Great Britain, Germany, Switzerland, and Japan make it possible to check whether or not central banks really stabilize deviations of the exchange rate from the target value, and whether their interventions were in response to changes in the exchange rate or were more focused on other macroeconomic parameters (see, for example, Edison, 1993). The results of the estimations indicate that exchange-rate deviations from target values and changes in the exchange rate are significant in equation (7).

The degree to which interventions are sterilized by open market operations or other tools can also be checked using simple equations (see Edison, 1993; Sarno and Taylor, 2001), the general idea of which is to estimate the coefficient of change in net foreign assets or international reserves in the equation for growth in domestic credit or the monetary base:

$$\Delta M_t = ft_0 + \beta_1 \Delta R_t + \beta_2 (y - y^*)_t - \beta_3 \pi_t + \varepsilon_t, \tag{8}$$

where

ΔM_t—change in the monetary base (or change in domestic credit) during period t;

ΔR_t—change in the central bank's international reserves during period t:

$y - y^*$—the deviation of aggregate output from the natural trajectory;

π_t—inflation;

ε_t—stochastic error of the regression equation;

$\beta_0, \beta_1, \beta_2, \beta_3$—coefficients of the regression equation.

So, if the coefficient β_1 is equal to -1, we can talk about complete sterilization; and if it is negative with an absolute value less than 1, about partial sterilization (this is the result of the estimations carried out in various studies). It must be noted that here we encounter the problem of endogeneity: a change in net foreign assets may depend on a change in domestic credit, for example, due to capital movements (see Kouri and Porter, 1974).

Obstfeld (1982) also did an empirical analysis of the consequences of sterilized interventions. To evaluate the redistribution of assets resulting from interventions he calculated the offset coefficients, which are equal to the portion of increase in domestic credit compensated by the decrease in official reserves. He points out two basic approaches for calculating offset coefficients:

• on the basis of balance ratios of the central bank's assets and liabilities, as well as equilibrium conditions in the money market and the securities market, a linear equation can be derived for the capital account balance;

• estimation of a structural model, including the demand equation in the securities market.

In Obstfeld (1982), the estimations are done using the first approach (for estimations using the second approach, see, for example, Herring and Marston, 1977; Obstfeld, 1980; Cumby and Obstfeld, 1981; and others) with the following equation:

$$CAP_t = \beta_0 + ft, \Delta DC_t + \beta_2 \Delta i^* + \beta_3 \Delta Y_t + \beta_4 CA_t + \zeta X_t + u_t, \quad (9)$$

where .

CAP_t — capital account for period r;

ΔDC_t — change in domestic credit during the period;

Δi_t^* — change in the interest rate for domestic assets;

ΔY_t — change in nominal aggregate income;

CA_t — current account;

X_t — additional exogenous factors influencing the capital account;

u_t — stochastic error of the regression equation;

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \zeta$ — coefficients of the regression equation.

β_1 is the estimated offset coefficient. It is" pointed out in the study that when sterilization is being conducted, if domestic credit systematically responds to changes in the balance of payments, then the variable ΔDC_t will correlate with an error in equation (9), which will lead to invalid estimations using the least-squares method. One way to solve this problem is to use a two-stage least-squares method (see also Kouri and Porter, 1974). Estimations that take this into account and check bias with the Hausman test have shown that the value of the offset coefficient for West Germany in 1960–70 was about 0.6.

Edwards (1983) investigates differences in the demand for international reserves in developed and developing countries. He notes that, in addition to differences in the level of aggregate output (per capita), the amount of reserves can be affected by the amount and structure of foreign-debt payments, as well as the possibility of unforeseen spending in the coming years. Thus, the results of the estimations show that the level of reserves depends positively on the amount of foreign-debt payments (see also Kelly, 1970, and others) as well as on how open the economy is: the more open a country's economy, the more vulnerable it is to external shocks, that is, the more reserves are needed to maintain stability (see also Frenkel, 1974, and others).

Edwards (1983) did estimations for twenty-three developing countries that maintained a fixed exchange rate in 3 964–72 (devaluation

of less than 1 percent per year) and eighteen developing countries that devalued their currency by more than 10 percent at least once during that period. The following equation was estimated:

$$\log R_n = \beta_0 + \beta_1 \log Y_n + \beta_2 \log m_n + \beta_3 \log \sigma_n + u_n, \qquad (10)$$

where

R_n—international reserves of country n;

Y_n—aggregate income (a characteristic of the size of the economy);

m_n—average propensity to import (marginal propensity to import as a measure of how open the economy is);

σ_n—variance of foreign-debt payments;

u_n—stochastic error of the regression equation;

$\beta_0, \beta_1, \beta_2, \beta_3$—coefficients of the regression equation (it is assumed that all of the coefficients are positive).

On the whole, the results in this study indicate that such factors as the openness of the economy and the size of external shocks (for countries that maintain a fixed exchange rate) actually do influence the demand for international reserves (their amount and accumulation).

The relationship between interventions and the exchange rate can also be econometrically evaluated using the ARCH and generalized autoregressive conditional heteroskedasticity (GARCH) models, which can estimate the effects of interventions on both the value and the variance of the exchange rate. The results of these estimations indicate that reductions in exchange-rate variance generally result from interventions.

- Bosner-Neal, Roley, and Sellon (1998) analyzed how interventions by the U.S. Federal Reserve System and other monetary policy tools influence exchange rate fluctuations. Via the use of vector autoregression (VAR) models, it was shown that a change in the Federal Reserve discount rate affected the exchange rate. In a number of cases, an overshooting effect was observed: the exchange rate experienced sharp fluctuations with a subsequent adjustment.

The hypothesis that official interventions reflect future monetary policy adjustments could not be rejected, indicating the possibility that interventions influence the exchange rate via signaling. Similar results were also obtained by Lewis (1995).

Interventions can be considered efficient if the central bank makes a profit on them while speculators lose money. This can be empirically verified on the basis of data on actual interventions and changes in the exchange rate during the period according to the following formula (see Taylor, 1982); profitability is assessed by comparing the profit of actual interventions to a random flow of interventions with zero mean and the same variance):

$$z_t = \sum_{k=1}^{t}\left[n_k\left(1 - \frac{e_k}{e_t}\right)\right] = \sum_{k=1}^{t} n_k g_k = n'g, \tag{11}$$

where

z_t—profit from interventions in the foreign exchange market by the point in time ?;

n_k—amount of currency purchased during period k;

e_k—exchange rate at the end of period k;

g_k—rate of change in the exchange rate by period t in comparison to period k.

On the assumption that the rate of change in the exchange rate stays the same, the statistic (11) has a Student distribution (t-distribution). Spencer (1985) points out that this fairly stringent assumption can be relaxed. The statistic that he suggests has a t-distribution, as in the following:

$$z_t = \frac{n'}{g'g(n'n/\sqrt{t-1})} \tag{12}$$

where

z_t—profit from interventions in the foreign exchange market by the point in time t;

n—t-dimensional vector of the size of interventions during periods $[1; t]$;

g—t-dimensional vector of the rate of change in the exchange rate in the last period in comparison to the current period during $[1; t]$.

This statistic was constructed for interventions by the central banks of Spain (from February 1974 through December 1979), Great Britain (July 1972–December 1979), and Germany (June 1973–December 1979). The results showed that statistically significant losses were observed only for Spain, while strict results (profits or losses) could not be obtained for Great Britain or Germany during the time intervals under consideration.

The profitability of central bank interventions can be calculated more strictly according to the following formula (see Sarno and Taylor, 2001):

$$z_t = \sum_{k=1}^{t} \left[n_k \left(1 - \frac{e_k}{e_t} \right) + \frac{e_k}{e_t} (i_k^* - i_k) \sum_{j=1}^{k} n_j \right], \tag{13}$$

where

z_t—profit from interventions in the foreign exchange market by the point in time t;

n_k—amount of currency purchased during period k;

e_k—exchange rate at the end of period k;

i_k—domestic interest rate in period k;

i_k^*—foreign interest rate in period k.

In this case, the profitability of actual interventions is compared to random interventions, allowing for differences in the interest rate for domestic and foreign assets. Quite a few studies have estimated the profitability of interventions in this sense (see Sweeney, 1997; Neely, 1998; and others), the general result of which is that the profitability of interventions varies sharply over time and depends on the period under consideration, but in the long run central banks are more likely to make a profit from buying and selling currency than to suffer a loss.[3]

The development of optimal rules for currency traders depending on central bank intervention policy is a separate class of empirical studies, which models central bank intervention in the foreign exchange market. For instance, a number of studies have shown that taking intervention policy into account, for example, by constructing and estimating an intervention function may im-

prove the quality of forecasting exchange rates (see, for example, Taylor and Allen, 1992; Szakmarky and Mathur, 1997). However, a number of studies indicate that excluding periods when the central bank actively participates in tenders sharply reduces the forecasting ability of interventions in relation to the exchange rate (see LeBaron, 1996; and others).

Analysis of interventions in the foreign exchange market and their influence on traders' behavior also shows (see Sarno and Taylor, 2001) that central bank interventions can have a coordination effect if the exchange rate deviates significantly from its equilibrium value, for example, in the case of formation of speculative bubbles. In this case, in addition to information about the exchange-rate policy being pursued, interventions coordinate the actions of market participants and guide the exchange rate toward its equilibrium value.

Taylor (2001) surveys empirical studies and analyzes the extent to which the exchange rate can be used to control interest rates (see also Ball, 1999; Svensson, 2000). The analysis points out that rules directly reacting to the nominal exchange rate (like rules that directly target inflation and aggregate output) are not very effective in lowering inflation, and often do not work as well as more indirect rules. Optimal monetary and exchange-rate policy rules are also considered in Ghironi and Rebucci (2002), who showed that if the reserves are large, the use of a currency board regime is more efficient than dollarization of the economy (see also LeBaron and McCulloch, 2000).

Currency crises have been the subject of a large number of studies. Blanco and Garber (1986) showed that, in the Mexican case, the devaluations that actually took place corresponded to the sharpest peaks of the probability of their occurrence. Moreover, the predicted exchange rate set after devaluation approximately corresponds to the actual data. The authors also showed that devaluation could not be avoided if the equilibrium market exchange rate, which depends on the central bank's policy, exceeded the actual exchange rate for a significant time.

Cumby and van Wijnbergen (1989) used a similar model to

analyze the stabilization program in Argentina in 1978–81, which featured preannounced daily exchange-rate tables. From the modeling point of view, the announced values can be considered as a fixed exchange rate. In this case, rapid domestic credit expansion may intensify the pressures on the exchange rate that would be reflected in the next day's rate. The model suggests that the sharp increase in domestic credit observed in the second quarter of 1980 reduced confidence in the central bank's ability to maintain the exchange rate. In this case, immediately before the devaluation in June 1981 there was a sharp jump in the probability of devaluation in the following period (up to 80 percent).

Eichengreen, Rose, and Wyplosz (1996) analyze trends in exchange rates, international reserves, and interest rates for 20 industrial countries on the basis of quarterly data from 1953 through 1993. The authors construct an indicator of pressure on the foreign exchange market, which includes the rate of change in the exchange rate, relative values of interest rates, and changes" in reserves in comparison to a base country (Germany). If this indicator exceeded the mathematical expectation plus 1.5 of the variance on the average for the sample, then that event was considered a crisis, and the corresponding logical variable was equated to one; otherwise it was taken as equal to zero. Next, the authors estimated probit models of the dependence of the logical variable that was constructed on basic macroeconomic indicators (economic growth, balance of payments, budget indexes, inflation, unemployment, domestic credit, etc.). Considerable attention was paid to contagion: one of the explanatory variables is the presence of a crisis in other countries. The authors concluded that crises actually did spill over "from one country to another, and that trading links were more likely to be a significant condition for this to happen than a similar macroeconomic situation in the countries.

Frankel and Rose (1996) analyzed currency crises according to annual panel data from 1971 through 1992 for 100 developing countries. The study sought common features of currency crises in a large sample of developing countries by investigating domestic and foreign macroeconomic indicators as well as the debt struc-

ture. A crisis was defined as a devaluation by more than 25 percent. The authors presented a graphic analysis of the results, estimated probit models, and checked for stability. The comparative estimations and calculations showed that crises occurred in countries with rapid domestic credit growth, low international reserves, and an overvalued real exchange rate, while neither the current account nor the budget deficit was helpful in predicting a crisis.

This survey enables us to systematize experience in this field and formulate possible ways to analyze the external factors affecting monetary policy in the Russian Federation. We have pointed out that the basic approaches for testing hypotheses about the effect of intervention on equilibrium conditions are analyzing the portfolio-balance and signaling transmission mechanisms, evaluating the effect of interventions on monetary aggregates and domestic credit, analyzing currency crises, evaluating the profitability of interventions, and so on. We now analyze trends in the Russian Federation's balance of payments, the RF Central Bank's gold and foreign exchange reserves, the exchange rate, and monetary aggregates. We then formulate some basic hypotheses that are tested econometrically. We will be looking at the period from the beginning of 1999 through the first half of 2002, that is, excluding the time of the 1998 financial crisis. For this reason, the analysis will not cover theoretical and empirical models of currency crises in detail, but only issues related to the central bank's interventions in the foreign exchange market, along with their sterilization and the effect of interventions on the money market.

**Basic reasons for and consequences of the
accumulation of gold and foreign exchange
reserves in the RF Central Bank in 1999
through the first half of 2002**

In this section, we will look at trends in international oil prices, imports. exports, the current account balance and balance of payments, the RF Central Bank's gold and foreign exchange reserves,

and the monetary base. We also analyze how the accumulation of official gold and foreign exchange reserves affected the monetary base and the nominal and real exchange rates. As we pointed out above, the RF Central Bank's intervention policy depends largely on international oil prices and the trade balance; foreign-trade indicators are therefore the key to formulating hypotheses about the factors that influence the RF Central Bank's purchase and sale of foreign currency.

International oil price trends are among the most important exogenous factors influencing Russia's monetary policy. An increase in oil prices leads to an increase in exports, which consist mainly of mineral raw materials (oil and gas products made up 54.1 percent of the total value of exports in 2001). Since world prices for gas and ferrous and nonferrous metal exports change more slowly than those for oil, significant fluctuations in international oil prices are the main source of variability in the value of exports from the Russian Federation (see Figure 1).

Higher exports during periods of high oil prices (2000 through the first half of 2002) strengthen the flow of foreign exchange into the country, which, in turn, due to the mandatory sale of part of exporters' foreign exchange earnings, increases supply on the foreign exchange market. Here we must note the low price elasticity of oil exports: the amount of oil exported is determined, to a significant extent, by the export capacity of the transportation and pipeline system, which imposes natural (binding) constraints on the physical volume of a major portion of exports.

Foreign exchange "inflows into the country are redistributed among the following factors:

Imports of goods and services

From 1999 through the first half of 2002, the real exchange rate strengthened. Imports increased (see Figure 2), which can be explained by the following factors:

• an increase in the real exchange rate means reductions in the
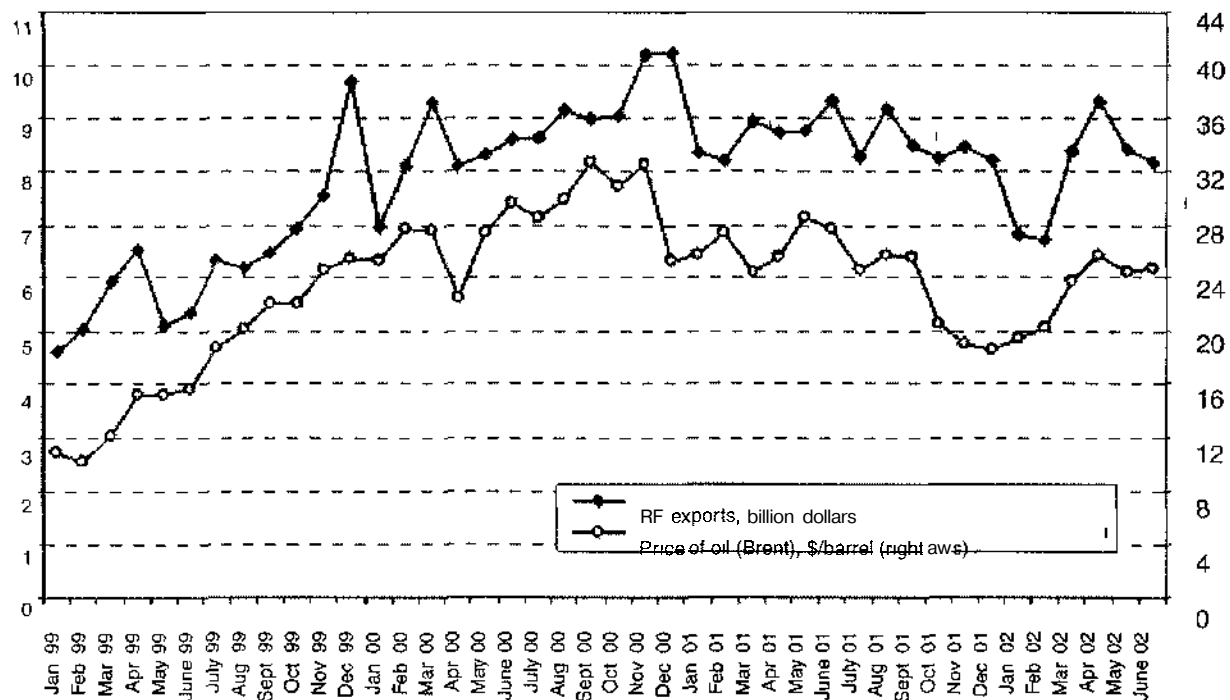
Source: RF Central Bank and International Monetary Fund, *International Financial Statistics.*

Figure 2. Real Exchange Rate Index and Imports from 1999 Through the Beginning of 2002
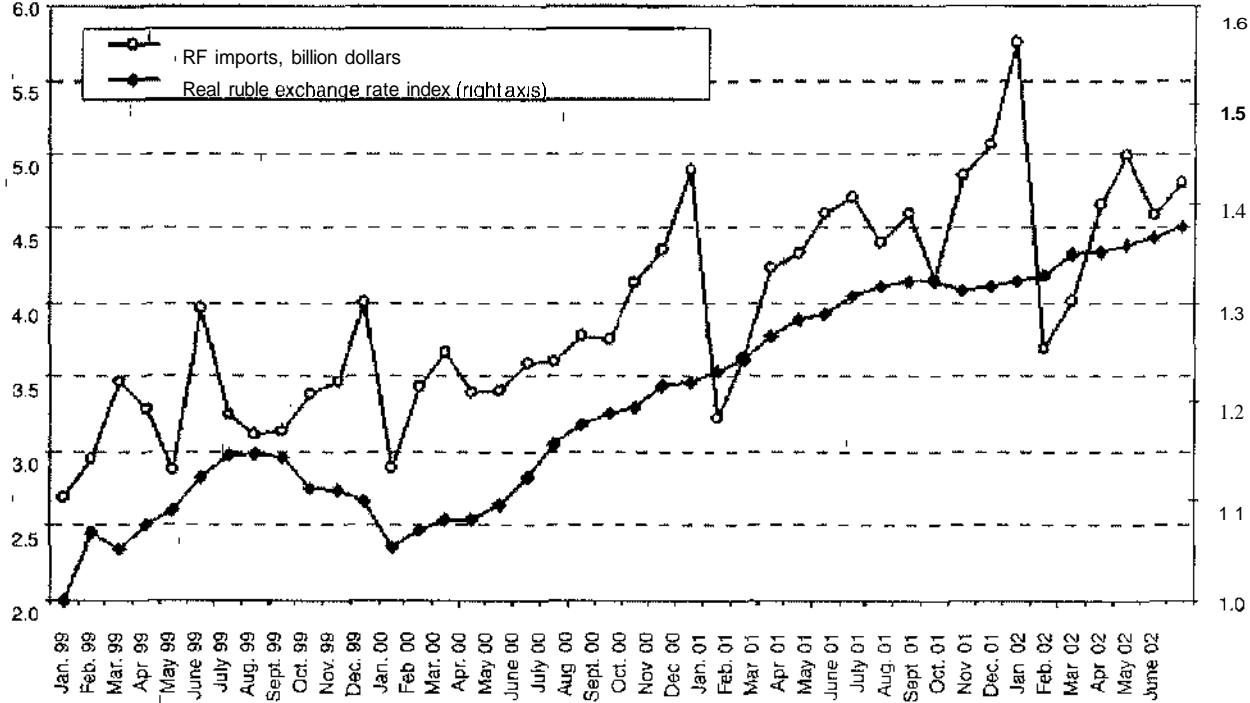
Source: RF Central Bank and author's calculations.

relative price of imported goods and hence the partial substitution of imports for Russian ones;

• when real household incomes, in rubles, are holding steady, the real appreciation of the ruble makes consumers more prosperous and companies more profitable in that they can afford a wider range of imported goods;

-• the economic growth that began in 1999 fostered an increase in the real incomes of households and enterprises which, assuming that the savings rate does not increase too fast, also leads to an increase in demand for all types of goods, including imported ones.

Against the background of relatively high but declining international oil prices, increased imports reduced the trade balance, lowering "net foreign exchange inflows.

Foreign debt payments and the capital account balance

The next important use of foreign exchange is foreign debt payments. The outflow of capital results in a stable capital account deficit (see Figure 3), which partially offsets the Russian Federation's positive trade balance. As we can see from Figure 3, the fluctuations of foreign debt payments correspond, by and large, to fluctuations of the capital account balance.

Accumulation of gold and foreign exchange reserves by the RF Central Bank

The next important use of foreign exchange entering the RF as a result of export receipts is the accumulation of gold and foreign exchange reserves by the RF Central bank. As we can see in the trends in official gold and foreign exchange reserves from 1999 through the first half of 2002 (see Figure 4), the increment in reserves corresponded, on the whole, to trends in the trade balance. The beginning of 2002 is an exception, when reserves were accumulated more rapidly, in spite of moderate fluctuations of

Figure 3. Trends in the Russian Federation's Capital Account and Net Foreign Debt Repayment (Not Counting Interest Payments) from 1999 Through the Beginning of 2002
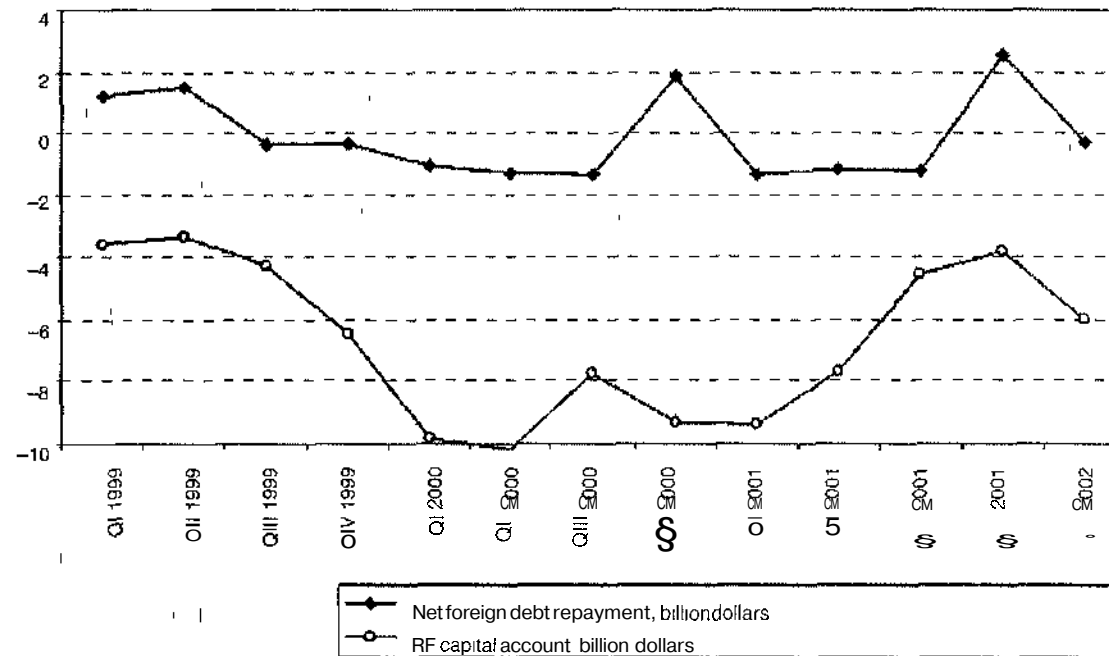
Source: **RF** Central **Bank, Ministry** of Finance of the Russian Federation, and author's calculations.

Figure 4. Trade Balance and Official Reserves from 1999 Through the Beginning of 2002
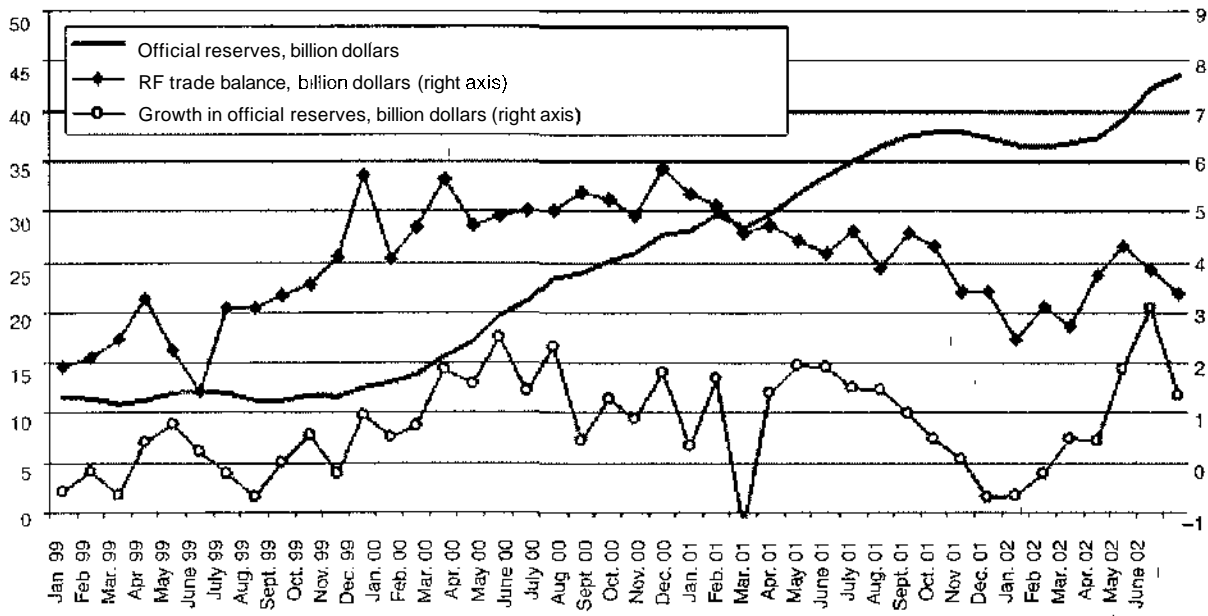
Source: RF Central Bank and author's calculations.

the trade balance. The most likely explanation for this is reduced capital flight and the return to Russia of previously exported capital, thanks to increased stability and an improved macroeconomic situation.

From 1999 through the first half of 2002, the increase in gold and foreign exchange reserves was accompanied by comparable growth in the monetary base which, in turn, created the monetary prerequisites for inflation. Official purchases of foreign currency can be considered an intervention to prevent strengthening of the nominal ruble exchange rate. This led to strengthening of the real exchange rate, and, accordingly, to a decline in the current account surplus. This situation raised the problem of sterilizing the money supply growth, either by reducing the central bank's other assets (besides reserves) or substituting other types of liabilities for the monetary base. An additional motivation to restrain money supply growth is the announced objectives of the RF government in the coming years to lower inflation (to 8-10 percent per year by 2005).

The shallowness of Russia's financial markets, particularly the market for government securities after the default in August 1998, meant that the central bank did not have effective tools for conducting open market operations in 1999 through the first half of 2002. As a result it was unable to engage in sterilized interventions on the foreign exchange market.

Trends in the RF Central Bank's gold and foreign exchange reserves (in rubles), the monetary base, and inflation (in terms of the consumer price index) are shown in Figure 5. -

As we can see from Figure 5, the increase in the central bank's gold and foreign exchange reserves, converted into rubles via the monthly exchange rate, was significantly higher than the increase in the monetary base in certain months. The interventions were partially sterilized therefore, in spite of the absence of effective open market operations.

Tax payments in the Russian Federation do not go directly to the Ministry of Finance's accounts in commercial banks (as they

Figure 5 Trend in **Official Reserves, the Monetary Base** and the Consumer Price Index from 1999 Through the Beginning of 2002

120
100
80
60
40
20
0
-20
-40

4 0%
3 0%
2 0%
1 0%
0 0%
-1 0%
-2 0%
-3 0%
-4 0%

Jan 99 Feb 99 Mar 99 Apr 99 May 99 June 99 July 99 Aug 99 Sept 99 Oct 99 Nov 99 Dec 99 Jan 00 Feb 00 Mar 00 Apr 00 May 00 June 00 July 00 Aug 00 Sept 00 Oct 00 Nov 00 Dec 00 Jan 01 Feb 01 Mar 01 Apr 01 May 01 June 01 July 01 Aug 01 Sept 01 Oct 01 Nov 01 Dec 01 Jan 02 Feb 02 Mar 02 Apr 02 May 02 June 02

Growth in official reserves (multiplied by the exchange rate), billion rubles
Growth in the monetary base, billion rubles
Growth in the consumer price index, % per month (right axis)

Source. RF Central Bank and author's calculations.

do in most countries), but to accounts in the Federal Treasury. These funds are not counted in statistics on the monetary base, that is, each tax payment results in a decrease in the monetary base. If balanced budget funds are received and spent uniformly, there will be no change in the average monetary base for a period. When part of a surplus accumulates in the RF government's (Ministry of Finance's) accounts in the Federal Treasury, the monetary base decreases.

Increased foreign exchange inflows due to higher exports would have strengthened the nominal exchange rate if the Central bank had not purchased foreign exchange the foreign exchange market. But whereas regular foreign exchange purchases kept the nominal exchange rate from strengthening, fairly high inflation (20.2 percent in 2000 and 18.8 percent in 2001) strengthened the real exchange rate (see Figure 6), raising imports and therefore reducing the trade balance.

In addition to increasing export earnings, higher oil prices also raised budget revenues. This occurred via direct increases in export duties, as well as higher basic tax revenues thanks to the economic recovery stimulated by higher income and profits in export-oriented industries. On the one hand, the opportunity to accumulate a budget surplus in the Federal Treasury accounts was used to sterilize the Central bank's purchase of currency. On the other hand, part of the budget surplus was converted to foreign currency, creating additional demand for it in the foreign exchange market, and was used for repayment and early buyback of foreign debt, increasing the capital account deficit.

Graphs comparing the disparities between changes in the central bank's gold and foreign exchange reserves (in rubles) and the monetary base on the one hand, and changes in the balances of government agencies' accounts in the central bank on the other, are shown below. There are several statistical sources that can be used to evaluate the balances in government agencies' accounts:

• balances in federal budget accounts according to statistics from the RF Ministry of Finance (the sum of changes in ruble

Figure 6. Trends in the Nominal Exchange Rate, Consumer Price Index, Real Exchange Rate Index, and Official Reserves from 1999 Through the Beginning of 2002
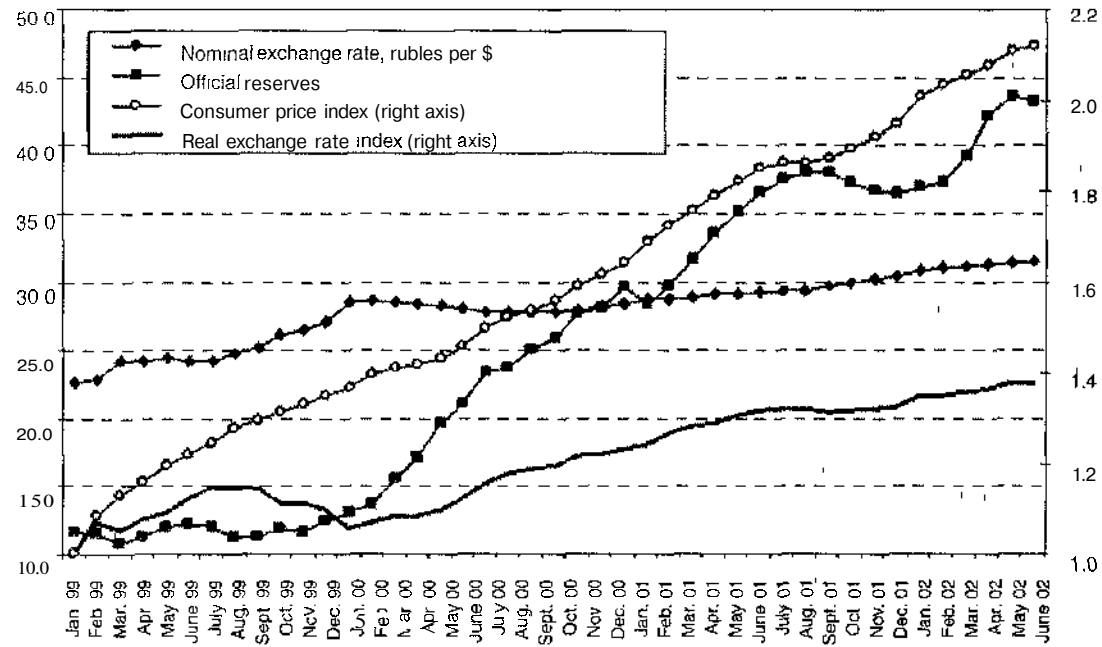
Source: RF Central Bank, RF Goskomstat, and author's calculations.

and foreign-currency balances; source: monthly reports from the RF Ministry of Finance);

• balances in federal budget accounts according to statistics from the RF Central Bank (source: *Bulletin of Banking Statistics*);

• changes in the deposits of government agencies in monetary-regulation agencies according to statistics of the RF Central Bank (source: *Bulletin of Banking Statistics*);

• changes in the RF government's funds in the RF Central Bank's liabilities (source: balance sheet of the RF Central Bank).

Trends in these indexes, along with the amounts of sterilization from 1999 through the first half of 2002, are shown in Figures 7 and 8.

As the figures show, the changes in government agencies' treasury deposits are closest to the size of the central bank's currency purchases (sterilized interventions). This can be explained by the fact that changes in these deposits reflect changes in the balances of both the federal and regional budgets, and is therefore a more accurate estimate of the total change in the balances of accounts with the central bank.

The figures presented indicate that the part of the central bank's interventions that was sterilized—the part that did not increase the monetary base—corresponded largely to the fluctuations of balances in the federal budget system. This means that the growth in exports and in gold and foreign exchange reserves observed together with a rise in oil prices were accompanied by a rise in the budget system's revenues and accumulation of a surplus, which made it possible to partly sterilize the RF Central Bank's currency purchases. Those interventions that were not sterilized increased the monetary base, creating the monetary prerequisites for inflation which, combined with a slowly changing nominal exchange rate, strengthened the real exchange rate, stimulated import growth and reduced net foreign exchange inflows.

In order to more clearly distinguish the most important factors influencing trends in the exchange rate, foreign exchange reserves, and monetary aggregates, we will formulate and test some hypotheses, using the basic approaches set forth above.

Figure 7. Sterilization of the RF Central Bank's Foreign **Exchange Purchases and Changes in Federal Budget**
Accounts from 1999 Through the Beginning of 2002
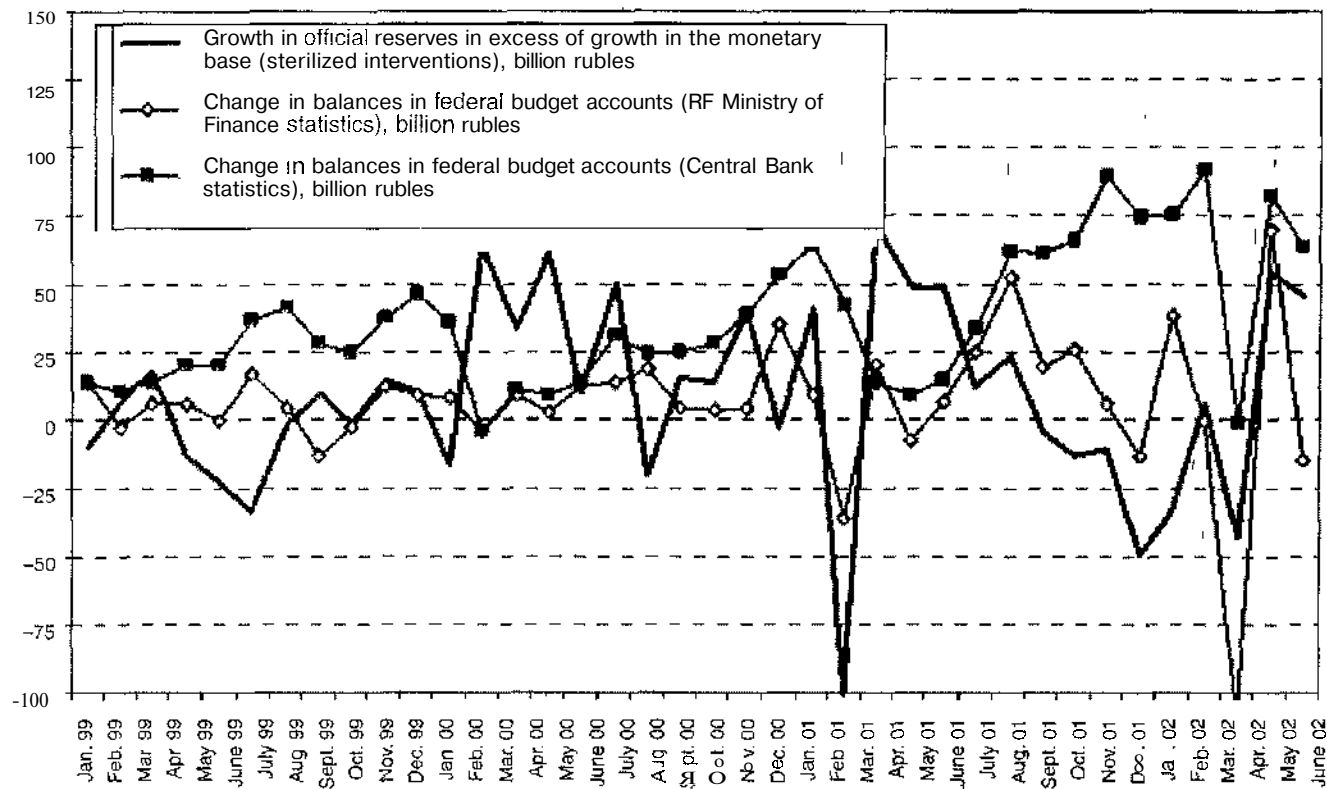
Source: RF Central Bank, RF Ministry of Finance, and author's calculations.

Figure 8. Sterilized Purchases of Foreign Exchange by the RF Central Bank, Changes in Government Agencies' Foreign Exchange Deposits, and RF Government Funds in Central Bank Liabilities from 1999 Through the Beginning of 2002
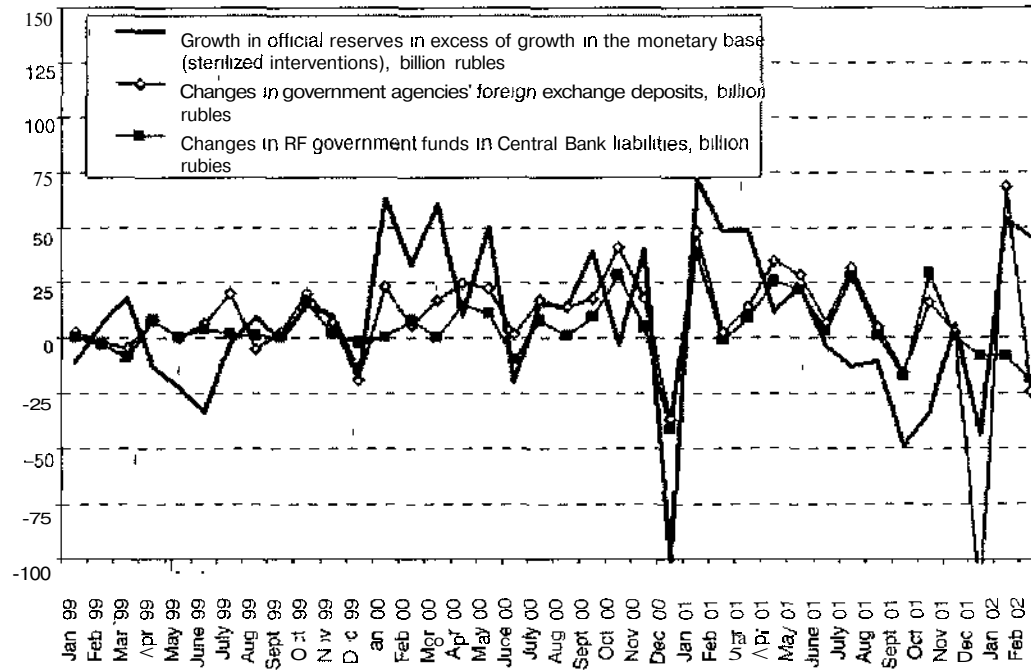
Source: RF Central Bank and author's calculations.

Econometric analysis of the external factors influencing exchange-rate and monetary policies in the Russian Federation

The graphic and qualitative analysis given in the previous section allows us to formulate some hypotheses about the interrelation of basic macroeconomic variables affecting monetary policy. Some of these hypotheses will be described in greater detail and verified econometrically in this section.

Relationship between exports and international oil prices

A specific feature of Russian exports, which consist mostly of energy, raw materials, minerals, metals, and products made from them, is that the physical volume of exports changes slowly. Consequently, the main factors influencing the value of exports are international prices for which they are sold. The most important source of fluctuations in exports are oil prices, which are more volatile than prices for gas or ferrous and nonferrous metals. As preliminary estimates showed, the price of oil alone has a statistically significant effect on the value of exports (estimated in increments).

As the results of a unit root test showed, time series of exports and international oil prices (monthly data) are nonstationary in levels and stationary in first-order differences. In order to check for the presence of a long-term relationship, we did a cointegration test between the series of monthly export volumes (billion dollars) and the average monthly UK Brent oil prices (dollars per barrel). The results of the test are given in Table 1.

The results of the test indicate that there is a first order cointegration relationship between exports and international oil prices, which takes the following form:

$$CE_t^{Oil-Ex} = Ex_t - 0.191 P_t^{Oil},\qquad (14)$$

where

Table 1

Verification of the Presence of a Cointegration Relationship Between Exports and International Oil Prices from 1999 Through the First Half of 2002

Estimation period	March 1999–June 2002		
Number of observations	40		

Verification of the presence of cointegration relationships

Hypothesis: Number of cointegration relationships	Eigenvalue	Statistic	5% confidence interval
With trace statistic:			
None*	0.422	30.222	19.960
Not more than 1	0.188	8.314	9.240
Based on maximum eigenvalue			
None*	0.422	21.907	15.670
Not more than 1	0.188	8.314	9.240

Coefficients of cointegration relationship	Exports	Oil prices	Constant
	-1.691	0.323	6.050
	−0.347	0.250	-3.460

Correction factors	Д (exports)	A (oil prices)	
	0.572	0.651	
	0.042	−0.950	

	Exports	Oil prices	Constant
Normalized coefficients	1.000	-0.191	-3.577
Standard errors		0.022	0,530

	A (exports)	Δ (oil prices)	
Normalized correction factors	-0.968	-1.101	
Standard errors	0.188	0.645	

*The hypothesis is rejected.

Table 2

Results of Estimations of Error Correction Model for the Relationship Between Exports and International Oil Prices from 1999 Through the First Half of 2002

Explained variable	Export growth	
Specification of equation .	Linear	
Estimation period	January 1999–June 2002	
Number of observations	42	

	Coefficient	*P*-value of *t*-statistic
Constant	-2.438	0.000
Growth in international oil prices	0.228	0.000
Cointegration relationship	0.707	0.000
Adj. R^2	0.349	
Significance of F-statistic	0.000	

Ex_t— exports from the RF in month t, billion dollars;

P_t—international UK Brent oil prices, average monthly values in month t, dollars per barrel.

These results show that within the framework of a long-term relationship a rise in oil prices by $1 per barrel increases exports in the long term by approximately $190 million. We can estimate the error correction model accordingly for the increments; the results are given in Table 2.

The results of estimating the error correction model indicate the presence of a correlation between exports and international oil prices: an increase in international prices has a statistically significant positive effect on export growth, with a significant cointegration relationship.

Imports and the real exchange rate

In contrast to exports, imports include goods with greater value added, including consumer goods, machines and tools used in

production. The impact of a stronger real exchange rate on the volume of imports can be divided into two components: the substitution effect, which influences the relative prices of domestic and imported goods, and the income effect, which reflects the fact that when the real exchange rate strengthens, a larger physical volume of goods becomes affordable for consumers and companies with the same incomes. The situation may be complicated by the fact that increasing households and enterprise incomes under conditions of economic growth may increase demand for all goods, including imported ones. We will not separate the income and substitution effects connected with a stronger real exchange rate.[4] We will focus instead on the overall effect of the real exchange rate and the increase in demand on the volume of imports in terms of value.

As the results of the unit root test show, the hypotheses about nonstationarity are not rejected for the series of imports (billion dollars, monthly data) and the real exchange rate index. Accordingly, as we did for the interrelation between international oil prices and exports, we will check for the presence of a cointegration relationship between imports and the real exchange rate index (an increase in the index corresponds to strengthening of the real exchange rate).

The results of verifying the presence of a cointegration relationship are given in Table 3.

As follows from the test results, there is a first order cointegration relationship, which takes the following form:

$$CE_t^{RER-Im} = Im_t - 5.110 RER_t, \qquad (15)$$

where

Im_t—imports into the RF in month t, billion dollars;

RER_t—real exchange rate index, an increase in which corresponds to a stronger real exchange rate. Equal to 1 in January 1999.

The numerical value of the coefficient of the real exchange rate index means that, in the long term, a 100 percent increase in

Table 3

Verification of the Presence of a Cointegration Relationship Between Imports and the Real Exchange Rate from 1999 Through the First Half of 2002

Estimation period	March 1999–June 2002
Number of observations	40

Verification of the presence of cointegration relationships

Hypothesis: Number of cointegration relationships	Eigenvalue	Statistic	5% confidence interval
With trace statistic			
None*	0.452	29.813	**19.960**
Not more than 1	0.133	5.731	**9.240**
Based on maximum eigenvalue			
None*	0.452	24.081	15.670"
Not more than 1	0.133	5.731	9.240

Coefficients of cointegration relationship	Imports	Real exchange rate	Constant
	3.243	-16.570	7.213
	0.236	-1.162	-0.647

Correction factors	A (imports)	Д (real exchange rate)	
	-0.361	0.002	
	-0.055	-0.006	

	Exports	Oil prices	Constant
Normalized coefficients	1.000	-5.110	2.225
Standard errors		0.543	0.655

	Δ (imports)	A (real exchange rate)	
Normalized correction factors	-1.171	0.006	
Standard errors	0.227	0.009	

The hypothesis is rejected.

Table 4

**Results of Estimations of Error Correction Model for the Relationship
Between Imports and the Real Ruble Exchange Rate from 1999
Through the First Half of 2002**

Explained variable	Import growth
Specification of equation	Linear
Estimation period	January 1999–June 2002
Number of observations	42

	Coefficient	P-value of t-statistic
Constant	1.590	0.000
Growth in real exchange rate	5.849	0.078
Growth in industrial production index	0.087	0.000
Cointegration relationship	0.731	0.000
Adj. R^2		0.349
Significance of F-statistic		0.000

the real exchange rate in comparison to the beginning of 1999 increases imports by more than $5 billion.

Import volume may also be influenced by household money incomes and by enterprise profit. The estimates showed that these indexes correlate strongly with each other. Therefore, in the error correction model we used the industrial production index, which by and large reflects the trend of household and enterprise incomes. The estimations of the corresponding error correction model including growth in the real exchange rate and the industrial production index as explanatory variables import growth are given in Table 4.

As we can see from the estimation results, growth in the real exchange rate and the industrial production index have a positive effect on import growth (the hypotheses that the coefficients are equal to zero is rejected are the 10 percent confidence level). In this case, as for the relationship between exports and international

oil prices, the (short-term) coefficient for the real exchange rate in the error correction model for the increment of imports is higher than the coefficient in the (long-term) cointegration relationship. With a one-point increase in the industrial production index (Jaauary 1993 = 100), imports increase by about $87 million.

Estimation of the monetary base equation

The basic factors determining trends in the monetary base during the period under study were changes in gold and foreign exchange reserves, which accumulated through unsterilized interventions on the foreign exchange market, leading to growth in the money supply and the balances in government agencies' accounts in the Federal Treasury. The monetary base can be changed by open market operations (changes in the security portfolio held by the RF Central Bank).

The monetary base can also be affected by government debt service and repayment. If the budget surplus in the Federal Treasury is used to service foreign debt, these funds go to the purchases on the foreign exchange market, increasing the money supply. Since the available statistical information does not permit us to separate spending on foreign and domestic debt service, we will use the total spending from the federal budget on government debt service as the explanatory variable. Considering the fact that spending on foreign debt service during the period under consideration was several times greater than spending on domestic debt service, the monthly data on total debt service are a satisfactory approximation of spending on foreign debt service. While repayment of foreign debt can have a similar effect on changes in the monetary base, preliminary estimates showed that this factor is not significant.

Growth in the monetary base may be affected by changes in household demand for money and foreign exchange. An increased demand for foreign exchange may be accompanied by a decreased demand for the domestic currency, which may lead the central

bank to reduce growth in the monetary base. It is quite difficult quantitatively estimate changes in household savings in foreign currency. The change in household foreign exchange deposits, for which monthly statistics are published, can provide an indirect estimate. At the same time, commercial banks can use household foreign exchange deposits to increase the supply on the foreign exchange market. In this case the sale of foreign exchange to the central bank or RF government agencies can increase the monetary base.

Accordingly, the equation to be estimated has the following form:

$$\Delta MB_t = a_0 + a_1 \cdot \Delta R_t + a_2 \cdot \_\Delta Acc_t + a_3 \cdot EServ_t +$$
$$+ a_4 \cdot \Delta Dep_t + a_5 \cdot \Delta FA_t + \varepsilon_t, \qquad (16)$$

where

ΔMB_t — change in the monetary base during period t, in prices at the beginning of 1999;

ΔR_t — change in the RF Central Bank's gold and foreign exchange reserves during period t, in rubles in prices at the beginning of 1999;

ΔAcc_t — change in balances in government agencies' accounts in the Federal Treasury, in prices at the beginning of 1999;

$\Delta EServ_t$ — spending from the federal budget on government debt service, in prices at the beginning of 1999;

ΔDep_t — change in foreign-currency deposits, in rubles in prices at the beginning of 1999;

ΔFA_t — change in amount of securities in the RF Central Bank's assets, in prices at the beginning of 1999;

ε_t — random regression error; •

a_0, a_1, a_2, a_3, a_4, a_5 — coefficients of the regression equation (according to the hypotheses formulated above, the coefficients a_1, a_3 and a_5 should be positive; the coefficient a_2 should be negative; and the sign of the coefficient a_4 is indeterminate).

The results of estimating equation (16) are given in Table 5.

Table 5

Results of Estimation of Model for Growth in the Monetary Base in 1999 Through the First Half of 2002

	Growth in the monetary base in prices at the beginning of 1999	
Explained variable		
Specification of equation	Linear	
Estimation period	January 1999–February 2002	
Number of observations	38	

	Coefficient	*P*-value of *t*-statistic
Constant-	-2.066	0.528
Growth in official reserves, in rubles at the rate at the end of the month in prices at the beginning of 1999	0.284	0,005
Growth in balances in the RF Ministry of Finance's accounts, in rubles in prices at the beginning of 1999	-0.234	0.078
Federal budget spending on government debt service, in rubles in prices at the beginning of 1999	0.362	0.048
Growth in household foreign-exchange deposits, in rubles at the rate at the end of the month in prices at the beginning of 1999	3.008	0.035
Growth in securities in RF Central Bank's assets, in rubles in prices at the beginning of 1999	0.000	0.552
Adj. R^2	0.413	
Significance of F-statistic	0.000	

The results show that growth in reserves by 1 billion rubles at the average monthly exchange rate increases the monetary base by approximately 0.28 billion rubles. This means that the central bank managed to sterilize more than 70 percent of its interventions.

The significant negative relationship between growth in the monetary base and changes in the balances in the Federal Treasury indicates that fiscal surpluses play an important coordinated or uncoordinated sterilization role, in terms of offsetting the

growth in the monetary base that results from central bank purchases of foreign exchange. In addition, the 0.35 value for the correlation coefficient between growth in the balances in the Federal Treasury accounts and the RF Central Bank's gold and foreign exchange reserves (in rubles in comparable prices) indicates that there is some coordination between the purchase of reserves and accumulation of balances in the accounts. That is, government spending seems to be somewhat restrained during periods of active central bank interventions.

Spending on government debt service and changes in household foreign exchange deposits also proved to be significant, with a positive sign. The increment of securities in the RF Central Bank's assets proved to be insignificant. This means that open market operations did not play a large role in sterilizing the Central bank's interventions on the foreign exchange market. The result obtained agrees with the hypotheses proposed above.

Estimating the relationship between the nominal exchange rate and official reserves

The problem of endogeneity comes up in modeling the interrelation between gold and foreign exchange reserves and the nominal exchange rate. On the one hand, central bank interventions may influence the exchange rate, at least in the short term. On the other hand, these interventions may be due to fluctuations or changes in exchange-rate trends. The relationship between official reserves and the nominal exchange rate should be estimated via systems of simultaneous equations (or VAR models).

Moreover, significant differences appear in the interrelation between official reserves and the nominal exchange rate, depending on the frequency of the data used for the estimations. Analysis based on intraday data may show that the central bank responds to exchange-rate fluctuations with interventions (sales of foreign exchange when the exchange rate (in rubles per dollar) rises, and purchases when it falls). The nominal exchange rate therefore declines when foreign exchange is sold and rises when it is pur-

chased. Over short intervals of time, such observations can isolate the mutual causality and separate cause from effect. In this case, the hypothesized positive relationship between the growth in reserves and the change in the nominal exchange rate is based on an ex ante analysis of supply and demand dynamics.

Unfortunately, the RF Central Bank's official interventions can be judged only from data showing weekly changes in official reserves. Intraweek, much less intraday, statistics on the change in reserves are not available. From observations over a longer interval, we can expect that such relationships may not show up. Thus, in conditions of a floating exchange rate, when the central bank sets its own guidelines for the nominal exchange rate and follows these guidelines, a situation may occur in which the exchange rate will be relatively stable, with short-term deviations and certain swings in reserves.

Suppose, for example, that the central bank purchases foreign currency when it sees the nominal exchange rate come under upward pressure. In this situation, an increase in official reserves will weaken this trend and promote a smaller increase in the exchange rate. Here, by ex post analysis of the changes in reserves and the exchange rate, we can see that the central bank will increase its reserves when the exchange rate rises and decrease them when it falls. It is unlikely, however, that such a relationship would be stable.

The hypothesis that the relationship is unstable can be substantiated as follows. Suppose that the central bank decided to accumulate reserves when it sees that the exchange rate is under upward pressure. In this case, the central bank may increase the amount of foreign currency that it purchases, weakening the appreciation trend, or even slightly devaluing the exchange rate (in order to slow its real appreciation). This means that in the long term reserves are more likely to increase under conditions of a relatively stable or even slightly depreciating exchange rate.

To check this hypothesis, we will use weekly and monthly data on changes in official reserves and the exchange rate, as well as data on the results of tenders.

As the unit root test results show, the nominal exchange rate

(rubles per dollar) and the RF Central Bank's official reserves are nonstationary in levels and stationary in differences. Before estimating differences, we tested for the presence of cointegration between these factors based on monthly and weekly data. The results of the test based on monthly data are given in Table 6.

The estimation results indicate that there is a first order cointegration relationship between the nominal exchange rate and the RF Central Bank's gold and foreign exchange reserves, which has the following form:

$$CE_t^{E-Rmonth} = E_t - 0.209R_t, \tag{17}$$

where

E_t—nominal exchange rate (rubles per dollar);

R_t—RF Central Bank's gold and foreign exchange reserves at the end of month t, billion dollars.

Substantively, in the long term, the presence of such a cointegration relationship means that an increase in the nominal exchange rate by 1 ruble per U.S. dollar is accompanied by an increase in the RF Central Bank's gold and foreign exchange reserves by approximately $5 billion.

As was already mentioned above, the estimations based on monthly and weekly data may differ, depending on how often the Central Bank's actions and the situation in the foreign exchange market adapt themselves to each other. For comparison, we can perform a cointegration test for official exchange reserves and the nominal exchange rate based on weekly data. The results are given in Table 7.

The results based on weekly data also indicate the presence of a first order cointegration relationship, which has the following form:

$$CE_t^{E-Rmonth} = E_t - 0.209R_t, \tag{18}$$

where

R_t—RF Central Bank's gold and foreign exchange reserves at the end of period t, billion dollars;

Table 6

Verification of the Presence of a Cointegration Relationship Between the Nominal Exchange Rate and Official Reserves from 1999 Through the First Half of 2002, Monthly Data

Estimation period	March 1999–July 2002
Number of-observations	41

Verification of presence of cointegration relationships

Hypothesis: number of cointegration relationships	Eigenvalue	Statistic	5% confidence interval
With trace statistic			
None*	0.355	26.884	19.960
Not more than 1	0.195	8.917	9.240
Based on maximum eigenvalue			
None*	0.355	17.967	15.670
Not more than 1	0.195	8.917	9.240

Coefficients of cointegration relationship	Exchange rate	Offcial reserves	Constant
	--0.409	0.086	7.631
	0.873	-0.131	-21.323

Correction factors	Д (exchange rate)	Д (official reserves)	
	-0.102	-0.452	
	-0.146	0.248	
	Exchange rate	Official reserves	Constant

Estimation period	March 1999–July 2002
Number of observations	41

Verification of presence of cointegration relationships

Normalized coefficients	1.000	-0.209	-18.652
Standard errors		0.051	1.534

	Д (exchange rate)	Д (official reserves)
Normalized coefficients	0.042	0.185
Standarderrors	0.024	0.055

'The hypothesis is rejected.

Table 7

Verification of the Presence of a Cointegration Relationship Between the Nominal Exchange Rate and Official Reserves from 1999 Through the First Half of 2002, Weekly Data

Estimation period	March 1999–July 2002
Number of observations	151

Verification of presence of cointegration relationships

Hypothesis: number of cointegration relationships	Eigenvalue	Statistic	5% confidence interval
With trace statistic			
None*	0.162	33.742	19.960
Not more than 1	0.045	7.002	9.240
Based on maximum eigenvalue			
None*	0.162	26.740	15.670
Not more than 1	0.045	7.002	9.240

Coefficients of cointegration relationship	Exchange rate	Official reserves	Constant
	–0.401	0.073	7.892
	0.795	–0.086	–20.110

Correction factors	Д (exchange rate)	Д (official reserves)	
	-0.043	–0.127	
	-0.040	0.041	

	Exchange rate	Official reserves	Constant
Normalized coefficients	1.000	-0.182	-19.692
Standard errors		0.050	1.318

	Д (exchange rate)	Д (official)	
Normalized coefficients	0.017	0.051	
Standard errors	0.007	0.012	

The hypothesis is rejected.

Table 8

Verification of the Presence of a Granger Effect Between Growth of the Nominal Exchange Rate and Growth of Official Reserves from 1999 Through the First Half of 2002

Null hypothesis	Monthly data (38 observations)		Weekly data (153 observations)	
	f-statistic	*p*-value	f-statistic	*p*-value
Growth of reserves does not influence growth of the nominal exchange rate	3.344	0.048	-1.063	0.348
Growth of the nominal exchange rate does not influence growth of reserves	0.942	0.400	2.126	0.123

E_t—nominal exchange rate (rubles per dollar).

In the long term, an increase in the nominal exchange rate by one ruble per U.S. dollar is accompanied by an increase in the RF Central Bank's gold and foreign exchange reserves by approximately $5.5 billion.

To estimate the relationship between official reserves and the nominal exchange rate, we will do a causality test for stationary increments of these factors. Estimation of a vector autoregression model with a Granger test enabled us to obtain the results shown in Table 8.

The Granger causality test based on monthly data indicates that growth in reserves affects the nominal exchange rate, but not vice versa. The results of tests on weekly data with more degrees of freedom do not reject either hypothesis about the absence of causality.

Estimation of a vector error correction model (VECM) including the trade balance as an explanatory variable for growth in official reserves showed that changes in the nominal exchange

rate proved to be insignificant in the corresponding equation, with and without lags.

Investigation of simple relationships between changes in the exchange rate and reserve growth produces some results, but they are fairly sensitive to whether the estimation is based on monthly or weekly data. Figure 9 shows a variance diagram of the growth in the RF Central Bank's gold and foreign exchange reserves and changes in the nominal exchange rate based on monthly data.

As we can see from the figure, there is a negative relationship between growth in official reserves and the nominal exchange rate, so that in a pair-wise regression growth in the nominal exchange rate is statistically significant for growth in official reserves. However, when the trade balance is added, for example, the change in the nominal exchange rate ceases to be significant.

We also find that growth in the exchange rate is positively influenced by growth in household and RF Ministry of Finance's foreign exchange deposits, factors determining the demand for money. When we estimated a GARCH model, it was found that growth in the nominal exchange rate is positively influenced by growth in household foreign exchange deposits, in the balances in the RF Ministry of Finance's foreign exchange accounts, and repayment of foreign debt. Reserve growth negatively influences growth in the nominal exchange rate as well as the variance of this growth. However, these estimates are highly unreliable, first, due to the possible mutual causality between reserve growth and growth in the exchange rate, and second, due to the low number of degrees of freedom (less than 20). For this reason, the system of equations was not estimated.

We will examine the variance diagram of growth in official reserves and the nominal exchange rate for the same period based on weekly data (see Figure 10).

On the variance diagram for weekly data, the negative relationship is less pronounced. In the pair-wise regression for growth in the nominal exchange rate, growth in official reserves is insignificant. The fact that reserve growth has a statistically insignificant effect

Figure 9. Variance Diagram of Growth in Official Reserves (Billion Dollars) and Changes in the Nominal Exchange Rate, Monthly Data from 1999 Through the First Half of 2002

Change in official reserves, billion dollars
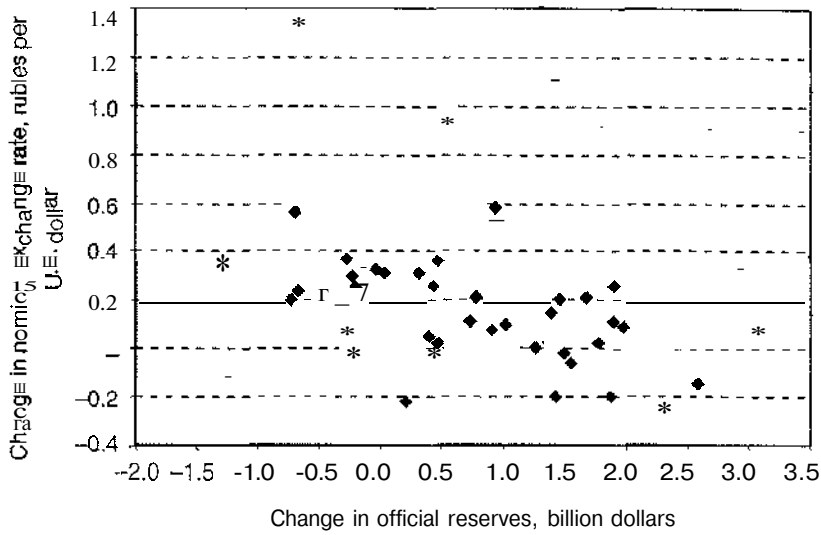
Figure 10. Variance Diagram of Growth in Official Reserves (Billion Dollars) and the Increment of the Nominal Exchange Rate, Weekly Data from 1999 Through the First Half of 2002

Change in official reserves, billion dollars
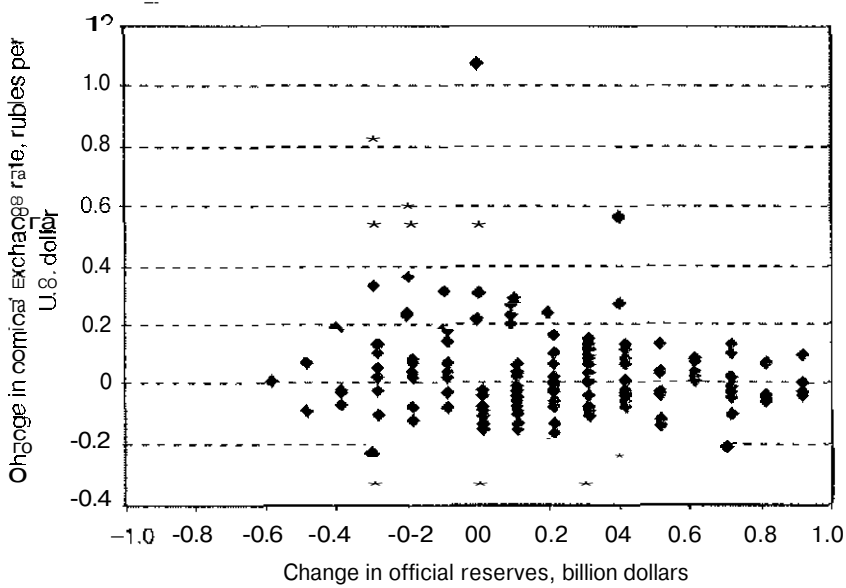
on the exchange rate, and vice versa, supports the idea that the central bank tried to stabilize the nominal exchange rate, not letting it strengthen or weaken too much, possibly compensating for excess supply or demand for foreign exchange and intra-day exchange-rate fluctuations, without causing additional fluctuations as a result of its interventions.

In the long term, an increase in reserves was accompanied by an increase in the exchange rate, which indicates that the policy being pursued resulted in a gradual accumulation of reserves, along with slow depreciation of the ruble.

Verification of the portfolio-balance and signaling effects of intervention

To check for the portfolio-balance effect, the following equation was estimated:

$$i_t - i_t^* - \frac{E_{t+1} - E_t}{E_t} = a_0 + a_1 \cdot \Delta R_t \varepsilon_t, \tag{19}$$

where

i — domestic interest rate for ruble interbank loans, percent per month;

i^* — domestic interest rate for dollar interbank loans, percent per month;

E_t — average nominal exchange rate during period t (rubles per dollar);

R_t — RF Central Bank's gold and foreign-currency reserves at the end of period t, billion dollars;

ε_t — random regression error;

a_0, a_1 — coefficients of the regression equation (according to the hypothesis, an increase in reserves "should reduce the risk premium for investment in domestic assets).

The estimation results showed that the coefficient for reserve growth in model (19) is insignificant. Analogous estimations were carried out for a GARCH model, which demonstrated that reserve growth has a statistically significant negative effect on the

variance of the risk premium for investment in domestic assets.

To determine how well central bank interventions on the foreign exchange market signal future monetary policy, we estimated the effect of growth in reserves on growth in the monetary base, and on the risk premium for future investments in domestic assets (from one to six months). These results showed tfiat a statistically significant effect is observed only for growth in the monetary base for the following month, and is apparently explained by a certain inertia in conducting intervention policy (reserve growth in consecutive months is comparable—the autocorrelation coefficient is about 0.4—so growth in the monetary base are also comparable, since sterilization is not fully accomplished). We were unable to find statistically significant evidence supporting the idea that intervention policy signals the parameters of future monetary policy over a longer period.

Verification of the profitability of interventions

We next checked the profitability of interventions, using equations (12) and (13) given in the first part of this study, which are based on statistical comparisons of the profitability of actual interventions to the profitability of random interventions with the same variance. According to these equations, the profitability of interventions comes from two main sources: (1) changes in the exchange rate between the times of foreign exchange purchases or sales, and (2) changes in interest rates for short-term loans in national and foreign currencies.

The results of verification of the hypothesis are given in Table 9.

The hypothesis that interventions were not aimed at making a profit cannot be rejected. This indicates that throughout the period under consideration the RF Central Bank's purpose was more interested in preventing the ruble's nominal appreciation, accumulating reserves, and stabilizing the foreign exchange market, than in profiting from currency speculation.

The results obtained in this empirical analysis can be summarized as follows:

Table 9

Verification of the Hypothesis About the Profitability of Interventions (Foreign-exchange Purchases) by the RF Central Bank from 1999 Through the First Half of 2002

Null hypothesis—profitability does not differ from the profitability of random interventions with the same variance	Monthly data	Weekly data
Number of observations	43	157
Confidence interval (5%) of *t*-statistic	2.017	1,975
Verification of profitability based on change in the exchange rate (Spencer, 1985), value of statistic	0.305	0.347
Verification of profitability based on change in the exchange rate and interest rates (Sarno and Taylor, 2001), value of statistic	0.004	no data
	not rejected	not rejected

Sources: L. Sarno and M.P. Taylor, "Official Intervention in the Foreign Exchange Market: Is It Effective and If So How Does It Work?" *Journal of Economic Literature,* vol. 39 (September 2001), pp. 839-68; P.D. Spencer, "Official Intervention in the Foreign Exchange Market," *Journal of Political Economy,* vol. 93, no. 5 (October 1985), pp. 1019–24.

1. The relationship between exports and international oil prices is stable, both in the long term (the presence of a cointegration relationship) and the short term (a relationship in increments). An increase in international oil prices by US$1 per barrel leads to an increase in exports by approximately $200 million.

2. The relationship between imports and the real exchange rate is a fairly stable, both in the long and short term (the ruble's real appreciation by 20 percent since the beginning of 1999 increased imports by approximately $1 billion). In addition to the real exchange rate, import growth was also influenced by growth in industrial production (as a factor characterizing demand). For a one-point increase in the industrial production index (January 1993 = 100), imports grow by about $87 million.

3. Growth in official reserves is one of the main factors responsible for the increases in the monetary base. Despite the partial sterilization of interventions, growth in the monetary base when foreign currency is purchased accounts for approximately 28 percent of the increase in reserves (in ruble terms).

4. Central bank interventions are partly sterilized via the accumulation of funds in Federal Treasury accounts. The correlation between changes in deposits and changes in reserves indicates that there is some level of coordination between the actions of the central bank and the RF Ministry of Finance. Transactions with securities in the RF Central Bank's assets are not used for sterilization.

5. Funds in Federal Treasury accounts are used in foreign debt service and repayment. When authorized agents of the RF Ministry of Finance purchase foreign exchange for these payments, they increase the monetary base and demand for foreign exchange.

6. The results of a cointegration test indicate the presence of cointegration between the nominal exchange rate and official reserves. An increase in the nominal exchange rate by 1 ruble per U.S. dollar is accompanied by an increase in international reserves by $5–5.5 billion. This relationship is present over the whole range of international oil prices observed during the period under consideration.

7. In the short term, monthly data suggest that there is a negative relationship between changes in the RF Central bank's official reserves and changes in the exchange rate. The relationship is insignificant based on weekly data. Apparently, this indicates that the central bank increased its reserves when the nominal exchange rate showed a tendency to appreciate, while trying at the same time to stabilize the nominal exchange rate and not letting it strengthen or weaken much, possibly compensating for excess supply or demand for foreign exchange and exchange-rate fluctuations over the course of a day, without causing additional fluctuations as a result of its interventions.

8. Verification of the profitability of interventions also supports the hypothesis about a gradual buildup of reserves within

the framework of a relatively stable nominal exchange rate. The hypothesis that the interventions were not aimed at making a speculative profit on fluctuations of the rate is not rejected.

Conclusion

This article analyzed the principal factors influencing monetary policy in the Russian Federation from 1999 through the first half of 2002. The survey of the literature given in the first part of the study enabled us to formulate the basic framework for analyzing the central bank's intervention policy, taking into account the distinctive characteristics and limitations of the situation in Russia.

In the second part of the study, qualitative graphical analysis of the behavior of basic indicators of the balance of payments, the foreign exchange market, and monetary policy showed that, despite the limited possibilities for sterilizing money supply growth resulting from the accumulation of official reserves, the RF Central Bank did sterilize significant this accumulation to a significant extent. Reserve growth (in ruble terms) was significantly greater than growth in the monetary base. In this case, the part of the interventions that was sterilized—that is, did not lead to an increase in the monetary base—corresponds largely to fluctuations in the budget system's accounts. Growth in exports and official reserves that followed the rise in oil prices was accompanied by increases in the budget system's revenues and the accumulation of fiscal surpluses. This sterilized a significant part of the RF Central bank's foreign exchange purchases. Those interventions that were not sterilized did generate inflationary increases in the monetary base which, when combined with a slowly changing nominal exchange rate, led to strengthening of the real exchange rate, stimulating import growth and reducing net inflows of foreign exchange.

Econometric verification of the hypothesized interrelations between the main indicators of the balance of payments, the foreign exchange market and monetary policy revealed stable long and short term relationships between international oil prices and

exports, and also showed the significant influence of growth in industrial production on import growth.

Increases in official reserves are one of the main factors responsible for growth in the monetary base, but growth in the monetary base due to unsterilized interventions only amounted to some 28 percent of the increase in reserves (in ruble terms). The accumulation of funds in Federal_Treasury accounts served as a primary sterilization tool, and the presence of a correlation between changes in these deposits and changes in reserves indicates that there is some coordination between the actions of the central bank and the RF Ministry of Finance. Open market operations involving the RF Central bank's assets are not used for sterilization. In addition to the actions of the RF Central bank, purchases of foreign exchange by the RF Ministry of Finance for foreign debt payments increase the monetary base and demand on the foreign exchange market.

In the long term, a positive interrelation between the nominal exchange rate and official reserves is apparent. In this case, an increase in the nominal exchange rate by 1 ruble per U.S. dollar is accompanied by an increase in international reserves by $5–5.5 billion (for the range of international oil prices observed from 1999 through the first half of 2002). In the short term, there is an unstable negative relationship between growth in official reserves and growth in the nominal exchange rate. This result indicates that by accumulating reserves when the nominal exchange rate showed a tendency to strengthen, the central bank limited exchange-rate fluctuations, meeting excess demand or buying up excess supply of foreign exchange and keeping the exchange rate relatively stable, without trying to make a speculative profit on exchange-rate fluctuations.

Notes

1. In a sterilized intervention, the sale of foreign exchange is most often accompanied by a purchase of securities on the open market to offset changes in the monetary base. In a partially or completely sterilized intervention, the

reduction in assets resulting from sale of part of the central bank's reserves is partially or completely compensated for by an increase in securities among its assets.

2. When foreign exchange is sold, the central bank's assets are reduced by the amount of reserves that are sold, along with a simultaneous reduction in liabilities by the amount of decrease in the monetary base.

3. The extent to which the profitability of interventions reflects their efficiency is a separate question (see Sarno and Taylor, 2001; Edison, 1993). For example, it is easy to imagine a very profitable destabilizing intervention, or, vice versa, an unprofitable but stabilizing one.

4. See Dynnikova (2001) for more details.

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