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

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Abstract. In this paper we build a stylized model of an export-oriented economy. 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. It is shown that the independence of the central bank does not play a crucial role. The effective interaction of fiscal and monetary policies is possible under Stackelberg interaction with the government as leader and under cooperation. Our analysis shows that this policy mix (contractionary fiscal policy and excessively loose monetary policy) is not optimal: social loss is lower under moderately expansionary policies pursued by both the central bank and the government.

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1. Introduction

The interaction of fiscal and monetary policies has become especially relevant during the last 20-25 years. The paper "Some Unpleasant Monetarist Arithmetic" by Sargent and 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. This paper is one of the most cited in articles dealing with this problem area.

Two lines of research have appeared in the economic literature. The first of these (Drazen, 1985; Bruno and Fischer, 1990) studied the effect of interaction of common fiscal and monetary policies on public debt without using a formal game-theoretic approach. The so-called "fiscal theory of inflation" appeared in the 1980s.[2] A new approach appeared in the 1990s: the fiscal theory of the price level (Sims, 1994; Woodford, 1995), which applied a non-traditional interpretation of the budget constraint of the government.

A second approach, which was formed by Blinder (1982), Tabellini (1986), Alesina and Tabellini (1987), Tabellini and La Via (1989), Nordhaus, Schultze and Fischer (1994), 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. He believes that one of the reasons that their coordination may not be effective is the wide range of instruments available by which fiscal and monetary authorities may achieve the major goals of stabilization policies: "When no one can be sure what is the right thing to do, no one can ensure us that a unified fiscal – monetary policy authority will do better than the two-headed horse we now ride."[3]

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[2] See, for example, Weil (1987), Drazen and Helpman (1990), Dornbusch (1996).
[3] Blinder (1982), pp. 25 – 26.

Literature on modeling the strategic interaction of the authorities

Two main groups of problems concerning the strategic interaction of the government and the central bank can be found in the modern literature. The first concerns the study of how fiscal and monetary policies influence the stability of public debt and the regulation of inflation. Following the groundbreaking work by Tabellini (1986), van Arle, Bovenberg and Raith (1995, 1997) enhanced the former's model so that fiscal policies were concerned not only with attaining their own goals, but also with attaining goals traditionally considered to be monetary.

Beetsma and Bovenberg (1995, 1997, 1999) also considered the conflict of interest between fiscal and monetary policies, namely the regulation of the 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. The authors note that under cooperation of fiscal and monetary policies the government does not have to use the debt as a stratgic instrument if the central bank stabilizes the price level. At the same time, if the monetary authorities are independent, efficient interaction is possible if the government is more intolerant of inflation than both the central bank and society. The authors also note that, in order to avoid the "unpleasant monetarist arithmetic" of Sargent and Wallace it is necessary to determine the optimal level of public debt in order to efficiently manage the economy.

The second 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. Andersen and Schneider (1986) were some of the first to consider this problem, and they noted that two independent authorities do not automatically guarantee optimal output.

Dixit and Lambertini (2001, 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. In their opinion, efficient interaction between the government and the central bank is possible if both have identical goals (output approaches social optimum and prices are stable) or if their goals are strictly separate (the central bank is concerned only with the price level, and the government is concerned only with optimal output). Lambertini (2004) comes to similar conclusions.

Practical applications of the research

The creation of the EMU influenced researchers to consider the interaction of fiscal and monetary authorities in more detail and to provide suggestions for solving real-life problems. Beetsma and Bovenberg (1997, 1999) generally approve of the EMU policies and determine that the Maastricht Treaty, which gave priority to the ECB in stabilizing prices, was reasonable. Van Aarle, Bovenberg and Raith (1997) noted that the monetary authorities in the EMU had significantly greater freedom of action than the separate fiscal authorities, and therefore they should carefully watch not only for the deviation of inflation rates from optimal levels, but for the deviation of public debt as well. In addition, van Aarle, Engwerda and Plasmans (2001) note that either partial or complete integration of fiscal authorities would be advisable for more efficient interaction with the ECB. Engwerda, van Aarle and Plasmans (2002) consider the possibility of an integration of fiscal authorities in the EU countries.

Dixit and Lambertini (2003) note 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. 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, dominate ECB.

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.

There are two more features of modern research. Firstly, many articles in this field are partly oriented to the institutional side of the interaction between the government and the central bank. For instance, Di Bartolomeo and Di Gioacchino (2003, 2004) considered two stages in a game-theoretic interaction. The two sides first determine their bargaining power and only afterwards does a differential game ensue. Unlike Nash equilibrium, this type of correlated equilibrium can be used to determine the interconnected behavior of the agents. Secondly, an ever-increasing number of studies have a microeconomic basis in the tradition of new Keynesian models with real and nominal rigidities.[4]

Motivation and outline of the paper

This paper explores fiscal and monetary policy interaction in an export-oriented economy. As a prototype we consider the development of Russian economy in the period between 2001 and the mid of 2008. We investigate interrelated problems of exchange rate management, disinflation policy, the accumulation of stabilization fund and the stimulation of economic growth. Monetary authorities face specific trade-off between inflation reduction and exchange-rate management aimed to stimulate national export. Indeed, as long as exchange rate is one of the key determinants of export revenues, which are in turn the significant part of the tax base, by managing exchange rate, monetary policy alters the set of fiscal policy alternatives. At the same time, fiscal surpluses and the accumulation of stabilization fund by the government pump the part of money out of circulation that reduces inflation.[5] It means that fiscal policy also alters the set of monetary policy alternatives. 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.

The paper has the following structure. In Section 2 we build a model of an export-oriented economy to study the impact of fiscal and monetary policy. In Section 3 we analyze different forms of strategic interaction between the government and the central bank. Section 4 provides general conclusions.

2. A model for the analysis of macroeconomic policy in an open economy

In this section we consider a two-period 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.[6] The model consists of seven equations that describe the macroeconomic relationships that are characteristic of an export-oriented economy. This section contains the derivation and analysis of the macroeconomic equilibrium. The next section presents an analysis of different forms of strategic interaction between the government and the central bank in the setup of the macroeconomic model.

The fiscal authority chooses the "strategic" budget surplus, defined as government expenditure minus net lump-sum taxes.[7] 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

[4] See, for example, Muscatelli, Tirelli and Trecroci (2004), Beetsma and Jensen (2005).

[5] Sterilization of excess money is important, but not the only goal of the accumulation of stabilization fund. We do not discuss all these goals as they are not in the focus of the paper.

[6] In this setup the model is essentially static, although it can be used in a multi-period analysis.

[7] The choice of the term "strategic" budget surplus has to do with the fact that it is this variable (and not the entire budget surplus) that is chosen by the government in its strategic interaction with the central bank.

keep the exchange rate at a high level in order to stimulate national export, it has to buy foreign currency. However, the accumulation of international reserves is accompanied by an increase in the base money that in turn stimulates inflation. The inflationary consequences of an expansionary monetary policy can be in part be sterilized by contractionary fiscal policy. Indeed, by accumulating a stabilization fund, the government takes part of the money out of circulation and brings inflationary pressure down. Thus, by determining the strategic 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.

Our model is not meant to describe any specific economy *in detail* and has more of a general and theoretic character. However, we included certain elements in our description of the interaction between fiscal and monetary policies that are stylized facts for Russian macroeconomic policy. This is, however, sufficient to arrive at qualitative conclusions about the effectiveness of Russian macroeconomic policy and to suggest an optimal form of interaction between the Russian government and the Bank of Russia under current conditions.

2.1. Building the model

The model is based on the following 7 equations:

(1)	$M_{E1}V(x) = P_1Y_1$	*Aggregate demand*
(2)	$\pi_1 - \pi_0 = \alpha(Y_1 - Y^*) + \beta(\varepsilon_1 - \varepsilon_0)$	*Open-economy Phillips curve*
(3)	$s_1 - s_0 = (\psi E_0 Ex_0 + tY_0 + x)P_0$	*Government budget constraint*
(4)	$Ex_0 - \mathrm{Im}_0 + CF_0 = z_1 - z_0$	*The balance of payments*
(5)	$M_1 - M_0 = (z_1 - z_0)E_1$	*Foreign exchange operations*
(6)	$M_1 - M_0 = s_1 - s_0 + M_{E1} - M_{E0}$	*Money decomposition*
(7)	$E_1 = P_1\varepsilon_1$	*Real exchange rate*

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.[8] 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 it will be discussed later.

We assume that money velocity declines with an increase in the strategic budget surplus, $V_1 = \overline{V} - kx$: an expansionary fiscal policy increases money velocity, and a contractionary policy slows down the economy. As a rule, the economic literature assumes that money velocity decreases with an increase in the interest rate. In essence, this is in line with our assumption. Indeed, the well-known crowding-out effect of an expansionary policy leads to an increase in the interest rate and thus decreases the money velocity, while a contractionary policy leads to a decrease in the interest rate and thus there should be an increase in money velocity. We should note that transmission mechanisms in Russia's economy function poorly, and the interest rate cannot be considered to be a regulator of economic activity. This supports the assumption of a direct dependence of money velocity on the fiscal policy variable.

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

[8] In what follows, the subscripts 0 and 1 refers to periods 0 and 1, respectively.

terms of increments: $\frac{M_{E1}-M_{E0}}{M_{E0}}+\frac{\bar{V}-kx-V_0}{V_0}=\pi_1+\frac{Y_1-Y_0}{Y_0}$, 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, ε is the real exchange rate of the foreign currency, and α and β are positive parameters. This modified equation is the simplest New Keynesian Phillips curve for an open economy.[9] 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 export 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 the 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. We show below that the second effect may dominate the first effect in a reasonable specification of the model, and therefore monetary policy aimed at strengthening foreign currency and expansionary export may lead to a decrease in output.

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 "strategic" 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 strategic budget surplus x. Note that the strategic budget surplus includes only lump-sum taxes [$x=T-G$] and differs from the total budget surplus by the taxes that depend on export and output [$budget\ surplus=\left(T-G\right)+\delta\left(\overline{Ex}+c\varepsilon\right)+tY$]. In our model, the strategic budget surplus x is the main instrument of fiscal policy.

In addition, the increase in the stabilization fund is determined by the volume of export, $E_0 Ex_0$ which is taxed at a rate of ψ. The volume of export positively depends on the real exchange rate [$Ex=\overline{Ex}+c\varepsilon$]. This mechanism of forming the stabilization fund significantly depends 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 $s_1-s_0=\left[\delta E_0\left(\overline{Ex}+c\varepsilon_0\right)+tY_0+x\right]P_0$.

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 $\left(z_1-z_0\right)$ is determined as the sum of current account $\left(Ex_0-\mathrm{Im}_0\right)$ and the capital account.

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

[9] For more detail, see Razin and Yuen (2002).

monetary policy is the rate of change of the nominal exchange rate $e_1 = \frac{E_1 - E_0}{E_0}$. By increasing international reserves, the central bank increases the supply of money; this is shown in equation (5). The growth rate of money, $\mu_1 = \frac{M_1 - M_0}{M_0}$ is determined by exchange-rate policy: $\mu_1 = \frac{(z_1 - z_0)E_0(1 + e_1)}{M_0}$.

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 ε. 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 μ_1, the rate of inflation π_1, the volume of money in circulation M_{E1}, the real exchange rate ε_1, the volume of 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.

2.2. Analysis of equilibrium

Given how cumbersome the formulas are for the equilibrium values of z_1, μ_1, π_1, M_{E1}, ε_1, s_1 and Y_1 (see Appendix A), we will use numerical examples for further analysis and practical conclusions.[10]

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 Appendix B) are not based on the results of empirical investigations or calibrations.

We will consider how changes in the strategic budget surplus x affect macroeconomic equilibrium. In numerical examples, the deficit and surplus were taken at levels that did not exceed 10 percent of output.

For $x > 0$, i.e. for contractionary fiscal policy, the equilibrium inflation rate is rather low and the stabilization fund increases significantly. Indeed, an increase in taxes allows the stabilization fund to accumulate, and also holds back inflation. However, on the other hand, this also influences output, which significantly decreases in comparison with the previous period and falls significantly behind its natural level.

For $x < 0$, i.e. for expansionary fiscal policy, the level of inflation is at a higher level in comparison with contractionary policy, and the stabilization fund increases to a lesser degree. From the point of view of social welfare, the losses from a higher level of inflation in the case of expansionary fiscal policy are compensated by the higher level of output. In its turn, the stabilization fund is less than 30% of output even if there is a deficit of the strategic budget equal to 10% of output.

[10] The analysis was conducted using *Mathcad*. All calculations are available upon request.

Changing the level of the strategic budget surplus x gives the following results. As x increases, the level of inflation, the money in circulation and output decrease (see Figure 1).[11]

These results have a simple intuitive explanation, taking into account the increasingly restrictive character of fiscal policy as x increases. Note that if the strategic budget surplus increases, then the rate of change of the real exchange rate also increases, as does the volume of the stabilization fund. However, the volume of the stabilization fund for any value of x is higher than 25% of output, and the rate of change of the real exchange rate does not exceed 3%. Also, as x increases, social welfare decreases. Social loss is minimal if there is a strategic budget deficit (see Figure 2). This is because of the increase in output for negative values of x (given expansionary fiscal policy).

We also note that the government budget can be in a surplus for negative values of x, since a strategic budget deficit is covered by taxes that depend on output, and by export taxes.

The way that the policy of the central bank influences the equilibrium values of the variables depends on the policy of the government (contractionary or expansionary).

If the government is pursuing a contractionary policy ($x > 0$) and there is an increase in the nominal exchange rate e, then there will be an increase in the rate of inflation and an increase in money in circulation.

If the government adopts an expansionary policy and sets x at a negative level, then an increase in the value of e will also imply an increase in both the rate of inflation and the volume of money in circulation (see Figure 3).

We observe the usual effects of expansionary monetary policy if fiscal policy is also expansionary: an increase in the rate of growth of the nominal exchange rate brings about an increase in the money in circulation. Figure 4 demonstrates that this situation is preferable for society.[12]

For negative values of x (expansionary fiscal policy), social loss is minimal if the national currency strengthens by about 2-3% (for this parameterization of the model). In practice the central bank strives to let the exchange rate change by no more than 8% under stable monetary policy.[13] Note that if $x > 0$ (contractionary fiscal policy), then social loss increases sharply.

Analysis of equilibrium in the model has shown that the way in which monetary policy affects the economy depends on the fiscal policy pursued by the government. Obviously, in this case the concrete mechanism of how the government and the central bank interact plays an important role. In the next section, we will model various forms of the strategic interaction of these agents, after first considering their own loss functions.

3. Strategic interaction

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.

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.

The loss function for the government:

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

Here π_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

[11] See all figures in Appendix C.

[12] A formal definition of the loss functions for the government, central bank and society are given in the next section.

[13] This wass an informal rule used by the Bank of Russia in the time period under consideration.

expression $(x-\bar{x})^2$ shows the square of the deviation of the strategic budget surplus from the government's optimal value of $\bar{x}$, which is determined by both economic and political considerations (the necessity of keeping government spending at a certain level, etc.). 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. The optimal value of output is given to be higher than its natural level.[14] Finally, the weight coefficients α_{xF} and α_{YF} characterize the priorities of the government in forming the strategic budget surplus and output, respectively. The weight coefficient for inflation is taken to be equal to one. For the main part, these coefficients are needed in order to compare the weight with the corresponding weight of the central bank and society.

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:

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

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. However, Russian experience is that the nominal exchange rate between the ruble and dollar has practically remained the same for some time, and this obviously implies that the real exchange rate has been changing.

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 a exchange-rate policy that keeps the revenue from export high. Appreciation of foreign currency stimulates export, and this in its turn brings about an increase in output and increases budget revenues from export taxes (and therefore allows the stabilization fund to grow). However, buying foreign currency in order to maintain its high exchange rate implies an increase in the money, and therefore an increase in the rate of inflation. The weights α_{eM} and α_{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:

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

The form for social loss function is the same as that of the central bank (except for the weight coefficients). The inclusion of e_1 in 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 π_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 $\bar{e}_1=0$. The weight coefficients α_{eS} and α_{YS} characterize the priorities

[14] This approach is traditional in the macroeconomic literature. See, for example, Kydland and Prescott (1977).

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.

The effectiveness of fiscal and monetary instruments depends to a large extent on the specific form of the strategic interaction of the government and the central bank. Below we will consider various types of this interaction, compare the results and draw conclusions about their relative efficiency.

3.1. 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 ω, 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 ω characterizes the relative bargaining power of the government.

Thus, the general loss function in the case of coordination can be written as:

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

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, μ_1, π_1, M_{E1}, ε_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 institutes 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 ω. For $\omega = 1$ the bargaining power of the government and the central bank are equal. For $\omega > 1$ the bargaining power of the government is higher than that of the central bank, and the opposite is true for $\omega < 1$. We note that irrespective of which of the policies has greater bargaining power, the output, the stabilization fund and money in circulation remain at almost constant levels.

We are mostly interested in comparing the losses of coordinated policy and of society for various values of the parameter ω. 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 5). Thus, the coordinated interaction of fiscal and monetary authorities is efficient only if the central bank has high bargaining power.

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 ω, the higher the strategic 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.

3.2. 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 (2003a) that leadership in fiscal policy is usually more efficient than leadership in monetary policy.

The equilibrium values of z_1, μ_1, π_1, M_{E1}, ε_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.

It can be seen from Figure 6 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 the low output and the 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 α_{eM}, or the sensitivity of the government to the formation of a strategic budget surplus α_{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 be 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 α_{YF} and α_{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 α_{YF} and α_{YM} and Stackelberg interaction of policies, the best outcome for society is achieved if the central bank is benevolent.

3.3. Cournot interaction

Cournot interaction is completely opposite to the case of coordination, since the actions of both policies are not coordinated in any way. In addition, unlike Stackelberg interaction, the central bank and the government do not take each others' actions into account when choosing their policies.

As in the previous setup, we find the equilibrium values of z_1, μ_1, π_1, M_{E1}, ε_1, Y_1 and s_1 for the values of x and e_1 that were found after optimizing the agents' policies. As in the setup of coordinated policies, Cournot interaction allows for only one value of x that determines the optimal fiscal policy.

Changes in the weight coefficients of the central bank, α_{eM} and α_{YM}, practically do not change the optimal value of x or macroeconomic policy in general. In their turn, the weight coefficients of fiscal policy play a central role. In essences, as for Stackelberg interaction, fiscal policy has the greater impact on equilibrium. Under Cournot interaction, the government chooses the optimal value of the strategic budget surplus based on its own priorities (the values of α_{xF} and α_{YF}).

We will consider how the variables in the model react to a change in the government's priority to stabilize output (weight coefficient α_{YF}).

We see from Figure 7 that x and e change in the same direction, given a change in α_{YF}. For relatively low values of α_{YF}, the government chooses an expansionary fiscal policy ($x < 0$), and the central bank answers with a tight monetary policy (low or negative values of e). However, as α_{YF} increases we see a sharp jump, and fiscal policy becomes tight, while monetary policy becomes loose ($x > 0$, $e > 0$). In other words, we arrive at the following important conclusion: in a case in which the government sets a high priority to stabilizing output, it prefers a contractionary fiscal policy, "delegating" the stimulation of the economy to monetary policy.

For relatively low values of α_{YF} (in this parameterization of the model, $\alpha_{YF} = 0{,}2$) output turns out to be higher than its potential level. In this case we note a significant increase in the money in circulation, and this is what causes the overheating in the economy. We also note that even a small change in α_{YF} brings about a sharp decrease in output and in money in circulation (see Figure 8).

Figure 9 shows that, despite the decrease in inflation, the significant deviation of output from its natural level means a decrease in social welfare. The benevolence of monetary policy does not play a major role under Cournot interaction. As the parameter α_{YF} increases, the losses of society and the central bank increase sharply and then stabilize at a rather high level. In its turn, the loss of the government are minimal for small values of α_{YF}. However, in this case the social loss are rather high and are comparable to the case of relatively large values of α_{YF}.

We have arrived at the following important result: under Cournot competition social welfare is greatest when the government is less concerned with stabilizing output and "delegates" the stimulation of the economy to the central bank. We also note that even in the best outcome for society (in this parameterization of the model, $\alpha_{YF} = 0{,}2$) output is slightly higher than the optimal level, and this, along with high inflation, creates additional losses for society. In determining the optimal value of x, the value of α_{xF} is less important than the value of α_{YF}.

In general, our analysis shows that Cournot interaction is the least efficient form of strategic interaction between the government and the central bank in an export-oriented economy.

4. Conclusion

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.

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 this case output approaches its optimal level, and the growth rate of money in circulation and the rate of inflation are relatively low; in addition, there is a high rate of growth of the stabilization fund. In the case in which monetary policy is loose and fiscal policy is contractionary, the social loss is rather high. In this case, the relatively large deviation of output from its natural level is not completely compensated by the decrease in inflation, and this increases social loss.

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. How the central bank and the government interact is of principle importance.

Cournot interaction of the government and the central bank in an export-oriented economy is the least effective, as it leads to high rate of inflation, a significant deviation of output from its optimal level (irrespectively of the character of fiscal policy) and, as a result, to high social loss.

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 Stackelberg interaction with the government as leader and under cooperation. Social loss is minimal under both forms of interaction, if fiscal and monetary policies are expansionary and allow output to approach its optimal level.

Our analysis shows that situation of contractionary fiscal policy and excessively loose monetary policy is not optimal: social loss is lower under moderately expansionary policies pursued by both the central bank and the government.

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Appendix A

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:

1. *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 π_1:

2. *International reserves*

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

3. *Base money growth*

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

4. *Money in circulation*

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

5. *Real exchange rate*

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

6. *Output*

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

7. *Stabilization fund*

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

Appendix B

Specification of parameters in our model:

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

Appendix C

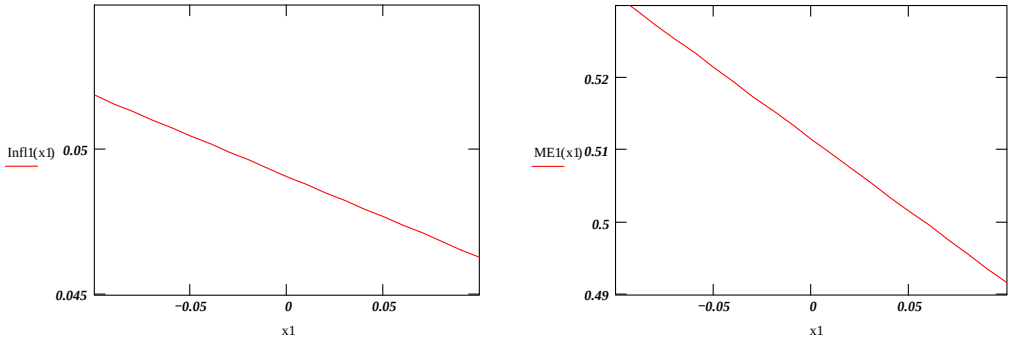


Figure 1. Inflation rate and money in circulation for different values of the strategic budget surplus

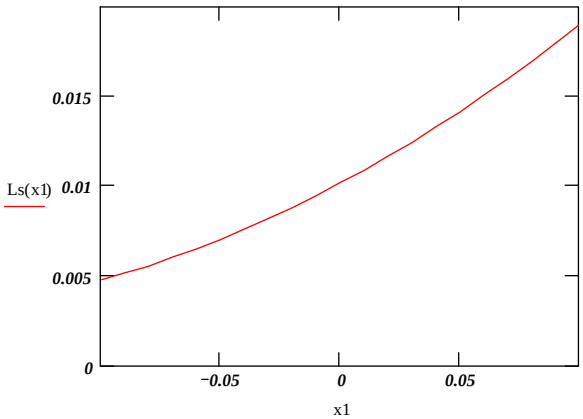


Figure 2. Social loss as a function of the strategic budget surplus

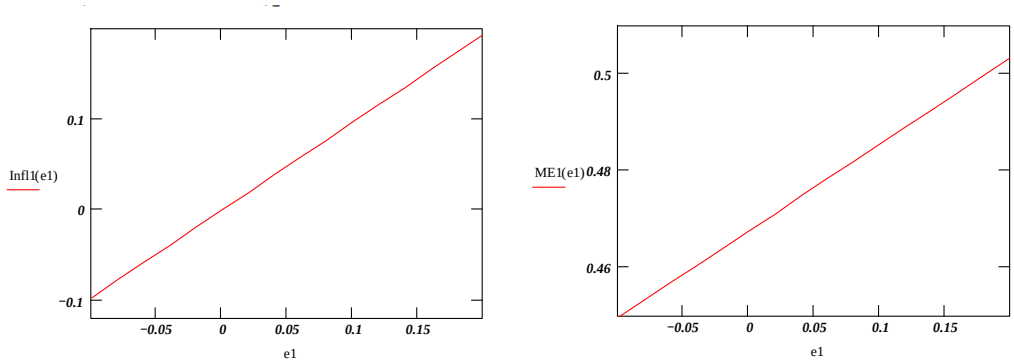


Figure 3. Inflation rate and money in circulation for different values of the growth rate of the nominal exchange rate under expansionary fiscal policy

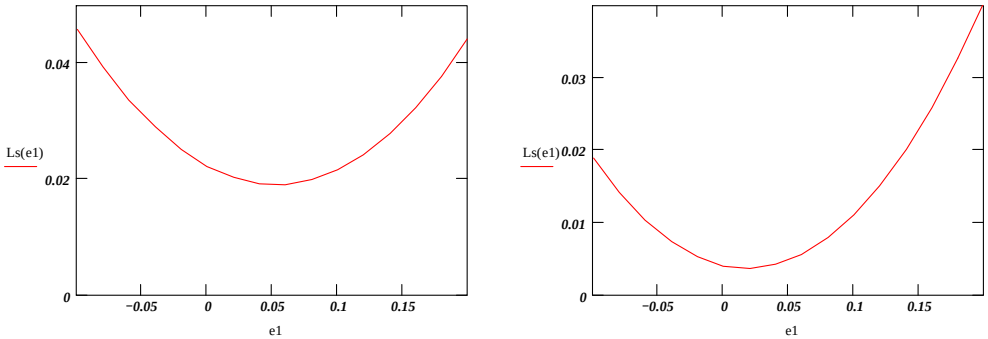


Figure 4. Social loss as a function of the growth rate of the nominal exchange rate under contractionary (*left*) and expansionary (*right*) fiscal policy

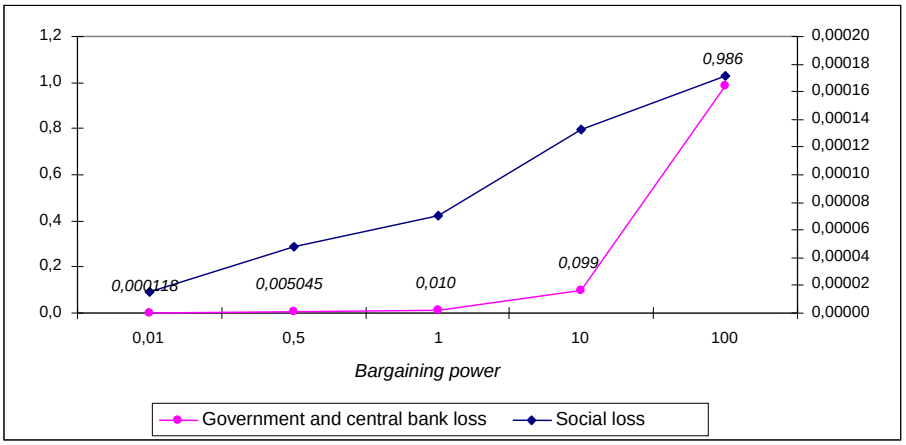


Figure 5. The losses of the coordinated policy and of society for various values of bargaining power parameter

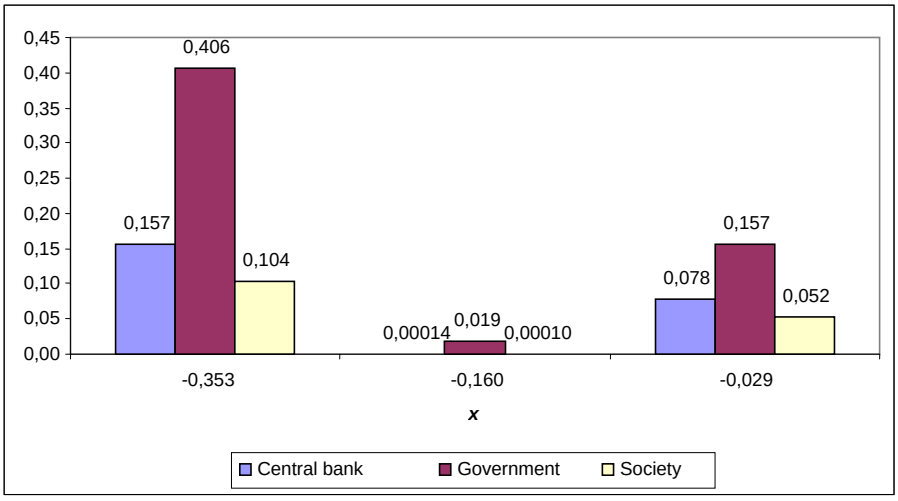
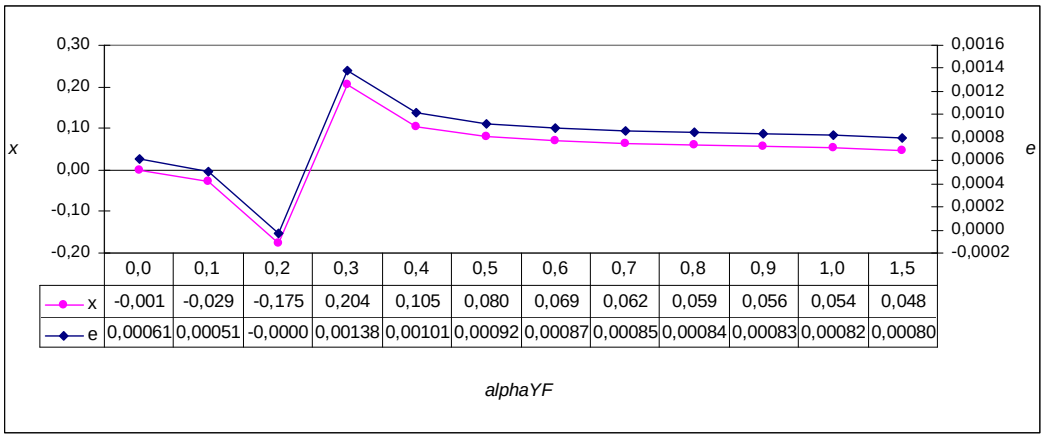


Figure 6. The losses of society, the government and the central bank given a high priority for stabilizing output



	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,5
x	-0,001	-0,029	-0,175	0,204	0,105	0,080	0,069	0,062	0,059	0,056	0,054	0,048
e	0,00061	0,00051	-0,0000	0,00138	0,00101	0,00092	0,00087	0,00085	0,00084	0,00083	0,00082	0,00080

Figure 7. The strategic budget surplus and the growth rate of the exchange rate for various values of α_{YF}

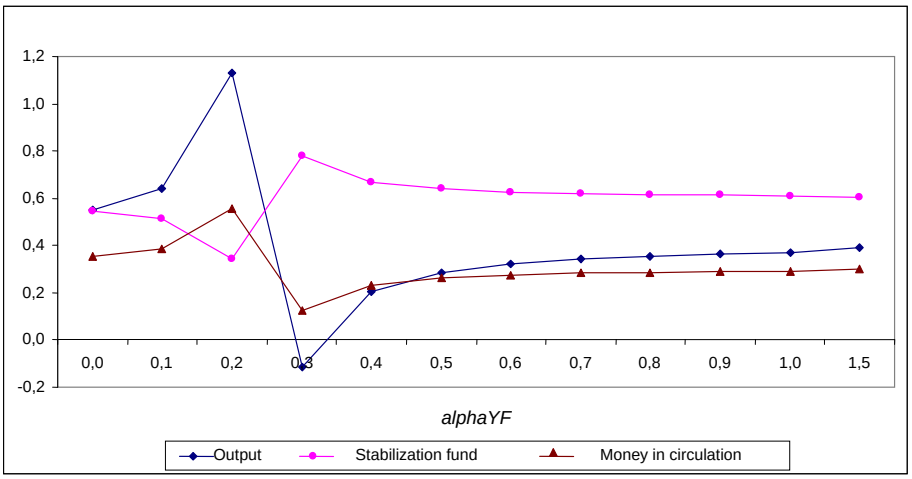


Figure 8. Output, the stabilization fund and money in circulation for various values of α_{YF}

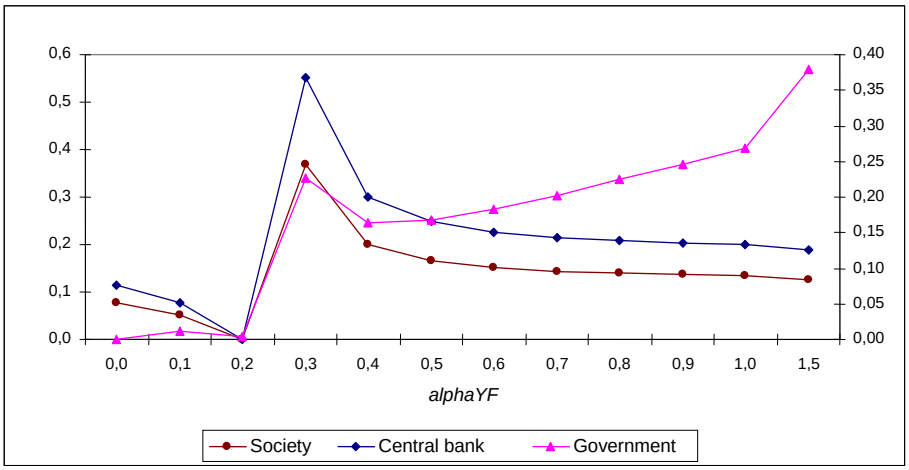


Figure 9. The losses of society, the government and the central bank for various values of α_{YF}