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# Strategic Interaction Between Fiscal and Monetary Policies in an Export-Oriented Economy

**Summary**: Solving the problem of stabilizing the economy is directly tied to the necessity of keeping the main macroeconomic variables stable. However, macroeconomic stability is not in the general case a purely fiscal or a purely monetary problem. How the central bank and the government interact is of principle importance. We investigate the impact of macroeconomic policies on the dynamics of the exchange rate, inflation, output and stabilization fund and consider different forms of strategic interaction between the government and the central bank. In this paper we build a stylized model of an export-oriented economy. We use numerical examples for our analysis and practical conclusions. The effective interaction of fiscal and monetary policies is possible under a cooperative Stackelberg game interaction with the government as leader. It is shown that the independence of the central bank does not play a crucial role.

**Key words:** Fiscal policy, Monetary policy, Exchange rate.

**JEL:** E41, E52, E61, E63.

The interaction of fiscal and monetary policies has become especially relevant during the last 30 years. The paper "Some Unpleasant Monetarist Arithmetic" by Thomas J. Sargent and Neil Wallace (1981) was groundbreaking; the authors showed that restricted monetary policy, given realistic assumptions, is not able to decrease inflation either in the long or short run without certain changes in fiscal policy.

Two lines of research have appeared in the economic literature. The first of these (Allan Drazen 1985; Michael Bruno and Stanley Fisher 1990) studied the effect of interaction of common fiscal and monetary policies on public debt without using a formal game-theoretic approach. A second approach, formed by Alan S. Blinder (1982), Guido Tabellini (1986), Alberto Alesina and Tabellini (1987) is based on the formal description of an optimal strategic interaction of the two policies. Blinder (1982) studied various means by which fiscal and monetary policies may interact, casting doubt on the assumption that their coordination can always be effective. Roel M. W. J. Beetsma and Lans Bovenberg (1995, 1999) also considered the conflict of interest between fiscal and monetary policies, namely the regulation of public debt and of the rate of inflation. They show that it is possible to achieve effective interaction of the two authorities irrespective of whether the central bank is independent or not.

Another area of research concerns the strategic complementarity problem: both fiscal and monetary policies can use instruments to influence aggregate demand and in doing so find a compromise between output and inflation. Torben M. Andersen and Friedrich Schneider (1986) were some of the first to consider this problem,

noting that two independent authorities do not automatically guarantee optimal output. Avinash Dixit and Luisa Lambertini (2003) showed that coordination entails a smaller output and higher inflation than either authority would like, if monetary policies are more conservative than fiscal policies. They also pointed out that in this case it would be preferable for the fiscal authorities to lead.

The creation of the European Monetary Union (EMU) influenced researchers to consider the interaction of fiscal and monetary authorities in more detail and to provide suggestions for solving real-life problems. See for example, Beetsma and Bovenberg (2000), Jordi Galí et al. (2003), Beetsma and Bovenberg (2005), Tatiana Kirsanova et al. (2007), Severine Menguy (2011). Beetsma and Bovenberg (2000) generally approved of the EMU policies and determined that the Maastricht Treaty, which gave priority to the European Central Bank (ECB) in stabilizing prices, was reasonable but insufficient. Dixit and Lambertini (2003) noted that the efficient functioning of the EMU is needed not so much for the coordination of fiscal and monetary authorities or for the integration of fiscal authorities in different countries, but rather for the consistency of goals with respect to the optimal levels of output and inflation. Silvia Staudinger (2003) suggested a rather different solution to the problem of interaction between fiscal and monetary authorities in the EMU. In her opinion, the most efficient interaction of the two authorities is determined by the weight that these two agents assign to output, inflation and other indices in their loss functions. She comes to the conclusion that under current conditions the EMU should prefer an independent, dominant ECB.

Bodo Herzog (2006) considers the problem of coordinating fiscal and monetary policies in the Commonwealth of Independent States (CIS). He shows that countries with more bargaining power (such as Russia) tend to coordinate less and more slowly. This is because of various factors, such as the risk premium in the interest rate, the free-rider problem and asymmetry of information.

This paper complements a number of papers on the subject of the interaction between fiscal and monetary policies. Our research is focused on the game-theoretical approach of strategic interaction between the government and the central bank. However, due to the specifics of an export-oriented economy, this paper's approach significantly differs from the approaches proposed by Tabellini (1986), Beetsma and Bovenberg (1995, 1999) and Dixit and Lambertini (2003). We explore fiscal and monetary policy interaction in an export-oriented (resource-based) economy. The problem of fiscal and monetary policy interaction in an export-oriented country with undeveloped financial markets requires considering specific macroeconomic relationships. We consider specific channels of fiscal and monetary policy interaction in an open economy with exchange rate management, which influences the fiscal position. Our basic model starts with aggregate relationships and as a prototype we consider the development of Russian economy in the period between 2001 and the mid of 2008. The managed exchange rate regime, when the exchange rate is determined by foreign exchange market operations conducted by the central bank, is assumed. If the central bank chooses to keep the exchange rate at a high level in order to stimulate national exports, it must buy foreign currency. However, the accumulation of international reserves is accompanied by an increase in the monetary

base that in turn stimulates inflation. The inflationary consequences of an expansionary monetary policy can be in part sterilized by contractionary fiscal policy. By accumulating a stabilization fund, the government removes money from circulation and brings inflationary pressure down. Thus, by determining the discretionary budget surplus and the nominal exchange rate, fiscal and monetary policies can affect the macroeconomic equilibrium. The choice of these control variables depends on the specific form of strategic interaction between the government and the central bank. While the model indeed captures main features of the Russian economy, the most important mechanisms of the model could be applied to other countries with undeveloped financial markets, that follow managed exchange-rate policies and whose budget revenues highly depend on their undifferentiated exports. Moreover, we investigate interrelated problems of exchange rate management, disinflation policy, the accumulation of a stabilization fund and effects on the real economy. Monetary authorities face a specific trade-off between inflation reduction and exchange-rate management aimed to stimulate national exports. Indeed, as long as the exchange rate is one of the key determinants of export revenues - in turn the significant part of the tax base - by managing the exchange rate, monetary policy alters the set of fiscal policy alternatives. At the same time, fiscal surpluses and the accumulation of a stabilization fund by the government pump money out of circulation which reduces inflation. It means that fiscal policy also alters the set of monetary policy alternatives. It should be mentioned, that sterilization of excess money is important but is not the only goal of accumulating stabilization funds. We do not discuss all these goals as they are not in the focus of the paper.

These considerations form the basis for investigation of the mechanism and demand the search for the best form of strategic interaction between fiscal and monetary authorities.

# 1. Model

## 1.1 Building the Model

We consider a static model for the interaction between fiscal and monetary policies. The values of all the variables in period 0 are given. The values of the variables in period 1 are determined exogenously or endogenously. In this setup the model is essentially static, although it can be used in a multi-period analysis. The fiscal authority chooses the discretionary budget surplus, defined as government expenditure minus net lump-sum taxes. The choice of the term discretionary budget surplus has to do with the fact that it is this variable (and not the overall budget surplus) that is chosen by the government in its strategic interaction with the central bank. Other taxes are determined endogenously: income tax revenues depend on output, while taxes on export revenues depend on the flow of export and the exchange rate. We assume a managed exchange rate regime, when the exchange rate is determined by foreign exchange market operations conducted by the central bank. If the central bank chooses to keep the exchange rate at a high level in order to stimulate national exports, it must buy foreign currency. However, the accumulation of international reserves is accompanied by an increase in the base money that in turn stimulates infla-

tion. The inflationary consequences of an expansionary monetary policy can be in part sterilized by contractionary fiscal policy. By accumulating a stabilization fund, the government removes money from circulation and brings inflationary pressure down. Thus, by determining the discretionary budget surplus and the nominal exchange rate, fiscal and monetary policies can affect the macroeconomic equilibrium. The choice of these control variables depends on the specific form of strategic interaction between the government and the central bank.

The model is based on the following seven equations:

$$M_{E1}V(x) = P_1Y_1 \quad \text{Aggregate demand} \quad (1)$$

$$\pi_1 - \pi_0 = \alpha(Y_1 - Y^*) + \beta(\varepsilon_1 - \varepsilon_0) \quad \text{Open-economy Phillips curve} \quad (2)$$

$$s_1 - s_0 = (\psi E_0 Ex_0 + tY_0 + x)P_0 \quad \text{Government budget constraint} \quad (3)$$

$$Ex_0 - \mathrm{Im}_0 + CF_0 = z_1 - z_0 \quad \text{The balance of payments} \quad (4)$$

$$M_1 - M_0 = (z_1 - z_0)E_1 \quad \text{Foreign exchange operations} \quad (5)$$

$$M_1 - M_0 = s_1 - s_0 + M_{E1} - M_{E0} \quad \text{Money decomposition} \quad (6)$$

$$E_1 = P_1\varepsilon_1 \quad \text{Real exchange rate} \quad (7)$$

The first equation describes aggregate demand in the tradition of the quantity theory of money. Money in circulation, $M_{E1}$, adjusted for the velocity, $V(x)$, equals nominal GDP, $P_1Y_1$. In what follows, the subscripts 0 and 1 refer to periods 0 and 1, respectively. We assume that only money in circulation, and not the whole amount of money, $M_1$, affects aggregate demand and prices. This is because money accumulated in the government's stabilization fund $s_1$ and thus removed from circulation does not affect either real production $Y_1$ or the price level $P_1$. Equation (6) determines the decomposition of the total amount of money injected into the economy by the central bank's operations on the foreign exchange market and will be discussed later.

We assume that money velocity declines with an increase in the discretionary budget surplus, $V_1 = \overline{V} - kx$: an expansionary fiscal policy increases money velocity and a contractionary policy slows it down. We should note that transmission mechanisms in emerging market economies (such as Russia) function poorly and the interest rate cannot be considered a regulator of economic activity. This supports the assumption of a direct dependence of money velocity on the fiscal policy variable. We should take into account that there are a number of mechanisms (such as taxes and transfers) that reflect the impact of the government on aggregate demand along with the money accumulation to the stabilization fund. In terms of the quantity theory of money, these mechanisms should be reflected in changes in the velocity of money. The velocity of money is a kind of "residual" in the equation that relates aggregate

output, price level and money in circulation. In other words, this assumption is a convenient way of modeling the inevitable direct effects of fiscal policy on aggregate demand. Thus, the model contains two channels through which fiscal policy can impact aggregate demand: by regulating the money in circulation and by varying the velocity of money. The value of $\overline{V}$ is assumed to be exogenous and constant. The relationship of the velocity of money and fiscal policy is crucial and nontrivial for our analysis of the interaction between fiscal and monetary policies.

As a practical matter, we consider a linear specification of a dynamic model so that an analytical solution can be found. In particular, it will be convenient to write the exchange equation in terms of increments: $\frac{M_{E1}-M_{E0}}{M_{E0}}+\frac{\overline{V}-kx-V_0}{V_0}=\pi_1+\frac{Y_1-Y_0}{Y_0}$, where $\pi_1=\frac{P_1-P_0}{P_0}$ is the inflation rate in the first period.

Equation (2) gives aggregate supply. The relationship between inflation and output is traditionally expressed by the Phillips curve. However, in our model the Phillips curve is written in a slightly modified way, $\pi_1-\pi_0=\alpha\left(Y_1-Y^*\right)+\beta\left(\varepsilon_1-\varepsilon_0\right)$, where $Y^*$ is the natural rate of output, $\varepsilon$ is the real exchange rate of the foreign currency, and $\alpha$ and $\beta$ are positive parameters. This modified equation is the simplest Phillips curve for an open economy (for more detail, see Assaf Razin and Chi Wa Yuen 2002). Intuitively, this form of the modified Phillips curve can be explained in the following manner. A real depreciation of the national currency brings about an increase in exports and in increase in output (as a result of an increase in aggregate demand). An increase in output brings about an increase in the price level both for final goods and services, and for resources. In particular, labor costs will increase. In its turn, the increase in wages determines a decrease in short-term aggregate demand and thus a decrease in output. This effect is known as the "Dutch disease" or "resource curse". Thus, in general there are two effects of an increase in exports and the exchange rate of foreign currency: an increase in aggregate demand and a decrease in aggregate supply. Since our model does not consider the problem of dynamic inconsistency of macroeconomic policy, the specification of the Phillips curve does not have rational expectations. It should be noted, that in contrast to Dixit and Lambertini (2003), we use a structural approach for the modeling of macroeconomic relationships and do not analyze the macroeconomic policy with binding commitment of the government or the central bank. For this reason, the paper does not address the problem of forming rational expectations of the private sector with regard to macroeconomic policy.

The government budget constraint is given by equation (3). An increase in the stabilization fund (in real terms), $\left(s_1-s_0\right)/P_0$, is determined by the total budget surplus $\psi E_0 Ex_0+tY_0+x$, where $E_0$ is the nominal exchange rate of the foreign currency. Thus, part of the stabilization fund is formed by the discretionary budget surplus and the income tax. In essence, this part of the stabilization fund is formed by

the government, which exogenously sets the tax rate $t$ and forms the discretionary budget surplus, $x$. Note that the discretionary budget surplus includes only lump-sum taxes, $x = T - G$, and differs from the total budget surplus by the taxes that depend on exports and output, $budget\ surplus = (T - G) + \delta\left(\overline{Ex} + c\varepsilon\right) + tY$. In our model, the discretionary budget surplus $x$ is the main instrument of fiscal policy.

In addition, the increase in the stabilization fund is determined by the volume of exports, $E_0 Ex_0$, which is taxed at a rate of $\psi$. The volume of exports positively depends on the real exchange rate, $Ex = \overline{Ex} + c\varepsilon$. This mechanism of forming the stabilization fund depends significantly on the policy of the central bank. The stabilization fund is measured in nominal terms, while the budget surplus is measured in real terms. Thus, the accumulation of the stabilization fund in the first period may be written as $s_1 - s_0 = \left[\delta\left(\overline{Ex} + c\varepsilon_0\right) + tY_0 + x\right]P_0$.

Equation (4) determines the balance of payments (in foreign currency). The capital account, $CF_0$, is taken to be exogenous. The increase in international reserves, $(z_1 - z_0)$, is determined as the sum of current account, $(Ex_0 - \mathrm{Im}_0)$, and the capital account. The volume of imports negatively depends on the real exchange rate, $\mathrm{Im} = aY - b\varepsilon$.

The next equation of system (5) determines the increase in money and the increase in the international reserves of the central bank. In an export-oriented economy, the main instrument of the central bank is foreign currency operations, in contrast to the traditional monetary instruments (open-market operations, the discount rate, the reserve ratio). Thus, in our model the main instrument of monetary policy is the rate of change of the nominal exchange rate, $e_1 = \dfrac{E_1 - E_0}{E_0}$. By increasing international reserves, the central bank increases the supply of money; this is shown in equation (5). The growth rate of money, $\mu_1 = \dfrac{M_1 - M_0}{M_0}$, is determined by exchange-rate policy, $\mu_1 = \dfrac{(z_1 - z_0)E_0(1 + e_1)}{M_0}$.

However, it is not the entire money that is of principle importance in our model; we are concerned mainly with that part which is in circulation. As noted above, the rest of the money is sterilized via the stabilization fund. In accordance with equation (6), the increase in money as a result of foreign currency operations, $M_1 - M_0$, consists of two components: the increase in the stabilization fund, $s_1 - s_0$, and the increase in the money in circulation, $M_{E1} - M_{E0}$.

Equation (7) determines the real exchange rate $\varepsilon$. The foreign price level is normalized to unity. We can rewrite equation (7) in terms of growth, $e_1 = \pi_1 + \frac{\varepsilon_1 - \varepsilon_0}{\varepsilon_0}$.

Thus, we have constructed a system of seven equations with seven endogenous variables: the international reserves $z_1$, the growth rate of money $\mu_1$, the rate of inflation $\pi_1$, the money in circulation $M_{E1}$, the real exchange rate $\varepsilon_1$, the stabilization fund $s_1$ and output $Y_1$ in the first period. Our model is completely determined, and the equilibrium value of each variable can be found. The values of variables in the zero period are given. The government and the central bank may influence macroeconomic equilibrium by using their instruments, $x$ and $e_1$.

## 1.2 Analysis of Equilibrium

We express the equilibrium values of the seven endogenous variables in terms of the parameters of the model, the pre-determined variables and the instruments of macroeconomic policy:

*Rate of inflation*

$$\pi_\tau = \frac{\alpha Y_0\left[e_1\left[(c+b)E_0(1+e_1)-\delta cP_0\right]+E_0(1+e_1)\left(\overline{Ex}-aY_0+CF_0\right)-P_0\left(\delta\overline{Ex}+tY_0+x\right)\right]}{\alpha Y_0\left[(c+b)E_0(1+e_1)-\delta cP_0\right]+M_{E_0}(1+\beta\varepsilon_0+\alpha Y_0)}+$$
$$+\frac{M_{E_0}\left(\pi_0+\beta\varepsilon_0 e_1-\alpha Y^*+\alpha Y_0\right)}{\alpha Y_0\left[(c+b)E_0(1+e_1)-\delta cP_0\right]+M_{E_0}(1+\beta\varepsilon_0+\alpha Y_0)}+$$
$$+\frac{\alpha Y_0 M_{E_0}\left(\overline{V}-kx-V_0\right)}{V_0\left[\alpha Y_0\left[(c+b)E_0(1+e_1)-\delta cP_0\right]+M_{E_0}(1+\beta\varepsilon_0+\alpha Y_0)\right]}$$

For convenience, the rest of the endogenous variables are written not only in terms of endogenous variables, but also in terms of inflation $\pi_1$:

*International reserves*

$$z_1 = z_0 + \overline{Ex} - aY_0 + CF_0 + (c+b)(e_1-\pi_1)$$

*Base money growth*

$$\mu_1 = \left(\overline{Ex} - aY_0 + CF_0 + (c+b)(e_1-\pi_1)\right)\frac{E_0(1+e_1)}{M_0}$$

*Money in circulation*

$$M_{E1} = \left( \overline{Ex} - aY_0 + CF_0 + (c+b)(e_1 - \pi_1) \right) E_0 (1 + e_1) - \left( \delta \overline{Ex} + \delta c(e_1 - \pi_1) + tY_0 + x \right) P_0 + M_{E0}$$

*Real exchange rate*

$$\varepsilon_1 = \varepsilon_0 (1 + e_1 - \pi_1)$$

*Output*

$$Y_1 = \frac{(1 + \beta\varepsilon_0)\pi_1 - \pi_0 - \beta\varepsilon_0 e_1}{\alpha} + Y^*$$

*Stabilization fund*

$$s_1 = \left( \delta \overline{Ex} + \delta c(e_1 - \pi_1) + tY_0 + x \right) P_0 + s_0$$

Given how cumbersome the formulas are for the equilibrium values of $z_1$, $\mu_1$, $\pi_1$, $M_{E1}$, $\varepsilon_1$, $s_1$ and $Y_1$, we will use numerical examples for further analysis and practical conclusions. The analysis was conducted using *Mathcad 2000 Professional*. All calculations are available upon request. Using numerical examples is appropriate form of analysis not only because of cumbersome formulas, but also because of the fact that our model is structural and the equilibrium of the model cannot definitely show the sign of the effects of the exogenous variables on the endogenous variables. However, determination of the sign of each effect is important for our analysis because the main goal is to evaluate how all effects influence the macroeconomic equilibrium together but not separately.

The purpose of our research is to arrive at qualitative, rather than quantitative, robust results, and therefore the specification of parameters in our model (see Table 1) are not based on the results of empirical investigations or calibrations.

**Table 1** Specification of Parameters in the Model

| | | | | | |
|---|---|---|---|---|---|
| $\pi_0 = 0{,}11$ | $Y_0 = 0{,}8$ | $\overline{Y} = 1{,}1$ | $Y^* = 1$ | $E_0 = 23$ | $\varepsilon_0 = 24$ |
| $s_0 = 0{,}08$ | $z_0 = 0{,}2$ | $\overline{Ex} = 0{,}3$ | $CF_0 = 0{,}2$ | $M_0 = 0{,}7$ | $M_{E0} = 0{,}3$ |
| $P_0 = 1{,}2$ | $a = 0{,}6$ | $b = 0{,}8$ | $c = 0{,}7$ | $\alpha = 1{,}25$ | $\beta = 1{,}5$ |
| $\delta = 0{,}5$ | $t = 0{,}13$ | $\alpha_{xF} = 0{,}75$ | $\alpha_{YF} = 1{,}5$ | $\alpha_{eM} = 1$ | $\alpha_{YM} = 0{,}75$ |
| $\alpha_{eS} = 1$ | $\alpha_{YS} = 0{,}5$ | $\overline{V} = 1$ | $V_0 = 2$ | $k = 0{,}8$ | $\overline{x} = 0$ |

**Source:** Data and calculations by the author.

The value of the natural rate of output $Y^*$ is equal to 1. The optimal value of output is given to be higher than its natural level. This approach is traditional in the macroeconomic literature. See, for example, Finn E. Kydland and Edward C. Prescott (1977). The set of predetermined variables (the stabilization fund

$s_0$, the international reserves $z_0$, the money in circulation $M_{E0}$, the capital flow $CF_0$, the autonomous export $\overline{Ex}$) are specified from considerations of scale and have been kept at a certain level for convenience. Fundamentally, however, the change of each parameter does not affect the qualitative results of the model. The same consideration applies to the model parameters such as $\delta, k$, as well as the velocity of money ($V_0$), real ($\varepsilon_0$) and nominal ($E_0$) exchange rates, and the tax rate $t$. Any variation in the price level ($P_0$) also does not affect the qualitative implications from the model. To obtain qualitative results a wide range of parameters that characterize the macroeconomic priorities of the agents ($\alpha_{xF}, \alpha_{YF}, \alpha_{eM}, \alpha_{YM}, \alpha_{eS}, \alpha_{YS}$) was considered. In numerical examples the deficit (surplus) was chosen at a level not exceeding 10% of output, which seems to be quite realistic assumption. It is also worth mentioning that parameter $a$ ranged from 0.3 to 0.9, parameters $b, c$ varied from 0.1 to 1, and parameters $\alpha, \beta$ ranged from 0.01 to 10. The most interesting and meaningful results of variation of parameters are presented below. Calculations prove that all the results are robust.

## 2. Strategic Interaction

The way in which monetary policy affects the economy depends on the fiscal policy pursued by the government. Clearly, in this case the concrete mechanism of how the government and the central bank interact plays an important role. Below we will model various forms of the strategic interaction of these agents, after first considering their own loss functions.

### 2.1 Loss Functions

Social loss, along with the losses of the government and the central bank, are the main criteria for the efficiency of the macroeconomic policy being conducted. Below we consider the loss functions for the government, central bank and society, which are necessary for the further analysis of the interaction between fiscal and monetary policies. These loss functions are not standard and that is why we should appropriately and in detail describe them. In fact, the loss functions are not micro-founded in the model, but we believe they properly describe the preferences of the main macroeconomic agents in a stylized model of a resource-based economy with undeveloped financial markets.

*The loss function for the government:*

$$L_F = \frac{1}{2}\left[\pi_1^2 + \alpha_{xF}\left(x - \bar{x}\right)^2 + \alpha_{YF}\left(Y_1 - \overline{Y}\right)^2\right] \tag{8}$$

Here $\pi_1^2$ is the square of the deviation of inflation from its optimal rate. For simplicity, but without lack of generality, the optimal rate of inflation can be taken to

be equal to zero. The expression $(x-\bar{x})^2$ shows the square of the deviation of the discretionary budget surplus from the government's optimal value of $\bar{x}$, which is determined by both economic and political considerations (such as the necessity of keeping government spending at a certain level). The discretionary budget surplus in the model differs from the overall budget surplus by the taxes that depend on export and output. We do not include taxes that depend on output in the government loss function to avoid double-counting because the deviation of output from its optimal level is already included in the loss function. The idea that government cares about the overall budget could be true for the developed countries, but it does not seem realistic for the resource-based economies with undeveloped financial markets, where the government tries to avoid political consequences (loss of popularity) related to export revenue fluctuations. For example, the government is reluctant to cut social payments following a decrease in export revenues. In sum, including taxes that depend on export into the loss function would be an unrealistic and inappropriate assumption for the resource-based economy. Therefore it is more reasonable to use the deviation of the discretionary budget, which includes lump-sum taxes and social payments, but not the deviation of the overall budget in the government loss function. In numerical examples, we took the optimal value to be $\bar{x}=0$. The expression $(Y_1-\bar{Y})^2$ is the square of the deviation of output from its optimal level. Finally, the weight coefficients $\alpha_{xF}$ and $\alpha_{YF}$ characterize the priorities of the government in forming the discretionary budget surplus and output, respectively. The weight coefficient for inflation is taken to be equal to one.

Thus, the government adheres to a fiscal policy that is a compromise between output and inflation and the government also has its own political and economic goals.

*The loss function for the central bank:*

$$L_M=\frac{1}{2}\left[\pi_1^2+\alpha_{eM}e_1^2+\alpha_{YM}(Y_1-\bar{Y})^2\right] \tag{9}$$

The loss function for the central bank has the same general form as the government. For simplicity, we assume that the optimal levels of output and inflation are the same for both agents. The specific target variable of monetary policy is the exchange rate. Here $e_1^2$ is the square of the deviation of the rate of growth of the nominal exchange rate from its optimal value. The fact that zero depreciation (appreciation) of the nominal exchange rate is optimal given a zero level of inflation is determined by purchasing power parity.

In our model the increase in the real exchange rate has assured that the stabilization fund will grow. Thus, aside from the standard output-inflation trade-off, the central bank must also manage the exchange rate of foreign currency. By conducting operations on the money market, the central bank can control the rate of growth of the nominal exchange rate. Here it needs to solve the problem of choosing between

stabilization of the rate of inflation or an exchange-rate policy that keeps export revenue high. Appreciation of foreign currency stimulates exports, in turn bringing about increases in output and budget revenues from export taxes (therefore allowing the stabilization fund to grow). However, buying foreign currency in order to maintain its high exchange rate implies an increase in the money supply and therefore an increase in the rate of inflation. The weights $\alpha_{eM}$ and $\alpha_{YM}$ characterize the priorities of the central bank in determining the nominal exchange rate and the expansionary output, respectively. As for the loss function for the government, the weight coefficient for the rate of inflation is normalized to unity.

*The social loss function:*

$$L_S = \frac{1}{2}\left[\pi_1^2 + \alpha_{eS} e_1^2 + \alpha_{YS}\left(Y_1 - \overline{Y}\right)^2\right] \tag{10}$$

The form of the social loss function is the same as that of the central bank (except for the weight coefficients). The inclusion of $e_1$ in the social loss function is reasoned by the fact that in emerging market economies (such as Russia) a significant part of households' wealth is in the form of foreign currency. Therefore, for the private sector it is optimal to keep $\pi_1$ and $e_1$ at zero, in other words, to avoid any shocks. However, for a zero value of inflation the society would prefer an increase in $e_1$, which determines the profitability of savings in foreign currency. On the other hand, an increase in the nominal exchange rate brings about an increase in the price of imported goods. We assume, given the two opposite effects, that $\overline{e}_1 = 0$. The weight coefficients $\alpha_{eS}$ and $\alpha_{YS}$ characterize the priorities of society with respect to changes in the nominal exchange rate and to increases in aggregate income, respectively. As in the loss functions considered above, the weight for the rate of inflation is taken to be equal to one.

It is worth mentioning that we do not assume equal weights in the loss functions of the central bank and the government. It would be analytically inappropriate to compare the weight coefficients of different macroeconomic agents between each other because of complete differences in the form of their loss functions. It seems to be more accurate to compare the weight coefficients of each agent separately. In the end, our aim is not to find out which agent's preference over inflation or output is higher, but to clarify what macroeconomic variable is more significant for every agent.

Unsurprisingly, benevolent government and central bank (the loss function of society, the government and central bank are the same) are most preferred in terms of design of fiscal and monetary policy and conducting the optimal macroeconomic policy. In this case, the problem of the optimal design of fiscal and monetary policy becomes trivial, so we do not consider the situation of benevolent fiscal and monetary policy in this paper. Thus, for our analysis it is essential that the loss functions of society, the government and central bank are different.

Below we will consider various types of this interaction, compare the results and draw conclusions about their relative efficiency.

## 2.2 Coordination

We consider this possibility, since often the independence of the government and central bank is nominal, and in reality the actions of these two agents are coordinated by some third party (for instance, by the president). In this regard, it is important to understand if this type of interaction is effective in our models and if so, under what conditions.

In the case of coordinated macroeconomic policy there is an additional parameter, $\omega$, the bargaining power of the agents. In our model this parameter will characterize the weights with which the loss functions of the fiscal and monetary authorities will be included in the total loss function. The bargaining power of the central bank is taken to be equal to one and $\omega$ characterizes the relative bargaining power of the government.

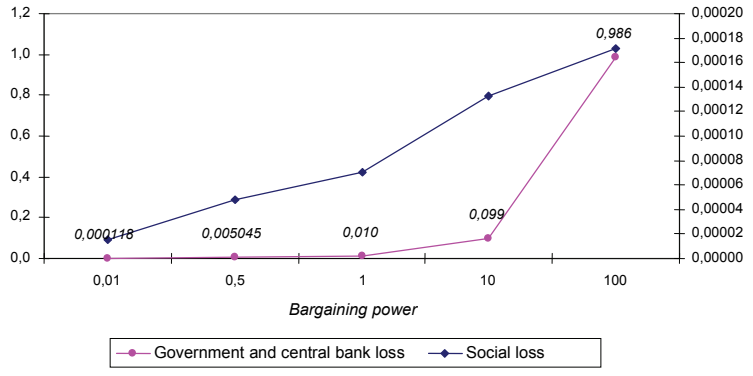
Thus, the general loss function in the case of coordination should be the loss function for a single agent and can be written as:

$$L_{F+M} = \frac{1}{2}\left[(1+\omega)\pi_1^2 + (\alpha_{YM} + \omega\alpha_{YF})(Y_1 - \bar{Y})^2 + \alpha_{eM}e_1^2 + \omega\alpha_{XF}(x - \bar{x})^2\right] \tag{11}$$

The optimal values of the control variables of the government and the central bank, $x$ and $e_1$, can be found by optimizing the loss function of the coordinated agents. We determine the equilibrium values of the variables $z_1$, $\mu_1$, $\pi_1$, $M_{E1}$, $\varepsilon_1$, $Y_1$ and $s_1$ for these optimal values. Numerical examples are used in order to analyze these results.

One of the main questions in the case of coordination between the fiscal and monetary policies is what the relative bargaining power of the government and central bank should be in order to achieve the best outcome. In essence, this is a question about how the third, coordinating agent should assign weights to fiscal and monetary goals. In other words, this is a problem of designing the optimal institutions of government.

In order to determine the optimal value of bargaining power, we compared the endogenous variables of the model as well as social loss and the coordinated policies for various values of $\omega$. We are mostly interested in comparing the losses of coordinated policy and of society for various values of the parameter $\omega$. As the bargaining power of the government increases, we observe a significant increase in the losses of the coordinated policy and especially of society (see Figure 1). Thus, the coordinated interaction of fiscal and monetary authorities is efficient only if the central bank has high bargaining power.




**Source:** Data and calculations by the author.

**Figure 1** The Losses of the Coordinated Policy and of Society for Various Values of Bargaining Power Parameter

Despite the critical significance of monetary policy in the case of coordination, the weights in the central bank's loss function do not have a decisive impact. This has to do for the main part with the fact that, given the central bank's high bargaining power, the equilibrium values of the endogenous variables are close to their optimal values. This also explains why changes in the weights in social loss function also do not lead to noticeable changes in social loss. We note, however, that the closer the weights of the policies (and especially of the central bank) to those of society, the smaller social loss will be. In other words, the most efficient interaction of the government and the central bank in the case of coordination is when the monetary authority is benevolent (when the loss functions of the central bank and of society coincide).

We also note that the smaller the value of $\omega$, the higher the discretionary budget deficit ($-x$). However, given high revenues from export taxes and stable growth of output, this does not bring about a general budget deficit for the government, $(-x)-\delta\left(\overline{Ex}+c\varepsilon\right)-tY$.

Actually, these results do not allow one to claim that the coordination of fiscal and monetary policies is always preferable. If the government and the central bank have opposing goals, adhere to different economic theories or make contradicting predictions about the country's future economic development, then coordination of policies may be inefficient from both a political and an economic viewpoint.

## 2.3 Stackelberg Interaction with the Government Leadership

We will now consider Stackelberg interaction. The most characteristic case is one in which the central bank is independent of the government, yet the latter, being the leader, affects the central bank's decision in order to achieve its goals. In determining

the optimal policy, the leader considers the possible reaction of the follower to its decisions.

In our investigation, we will consider Stackelberg interaction only with the government in the role of leader. The case in which the central bank plays the role of leader will remain outside this paper. For the main part, this is based on the conclusions of Dixit and Lambertini (2003) that leadership in fiscal policy is usually more efficient than leadership in monetary policy.

The equilibrium values of $z_1$, $\mu_1$, $\pi_1$, $M_{E1}$, $\varepsilon_1$, $Y_1$ and $s_1$ are determined after solving the optimization problems for the government and the central bank, given their Stackelberg interaction. We will use numerical examples for the analysis of our results.

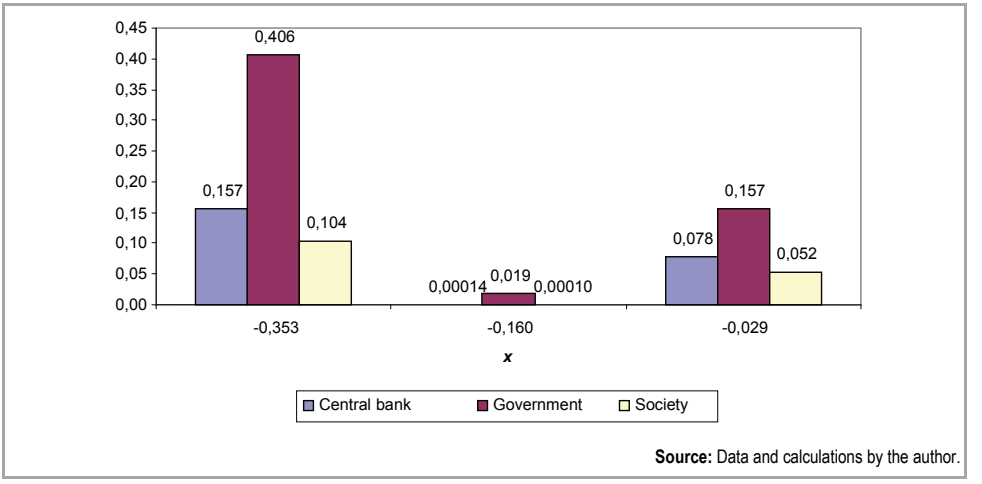



**Figure 2** The Losses of Society, the Government and the Central Bank Given a High Priority for Stabilizing Output

It can be seen from Figure 2 that the social loss as well as losses of fiscal and monetary agents are high for low, negative values of $x$ that characterize the degree of fiscal expansion. This can be explained mostly by the excessively high level of output, which is more than its natural level, and by the high rate of inflation. It turns out that in a situation in which the government (the leader) adheres to an excessively contractionary fiscal policy with a large negative value of $x$, the central bank (the follower) chooses a loose policy. The significant increase in the money in circulation "overheats" the economy and social welfare decreases.

However, in the case of the largest of the three equilibrium values of $x$, the losses of all macroeconomic agents are relatively high. This can be explained first of all by the extremely low level of output. In this case the low output is not compensated by low inflation. The choice of the leader to adhere to a relatively expansionary fiscal policy - that is, the choice of the largest (negative but close to zero) equilibrium value of $x$ - forces the follower to adhere to a rather tight monetary policy and this brings about low output and low inflation.

Our analysis shows that the optimal value of $x$ corresponds to the level of output that is closest to its natural level, rather than to the target level. The choice of optimal strategy also does not depend crucially on either the sensitivity of the central bank to changes in the nominal exchange rate $\alpha_{eM}$, or the sensitivity of the government to the formation of the discretionary budget surplus $\alpha_{xF}$.

If both agents give a relatively low priority to the stabilization of output as the level of fiscal expansion increases, output will exceed its natural level to an even greater degree, and a contractionary fiscal policy will make output too low. Thus, the economy will either be overheated or in a deep recession and this will bring about a significant increase in social loss for low values of $\alpha_{YF}$ and $\alpha_{YM}$. The only winner is the government, whose leadership allows it to systematically minimize its loss even if it is pursuing policies that are inefficient for society.

For high values of $\alpha_{YF}$ and $\alpha_{YM}$ and Stackelberg interaction of policies, the best outcome for society is achieved if the central bank is benevolent.

## 3. Conclusion

The analysis of equilibrium in the macroeconomic model of an export-oriented economy shows that, from the point of view of society, the most preferable situation is that in which the government and the central bank choose reasonably expansionary policies. In fact the increase in output, decrease in inflation and accumulation of the stabilization fund depend on what policies are pursued by the government and the central bank.

In an export-oriented economy, the independence of the central bank does not play a significant role. The effective interaction of fiscal and monetary policies is possible under a cooperative Stackelberg game interaction with the government as leader. Social loss is minimal under both forms of interaction, if fiscal and monetary policies are expansionary and allow output to approach its optimal level.

In other words, the efficient interaction of fiscal and monetary policies is possible given either coordination or political differences of opinion between the government and the central bank. Intuitively, this can be explained by the fact that the condition of independence of the central bank does not play a decisive role and is more a political rather than economic issue in a resource-based economy with undeveloped financial markets.

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