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Fiscal and Monetary Policy Interaction and the Sustainability of Public Debt

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Fiscal and Monetary Policy Interaction and the Sustainability of Public Debt

Interactie van fiscale en monetaire politiek
en de houdbaarheid van overheidsschuld

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Contents

Chapter 1
Introduction

1.1. Motivation

Problems of the utmost concern that are often faced by both developing and developed countries are those of inflation, the budget deficit and the accumulated public debt. It is believed that the main reason for high inflation in most developing countries and countries with transition economies is the financing of the budget deficit by seigniorage. This means that in most such cases it is the budget deficit that is responsible for high inflation. From time to time tensions that had accumulated in the fiscal sphere and mistakes that had been made in monetary policy have serious consequences, such as hyperinflation or a debt crisis.

The government and the central bank are interconnected by a consolidated public sector budget constraint: the operational deficit of the budget is financed by new borrowings and by seigniorage. On one hand, the central bank, which controls money emission, has an important goal to achieve, namely a low and stable level of inflation. On the other hand, the central bank must also be concerned about the stability of the financial system, and in particular about the sustainability of the public debt. This means that, even given the central bank's formal independence of the government, the former must nevertheless take into account problems in the fiscal sphere and cover a certain part of the budget deficit by seigniorage. In other words, the policies of the government and of the central bank interact with each other.

This work covers a series of questions which are of principle concern in the analysis of the interaction between fiscal and monetary policies:

- Is inflation a completely monetary phenomenon?
- Is there a simple cause-and-effect relationship between inflation and the budget deficit?
- Can chronic inflation be overcome only by a tight monetary policy that is formally independent of fiscal requirements?
- What importance do expectations of future stability have?
- Can monetary policy be permanently or only temporarily tightened given (exogenous) fiscal policy?
- Should an increase in the government's budget deficit be accompanied by an increase or a decrease in the growth rate of base money? What short-term and long-term results will this have for inflation?
- What situations are there in which neither fiscal nor monetary policies are able to avoid a financial crisis, and how can they be avoided?

The goal of this research is to elucidate the general principles for the formulation of the interaction between fiscal and monetary policies that would make hyperinflation and/or a debt crisis impossible.

We solve the following problems in achieving this goal:

- determination of the constraints that exist for the common policies of the government and the central bank;
- description of the general ways in which fiscal and monetary policies can interact;
- elucidation of potential difficulties that may arise in the formulation of uncoordinated macroeconomic policies.

In reality, the interaction of the government and the central bank is an important problem not just for developing countries or for transition economies. This important question about the interaction of fiscal and monetary policies was first posed in the 1980s, when the USA and many European countries faced acute problems that had to do with the budget deficit and public debt. At present this range of questions is being actively discussed by academics and policymakers with regard to the problem of the interaction of a common monetary policy and often uncoordinated fiscal policies in the countries of the European Union.

The questions posed above are of special relevance for the Russian economy, which has experienced the 1998 crisis. Russia's currently under-developed financial system and concern about the ability of the government to retain a high budget income in the case of unfavorable exogenous factors make the problem of cooperation in the formulation of fiscal and monetary policies no less important than a few years ago.

Several historical episodes of macroeconomic policies in quite different countries (such as Argentina, Chile, Indonesia, Israel, Korea, Malaysia, Mexico, Philippines, Russia, Thailand, and the United States) are considered in this paper. In considering all these case studies, our main goal was to illustrate the different ways in which fiscal and monetary policies can interact and to underline the potential problems of interaction. Some of these case studies are examples of successful stabilization programs, while others are examples of policy coordination failure. We did not intend to conduct rigorous empirical studies. Almost all of the episodes considered in this paper have been extensively studied in the literature on stabilization policy. For this reason, we have simply based our exposition on the descriptive parts of these works, interpreting macroeconomic policy in terms of fiscal and monetary policy interaction. At the same time, it would be difficult, and perhaps even impossible, to successfully apply econometric analysis in this area of inquiry. This is simply due to the nonlinear nature of the dynamics, and to the possibility that certain important factors that are not in line with our narrow fiscal-monetary framework may be omitted.

1.2. Literature on fiscal and monetary policy interaction

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 fist of these (Liviatan, 1984, 1986, 1988; Drazen, 1985; Aiyagari and Gertler, 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.[1] We base our research on this approach.

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 (1985, 1986, 1987a,b), Alesina and Tabellini (1987), Petit (1989), 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"[2].

Literature 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, 1997a, 2003) also considered the conflict of interest between fiscal and monetary policies, namely the regulation of the size of public debt and of the rate of inflation. The authors assume 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, assuming cooperation of fiscal and monetary policies, the government does not

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[1] More recent contributions to the fiscal theory of inflation are Weil (1987), Drazen and Helpman (1988, 1990), Bental and Eckstein (1990), Kawai and Maccini (1990), Miller, Skidelsky and Weller (1990), Dornbusch (1996), Miller and Zhang (1997), Bhattacharya, Guzman and Smith (1998), Bhattacharya and Haslag (1999), Ruge-Murcia (1999) among others.

[2] See Blinder (1982), pp. 25—26.

have to use the debt for optimizing the economy 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 following fact: 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, i.e. the government, 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 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. Beetsma and Bovenberg (1997b, 1999) did this; they 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. 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) noted 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) considered 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). It is shown in this article 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 (Linnemann and Schabert, 2002; Muscatelli, Tirelli and Trecroci, 2004; Beetsma and Jensen, 2005).

1.3. Outline of the thesis

Overview

We analyze the fiscal policy of the government and the monetary policy of the central bank under assumption that the central bank is formally independent of the government. The logic of the interaction between fiscal and monetary policies is determined by the existence of a consolidated budget constraint for both the government and the central bank, as well as their common goal of stabilizing the public debt and inflation. Monetary authorities determine of the growth rate of base money. The government determines the expenditures and the revenues of the budget, and thus determines the trajectory of the budget deficit (or surplus).

We provide the foundation for the analysis of the interaction of fiscal and monetary policies and give the main concepts in fiscal and monetary theory in Chapter 2. The budget constraint of the government determines the dynamics of the public debt. The principle of sustainable fiscal policy demands that at every point in time the accumulated volume of public debt is backed by the real value of future budget surpluses and of seigniorage. In turn, the dynamics of inflation and seigniorage are described by the framework of the generally accepted monetarist approach. Using this apparatus, we give an overview of the two modern approaches to the analysis of the interaction between fiscal and monetary policies, namely the fiscal theory of inflation and the fiscal theory of the price level.

Chapter 3 is devoted to the analysis of the influence of inflation on the primary budget deficit.[3] By considering the financing of the budget deficit by seigniorage, we give a compara-

[3] Chapter 3 draws on Pekarski (2000).

tive analysis of situations in which inflation does not influence the primary budget deficit and of situations in which the effect of inflation is positive or negative. We analyze bifurcations in the system describing dynamics of the public debt and real money balances. We suggest a description of fiscal and monetary policies that bring the economy to a catastrophe in the form of hyperinflation and a debt crisis (based on the Russian economy experience).

In Chapter 4 we consider various scenarios for the interaction of fiscal and monetary policies, assuming the simplest form of stabilizing the debt and inflation at a constant level.[4] We analyze admissible fiscal and monetary policies. Situations in which uncoordinated policies are impossible are determined. Given the feasibility constraint for fiscal policy, we determine situations in which neither fiscal nor monetary policies are able to avert hyperinflation and a debt crisis.

In Chapter 5 we suggest a wider view of the interaction between the government and the central bank.[5] Their common policy should not violate the principle of sustainability of the public debt. This approach accounts not only for the current state of the fiscal sphere and of the money market, but for expected future policies as well. Assuming rational forward-looking expectations formed by the private sector, we demonstrate the increased possibilities of fiscal and monetary policies if the expectations of society are actively influenced by policymakers.

Chapter 6 provides overview of the main results.

Methodology

The basis of this research is the fiscal theory of inflation, which was formulated in the beginning of the 1980s as part of the new classical economics. The fiscal theory of inflation allows for a wider understanding of monetary policy in comparison with the original monetarist approach and assumes that fiscal policy plays an important role in determining the rate of inflation. In the last decade a new direction of inquiry has been actively discussed — that of the fiscal theory of the price level. We provide an overview of this (still controversial) theory in the second chapter. After comparing it to the fiscal theory of inflation, we find the latter to be more acceptable.

An important assumption in the analysis of the fifth chapter is the hypothesis of rational forward-looking expectations that belongs to the same new classical school of economic thought. This hypothesis is the basis for the most interesting results.

This research makes significant use of mathematical modeling. We analyze the system of dynamic equations that was derived for the optimal behavior of a representative agent. The properties of the linearized system are considered, and we investigate the stability of the steady states of the economy and analyze the transition dynamics. In addition, as our model is characterized by nonlinear dynamics, it is of interest to analyze the bifurcation of the sys-

[4] Chapter 4 draws on Pekarski (2001).
[5] Chapter 5 draws on Pekarski (2003, 2004).

tem if various parameters of the model are changed. Finally, assuming rational expectations, we construct a forward-looking solution that is determined by the required transversality conditions. Some of the results were arrived at by using numerical methods.

Main results of the research

We suggest a modification of the basic model for the dynamics of inflation and public debt to account for the influence of inflation on the primary budget deficit in the third chapter. This new dynamic system has interesting nonlinear properties, which have not, to the best of the author's knowledge, been considered in the economic literature before. A new economic interpretation of the bifurcation exhibited in the nonlinear dynamics of inflation and public debt is presented, and can be applied as a possible explanation for the Russian crisis of 1998.

The analysis in the fourth chapter is conducted using the same basic system for the dynamics of inflation and public debt. Several new results were arrived at in the course of this research, which expand the fiscal theory of inflation. In particular, the well-known principle of "unpleasant monetarist arithmetic" has been amplified with consequences of «unpleasant monetarist arithmetic» for fiscal policy. In addition, the results allowed us to systemize the possible ways in which the government and the central bank interact. Moreover, the goals of fiscal and monetary policies that are in principle unattainable in the absence of coordination have been identified. An analysis of the constraints of sustainability and feasibility of macroeconomic policies in the framework of the model for the dynamics of inflation and public debt has allowed us to determine the region on the phase diagram in which even a coordinated macroeconomic policy is unable to avert a debt crisis and hyperinflation.

Unilateral and collaborative actions by the government and the central bank are investigated in the fifth chapter. Assuming that expectations are rational and allowing for the possibility of announcing changes in macroeconomic policy before they are actually implemented, new important results have been arrived at in the fiscal theory of inflation. Firstly, we were able to find a way to solve the problem of "unpleasant monetarist arithmetic". In particular, we show that under certain conditions monetary policy can be permanently tightened given (exogenous) fiscal policy. Secondly, our research finds out that it is not so much the current volume of seigniorage that is important for the interaction of fiscal and monetary policy, but rather the ability of the central bank to influence the expected present value of future seigniorage. Thirdly, we were able to identify the three main factors that jointly determine the feasibility of various ways in which fiscal and monetary policies may interact. These factors are: (i) the expectations of economic agents with respect to forthcoming changes in monetary policy, (ii) the level of inflation in the economy (inflationary regime), and (iii) the interest rate for the servicing of the public debt. This last factor not only determines the dynamics of the fiscal sphere, but also determines how monetary policy should be conducted.

Chapter 2
Fiscal and monetary policy: The basic concepts and models

2.1. Introduction

The current range of questions posed by the interaction of fiscal and monetary policy is presented in this chapter. The first goal of this introductory overview is to formulate the main concepts in the analysis of macroeconomic policy (e.g., the sustainability of fiscal policy or the concept of rational expectations) and to consider the two main models which serve as a basis for the analysis in the following chapters; these are the general model for the financing of the budget deficit and the Cagan model for the dynamics of inflation. The first two sections of this chapter are devoted to this purpose.

The second goal of this chapter is to describe the general logic of the interaction between fiscal and monetary policy.[1] This interaction has many aspects, and we can discern two main avenues of research in this area in the economic literature. The first is the analysis of the interaction between the government and the central bank in the context of the influence of macroeconomic policies on the real economy (production or unemployment).[2] As a rule, the possibility of a compromise between inflation and unemployment in the short run (for example, the Phillips curve) is the basis for the analysis. The goal functions of society, the government and the central bank, which are generally all different, are optimized in either static or dynamic frameworks. In the last few years, in the vein of the new political economy, it has become popular to consider the interaction between the central bank and the government in a game-theoretic manner.[3]

Our analysis in the following chapters belongs to the second avenue of research, in which the main goal of the interaction between fiscal and monetary policy is that of stabilizing inflation and the public debt. We discuss the two major approaches to this problem in the third and fourth sections, namely the fiscal theory of inflation and the fiscal theory of the price level. There are two main ideas in considering the interaction of fiscal and monetary policy. Firstly, the government and central bank have a consolidated public sector budget constraint. Namely, the two most common sources for the financing the government's budget deficit are new borrowings

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[1] The most complete overview of this area of research can be found in the papers by Dodge (2002) and Chadha and Nolan (2003).

[2] Among the first important studies in this field were those by Blinder (1982), Tabellini (1985, 1987a, b), and Petit (1989). See also the overview by Nordhaus, Schultze and Fischer (1994). Over the last decade this approach has become especially popular in discussing the policies of the European Central Bank and its interactions with the governments of European countries, and in discussing the Stability Pact (the Maastricht Treaty). See, for example, Beetsma and Bovenberg (1995, 1997, 2003), Aarle, Engwerda and Plasmans (2001), Dixit (2001), Dixit and Lambertini (2001, 2003).

[3] This applies also to the second avenue of research into the interaction of fiscal and monetary policy. The corresponding game-theoretic models are given in the papers by Tabellini (1986), Tabellini and LaVia (1989), Aarle, Bovenberg and Raith (1995), DiBartolomeo and DiGioacchino (2003, 2004).

and seigniorage (real income from money base emission). The volume of base money emission is determined by the operations of the central bank on the open market. A possible interpretation of this fact could be that while it is the government that determines the total volume of public sector obligations, it is the central bank that determines the composition of these obligations by exchanging government bonds for base money (creating seigniorage).[4] Therefore, the central bank shoulders part of the burden in financing the government's budget deficit.[5] Secondly, the government and the central bank are concerned with inflation and the stability of the financial market (in particular, with the sustainability of the public debt). This means that whether or not their policies were coordinated, the government and the central bank have common goals (even though it is possible that they assign different weights to them). As a result, fiscal and monetary policy are *forced* to interact in some fashion. This is the key idea in our study.

2.2. Fiscal policy, the budget deficit and the public debt

An analysis of fiscal policy in practically any aspect of macroeconomic dynamics should include the government's budget constraint. Since this constraint is central in the analysis given in the following chapters, we will begin by considering all of its possible interpretations. Let us introduce the main variables. Let d be the real primary deficit of the public sector, defined as the difference between government expenditures and net taxes: $d = G - T$. In most of the situations considered below it is quite enough to consider only the primary budget deficit as a "final" characteristic of fiscal policy.[6]

We will assume that at every point in time the government must meet expenses rb in order to service the public debt, where b is the volume of real public debt. Consideration of the real (or indexed) public debt as opposed to nominal public debt is meant to narrow the range of problems that we consider.[7] The real interest rate r (the rate of servicing of the public debt) is taken to be constant for simplicity.[8] In total, the primary budget deficit and payments for

[4] See Wallace (1981) and Sargent (1985).

[5] At the present time the central bank in most countries is an institution that is formally independent of the government. In practice, the direct crediting of the government by the central bank is prohibited by law.

[6] In some situations it will be more convenient to use the term budget surplus, which is naturally determined as $-d = T - G$.

[7] In reality, the practice of indexing the public debt is not widespread. However, in Sargent's opinion (1985), an analysis of the dynamics of the *real* public debt is quite justified. Formally, a state which issues a nominal debt can back it if actual inflation is higher than expected; this fact was noted earlier by Keynes (1923). However, it is probably not wise to consider this possibility as a conscious choice of the state. If the expectations of economic agents are rational, then this policy is dynamically inconsistent (Calvo, 1978). Dornbusch (1986) note that "... inflationary escape from debt is simply no longer an issue. Keynes preferred way is gone". By contrast, introduction of indexed state obligations has been practiced in some countries with high and unpredictable inflation in order to have an instrument that is insured against "inflation surprises" (see an overview of the practice of using various debt instruments in the monograph by Missale (1999)). The problems associated with the advisability of issued indexed debt obligations by the government have been studied, for example, in papers by Dornbusch and Fischer (1986), Calvo and Guidotti (1990), Bohn (1988, 1990, 1991), and Dornbusch (1996).

[8] The assumption that the interest rate is constant is quite widespread in investigations in fiscal and monetary policies; it allows the investigator to simplify his analysis without significantly influencing the main

the servicing of the debt comprise the operational deficit of the budget $d + rb$, which must be financed by either new borrowings $\dot{b}$, and (or) by seigniorage, S.[9] The latter is defined as the real profit from base money emission and we will consider it in detail in the next section. The following simple dynamic equation for the budget constraint is in essence the equation for the financing of the operational deficit of the budget: $d+rb=\dot{b}+S$, or

$$\dot{b}=rb+d-S. \tag{2.1}$$

Formally, equation (2.1) describes the dynamics of the public debt. The increment in the debt is defined as the difference between the operational budget deficit and seigniorage. At every point in time the volume of public debt is predetermined by previous fiscal policies. In other words, at every point in time the government has an *accumulated* volume of debt. In this sense, the most appropriate way to determine the trajectory of the debt seems to us to be the backward-looking approach.[10] Taking the point of time $t = 0$ to be the initial point and putting $b_0 = b(0)$ to be the initial volume of the debt, the solution of (2.1) can be written in the following form:

$$b(t)=b_0 e^{rt}+\int_0^t \left[d(\tau)-S(\tau)\right]e^{-r(\tau-t)}d\tau. \tag{2.2}$$

Obviously, for a positive root of equation (2.1), which is equal to the interest rate r, and for given acceptable trajectories of the primary budget deficit and seigniorage, equation (2.2) describes in the general case the unstable dynamics of public debt. In the simplest case with constant primary budget deficit and seigniorage equation (2.2) can be written as

$$b(t)=\frac{S-d}{r}+\left[b_0-\frac{S-d}{r}\right]e^{rt}. \tag{2.3}$$

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results. We give a simple model of dynamical optimization in the Appendix at the end of Chapter 2, which provides the microeconomic foundation of our analysis. In the framework of the suggested model, first order condition equates real interest rate to (constant) subjective discount factor of consumer's intertemporal preferences. Sometimes it is useful to consider the dependence of the interest rate of the debt on the size of the debt, i.e. include the risk premium (see, for example, Drazen and Helpman (1990)). However, we are analyzing the conduction of a macroeconomic policy that does not allow for a default, and so we should not consider the public debt as a risk asset.

[9] All variables in the general case are functions of time, but this, however, is not shown in the text in order to simplify understanding. A dot above a variable indicates a derivative with respect to time. For example, $\dot{b}$ is the increase in time of the volume of real public debt.

[10] Equation (2.1), obviously, defines many possible trajectories of the public debt. In a dynamic economics there are two methods to choose a concrete trajectory (particular solutions of the dynamic equation): backward-looking solutions and forward-looking solutions. In this and following chapters we will use both approaches and explain the reason for choosing one or the other in each situation. A general overview of these methods can be found in Leslie (1993) and Turnovsky (2000). A revolutionary paper, which changed the views of macroeconomists on the modeling of economic dynamics, is the paper by Sargent and Wallace (1973).

In this case, if the government is initially unable to finance the operational deficit by seigniorage, i.e. $d + rb_0 > S$, then the public debt will exponentially increase to infinity.

Clearly, this type of description of the dynamics in the fiscal sphere cannot be used as a basis for formulating macroeconomic policy without additional comments. We suggest three approaches to the solution of this problem.

Dynamics of the public debt to output ratio

One of the first possible explanations for why the description of the dynamics of public debt (2.2) is problematic is this: The assumption that the interest rate is constant does not at all mean that the private sector is ready to hold an arbitrarily large public debt; at each point in time the increment of public debt should not be greater than (at least) the volume of private saving. The exponential increase in the public debt (with rate r) can sooner or later bring the situation to this dangerous point. In order to understand whether or not the increase in public debt is a problem that should be dealt with, we can simply consider the dynamics of the ratio of public debt to output in the economy. Suppose for simplicity that the aggregate output y is increasing with a constant rate equal to g_Y (beginning from some initial level y_0). Consider not the public debt, the primary budget deficit and seigniorage, but rather their share in the aggregate output, $b_y = b/y$, $d_y = d/y$ and $S_y = S/y$. Equation (2.1) and its solution (2.2) can then be rewritten in terms of the new variables as

$$\dot{b}_y = \left(r - g_y\right) b_y + d_y - S_y. \tag{2.4}$$

$$b_y(t) = b_y(0) e^{(r-g_y)t} + \int_0^t \left[d_y(\tau) - S_y(\tau) \right] e^{-(r-g_y)(\tau - t)} d\tau, \quad b_y(0) = \frac{b_0}{y_0}. \tag{2.5}$$

In this case, the root of the characteristic equation is equal to $r - g_y$. If the interest rate is less than the growth rate of aggregate output, then the dynamics of the debt to output ratio will be stable. By analogy with (2.3), in the simplest case of constant ratios of the deficit and of seigniorage to the aggregate demand, the debt to output ratio will asymptotically approach a stationary level $b_y^* = \left(r - g_y\right)^{-1} \left(S_y - d_y\right)$. In reality, this removes many possible problems and in a certain sense changes the logic of building models of macroeconomic dynamics. First of all, it is not necessary to introduce additional constraints for macroeconomic policies, since (2.5) describes stable dynamics for almost any "reasonable" trajectories $d_y(t)$ and $S_y(t)$. This also means that we do not come to the inevitability of interaction between fiscal and monetary policy via the budget constraint (2.1) — a problem which lies at the core of this entire work.[11]

[11] In this respect, the condition $r > g_y$ is undoubtedly the key assumption of the entire investigation presented here. This also applies to the paper by Sargent and Wallace (1981), which is foundational in this area, and one to which we will often return. We should not, however, take this assumption as making the entire analysis sensitive (fragile). If it were so, then this would apply to practically everything in dynamic macroeconomics. This obvious fact was noted in the classical model of overlapping generations (Diamond, 1965). It is well known that the assumption $r > g_y$ in the basic version of the overlapping generations model is a necessary

In reality, however, a more realistic assumption is $r - g_y > 0$.[12] If the interest rate is greater than the growth rate of aggregate output, then (2.5) as well as (2.2) describes unstable dynamics. If so, then model (2.1) is qualitatively the same (from the point of view of stability) as the model (2.4). Below, in simplifying the analysis, we will consider equation (2.1) and remember that the principle results of this work will not change if we switch from (2.1) to (2.4)[13, 14].

Macroeconomic policy that keeps the public debt at a stationary level

The simplest way to solve the problem of the instability of (2.1) is the following. We can introduce an additional constraint on macroeconomic policy by demanding fiscal and monetary policy to be trajectories $d(t)$ and $S(t)$ such that the public debt remains at a stationary level. In a more general case, we can consider fiscal and monetary policy that shift the public debt (as well as other variables) from one steady state to another. This is considered in the third chapter.

We suggest the following simple example. Macroeconomic policies will keep the public debt at a stationary level if

$$rb_0 + d(t) - S(t) = 0. \qquad (2.6)$$

In essence, this is a further constraint on macroeconomic policies. But what is important is that this is a *joint constraint* on fiscal and monetary policy, since the former determines the trajectory $d(t)$, while the latter determines the trajectory $S(t)$. We see that macroeconomic policy has only one degree of freedom[15]: either the central bank must "produce" the seignior-

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condition for the so-called *dynamic efficiency* of the economy. If the economy is dynamically efficient, then the government cannot accumulate debt by Ponzi scheme. And vice versa, the public debt cannot move along an unstable trajectory, if the economy displays the property of dynamic inefficiency $r > g_y$. See also modern investigations of this problem in the papers by Abel et al. (1991), Blanchard and Weil (1992), and Buiter and Kletzer (1994).

[12] This fact, beyond doubt, holds for the vast majority of developing countries and economies in crisis. Most industrially developed countries, which used the advantages of low (or even negative) interest rates in the 1960s and 70s, have also faced the problem of an increase of the ratio of public debt to GDP in the last few decades. This was to a significant extent determined by the fact that the interest rates on average became larger than the rate of growth of the economy.

[13] Moreover, we may easily change the notation of the variables and understand relative indexes (interest rate, growth rate of base money, etc.) to simply be variables that are corrected for the growth rate of output, and consider all real indexes as ratios of output.

[14] We will return once more to the case $r > g_y$ in the next chapter, in order to characterize the stability of the common dynamics of public debt and real money balances.

[15] One of the first to introduce this idea was Christ (1979, p. 526): "...the effects of their [central bank and government] separate and joint policies depend on the actions of their consolidated sector vis-à-vis the rest of the economy, independent of any additional transactions that they may undertake between themselves alone", and later "The most fundamental implication of the *GBR* [government budget restraint] is that the authorities cannot fix arbitrary paths for all of the macro-economic policy variables at once. At least one policy variable must have its path endogenously determined by the joint actions of the *GBR* and the economy's structure". These ideas have been used as a foundation for the analysis given in later chapters in this work.

age necessary to keep the public debt at a stationary level given exogenous fiscal policies, or the government must control the trajectory of the primary budget deficit for given monetary policy (for whatever volume of seigniorage is given). In other words, we face the necessity of the two policies interacting in various forms. We will return to this problem in the second chapter. Also, in the third chapter, we will show that analogous ideas arise in a more general case, when fiscal and monetary policy, working together, shift the economy from one steady state to another.

Sustainable macroeconomic policies

The constraint (2.6) does imply that the volume of public debt remains stable, but "removes its dynamics", and this considerably decreases its use for applications. Indeed, it is possible to formulate a more general constraint on macroeconomic policy, one that would guarantee the sustainability of public debt:

$$\lim_{t\to\infty} b(t)e^{-rt} = 0. \tag{2.7}$$

This condition is nothing but a condition for the absence of Ponzi games[16]. The growth of the public debt should not be "too fast"; the rate of growth of $b(t)$ should not systematically be greater than the interest rate. The solution of (2.1), given (2.7), can be written as

$$b(t) = \int_t^\infty \big(S(\tau) - d(\tau)\big)e^{-r(\tau-t)}d\tau, \tag{2.8}$$

Equation (2.8) is a forward-looking solution of the differential equation (2.1). As in (2.1), equation (2.8) is a budget constraint for the government, or, in the context of this discussion, a joint budget constraint on the policies of the government and of the central bank[17]. From a formal point of view, budget constraints written as (2.1) or (2.8) are identical, if condition (2.7) is satisfied. However, unlike the dynamic budget constraint given in (2.1), which determines the dynamics of the debt at each point in time, constraint (2.8) is given in terms of present value. It requires that the public debt at each point in time be not greater than the present value of future budget surpluses and seigniorage. Fiscal policies that satisfy (2.8) are called sustainable. As in the previous section, here we need to deal with the inevitability of the interaction between fiscal and monetary policy. Regardless of the fact that we are now considering the sustainability of public debt (of the government's debt), the integrand in the

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[16] In a wide class of dynamic optimization models of general economic equilibrium this condition is a necessary condition of transversality (see, e.g., the model of dynamic optimization in the Appendix to Chapter 3). In the context of general equilibrium, equations (2.1) and (2.7) are joint constraints for the private sector and the government.

[17] The term "consolidated budget constraint for the government and the central bank" can also be found in the literature. Below we will for brevity continue to use the term "budget constraint of the government", understanding that this constraint involves both the government and the central bank.

right side of (2.8) is determined not only by fiscal policy, but by monetary policy as well. An analysis of the possible interactions in the context of sustainable macroeconomic policies is given in the fourth chapter.[18]

The concept of a forward-looking solution, suggested in 1973 by T. Sargent and N. Wallace, is based on the assumption that economic agents are rational. Their actions, which determine the current state and the dynamics of the economic system, are based on their expectations concerning future states of the system. Formally, one assumes that (i) the expectations of economic agents are rational; (ii) it is necessary to use conditions about the future states of the system rather than initial conditions in order to choose a certain trajectory; (iii) the possibility of changing the expectations (the availability of information) of economic agents about the future presupposes the possibility of a discrete (jump) change in the values of the variables in the system.

Several important comments on the applications of this concept to the analysis of macroeconomic policy and to the dynamics of public debt are necessary. The future trajectories $d(t)$ and $S(t)$ may be unknown. Thus, the form of (2.8) implicitly means that economic agents holding government bonds have perfect foresight with respect to the future macroeconomic policies of the government and of the central bank. In practice, this assumption is a convenient starting point for analysis and it can often be found in the literature. In the general case, there should be an operator of rational expectations in front of the integral in the right side of (2.8).

The use of the terminal condition (2.7) instead of an initial condition to arrive at a forward-looking specification of the dynamics of public debt should not be considered to be a simple "technical" assumption in the analysis. The problem is that the initial condition $b(0) = b_0$ remains. The public debt is what is known as a "sluggish" variable, rather than a "jump" variable, in other words, its value at each point in time is determined by its previous dynamics (by the accumulation process of the government). From a technical point of view, the superposition of two conditions, the initial condition and the terminal condition, is simply impossible, as each is able to determine a unique trajectory on the vector field, and we have an over-defined problem (a lack of one degree of freedom). The only "lucky" exclusion is when the initial and terminal conditions determine the same trajectory. This case characterizes the principle of sustainable fiscal policy. This assumed coincidence of two trajectories is not an "improbable" assumption, but in fact an additional constraint on macroeconomic policy. The initial and terminal conditions are principally different from each other. The initial condition is determined by the previous history of the process, and it cannot be changed

[18] Below, in the fourth chapter, we will pay due attention to the following important idea: an analysis of the interaction of fiscal and monetary policies in the context of the budget constraint (2.8) must be focused on the present value of future budget deficits and seigniorage. The analysis of their trajectories may then be of intermediate use. In this respect we go against the postulate by C. Christ: "It is not possible to change just one policy variable from its previous path, leaving all others on their previous paths" (Christ, 1979, p. 527). This is quite possible, if the changes in the trajectory of the variable do not change the present price of its future values.

post factum by any means, while (2.7) can be rewritten in terms of future macroeconomic policy; the determination of this policy is what we wish to achieve. Indeed, the general solution of (2.1) can be written as

$$b(t) = C_b e^{rt} + \int_0^t \left[d(\tau) - S(\tau) \right] e^{-r(\tau - t)} d\tau , \tag{2.9}$$

where C_b is an arbitrary constant. Applying (2.7) determines the value of C_b:

$$C_b = \int_0^\infty \left[S(\tau) - d(\tau) \right] e^{-r\tau} d\tau . \tag{2.10}$$

Therefore, the choice of C_b and, therefore, the no-Ponzi game condition (2.7), is determined by a macroeconomic policy that determines the trajectory $S(\tau) - d(\tau)$.

The initial and terminal conditions determine one and the same trajectory, on which the government and the central bank choose policies such that for a given accumulated level of debt $b_0 = C_b = \int_0^\infty \left[S(\tau) - d(\tau) \right] e^{-r\tau} d\tau$. We can now formulate more accurately the principle of sustainable fiscal policy: a fiscal policy will be sustainable, if at each point in time t and accumulated volume of public debt $b(t)$ future policies are characterized by the choice of trajectories $d(t)$ and $S(t)$ that satisfy (2.8).

The concept of a sustainable fiscal policy is connected to another important concept in government finance. Equation (2.8) implicitly defines the *backing of government bonds*. As T. Sargent put it[19]: "To attract funds, the government must offer lenders a prospective stream of net revenues sufficient to support the value that it presently proposes to borrow... The present value of [the stream of net revenues] forms the "backing" for the government borrowings, just as the present value of a stream of prospective net revenues from a new machine might form the backing for a private loan. Furthermore, like any private borrower, the government can borrow in interest-bearing form only a limited amount determined by the maximum present value of the prospective government surpluses that the economy can support". Again, given the general direction of our research, it is important how the public debt is backed, as above: this could be either the future budget surplus or future seigniorage, or a mixture of the two. The choice of backing for public debt is determined by the necessity of interaction (coordination) between fiscal and monetary policy, and beyond doubt this plays a crucial role in determining the effect of the budget deficit on economic activity.[20]

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[19] Sargent (1985, reprinted in 1993, p. 31). This approach has a long tradition in macroeconomics. Keynes noted the role of fiscal policy with regards to the problems of the gold standard and hyperinflation: "It is not lack of gold but the absence of other internal adjustments which prevents the leading European countries from returning to a pre-war gold standard" (Keynes, 1925, p. 132).

[20] As noted in the classic paper by Aiyagari and Gertler (1985, p. 20), the choice of backing of the public debt is important "...since rational agents discount future direct tax levies differently than future money creation". Later, in the third and fourth chapters we will also show the role of differences in the corresponding discount factors.

2.3. Monetary policy and inflation

One of the most popular models of inflation dynamics is the Cagan model. Originally, Cagan (1956) considered the dynamics of the money market, assuming adaptive inflation expectations. At present, researches usually use the Cagan model for forward-looking rational expectations. However, any modification of the Cagan model should incorporate two elements: (i) demand for real money balances, which decreases with an increase in expected inflation, and (ii) a hypothesis for how inflation expectations are formed (the interconnection between expected and actual inflation).

The most convenient (at least, for continuous time), is the log-linear specification of the demand function for real money balances suggested by Cagan:

$$m^d = Ae^{-\alpha\pi^e}. \tag{2.11}$$

Here $m^d = \left(\frac{M}{P}\right)^d$ is the volume of demand for real money balances. In the following analysis we will assume that the money market is in equilibrium, $m^d = \frac{M^s}{P} = m$. The parameter A may depend on the real interest rate and output. The parameter $\alpha = -\frac{dm^d / m^d}{d\pi^e} > 0$ characterizes the semi-elasticity of demand for real money balances with respect to expected rate of inflation (in the general case, by the nominal interest rate)[21]. The specification (2.11) is supposed to emphasize the dependence of the demand for real money balances on expected rate of inflation.[22] Without loss of generality, we can assume that $A = 1$. Let $x = \ln m^d$, and then (2.11) can be rewritten as

$$x = -\alpha\pi^e. \tag{2.12}$$

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[21] McCallum (1989) uses the specification $\ln m^d = a_0 + a_1 \ln y - a_2 R,\ a_1, a_2 > 0$, where y is real output and R is the nominal interest rate. The constant A then characterizes the dependence of the demand for real balances on the real income and real interest rate. This functional form seems to be *ad hoc*. In the Appendix to Chapter 3 we will give the derivation of the demand function (2.11) for a certain specification of the utility function in Sidrausky's model. There, however, the characteristic of semi-elasticity α will depend on the aggregate output (or consumption). However, from the point of view of the general analysis presented this is not of principle importance.

[22] The use of (2.11) in the analysis of monetary policy and the dynamics of inflation implicitly assumes the constancy of (at least) real output and the real interest rate. Cagan used this assumption in the analysis of hyperinflation, when indeed changes in real variables are negligibly small with respect to changes in the nominal variables. Using analogous assumptions, we do not at all intend to confine ourselves to the discussion of hyperinflation, or even to high inflation. Of course, we inevitably simplify the analysis, in order to concentrate on certain specific questions.

The dynamics of real money balances can be determined by simple arithmetic: their rate of growth is equal to the difference between the rate of growth of the base money $\mu = \frac{\dot{M}^s(t)}{M^s(t)}$ and inflation rate:

$$\dot{x}(t) = \frac{\dot{m}(t)}{m(t)} = \mu - \pi(t). \tag{2.13}$$

Let us first consider the hypothesis of adaptive expectations, in accordance with which the dynamics of the expected rate of inflation, and therefore of the real money balances, will be backward-looking. Economic agents have a systematic forecast error and adapt their expectations with speed θ:

$$\dot{\pi}^e(t) = \theta\left(\pi(t) - \pi^e(t)\right), \quad \theta > 0. \tag{2.14}$$

Taken together, (2.12), (2.13) and (2.14) determine the dynamics of inflation:

$$\dot{\pi}(t) = \frac{\theta}{1-\alpha\theta}\left(\mu - \pi(t)\right). \tag{2.15}$$

For an initial level of inflation that is different from the (say, constant) growth rate of base money, the backward-looking solution is

$$\pi(t) = \mu + (\pi_0 - \mu)e^{-\frac{\theta}{1-\alpha\theta}t}. \tag{2.16}$$

The dynamics of inflation are stable and the level of inflation asymptotically approaches the growth rate of base money, if the reactions of economic agents are not sensitive: $d\theta < 1$ (a low speed of expectation adaptation and/or low demand sensitivity). Alternatively, sensitive behavior of economic agents ($d\theta > 1$) will make the dynamics of the money market unstable, which may lead to hyperinflation or hyperdeflation.

In the same way, we may analyze the dynamics of the money market under assumption of perfect foresight in forming expected rate of inflation[23]:

$$\pi^e(t) = \pi(t). \tag{2.17}$$

[23] From a technical point of view, the hypothesis of perfect foresight can be considered to be a limiting case of (2.14) with an infinitely high speed of adaptation, $\theta \to \infty$. From a conceptual point of view, the hypothesis of perfect foresight and the related hypothesis of perfect myopic foresight is the simplest form of rational expectations. See, for example, Turnovsky (2000).

Taking equation (2.17) along with equations (2.12) and (2.13), we can write the equation for the dynamics of inflation in the same way as (2.15):

$$\dot{\pi}(t) = -\frac{1}{\alpha}\left(\mu(t) - \pi(t)\right). \tag{2.18}$$

The general solution of this dynamics equation for a variable (in the general case) growth rate of base money can be written as:

$$\pi(t) = C_\pi e^{\frac{1}{\alpha}t} - \frac{1}{\alpha}\int_0^t \mu(\tau) e^{-\frac{1}{\alpha}(\tau - t)} d\tau. \tag{2.19}$$

Equation (2.18) has a positive root equal to a^{-1}. Therefore, a backward-looking solution will be unstable. For the particular case when is $\pi(0) = \pi_0$ constant and the initial value is μ, (2.19) can be written in the form

$$\pi(t) = \mu + (\pi_0 - \mu)e^{\frac{1}{\alpha}t}. \tag{2.20}$$

On the other hand, the forward-looking solution (2.18) will be stable. Imposing the additional condition for the absence of a (hyperinflationary) bubble,

$$\lim_{t\to\infty} \pi(t) e^{-\frac{1}{\alpha}t} = 0, \tag{2.21}$$

and thus determining the arbitrary constant $C_\pi = \frac{1}{\alpha}\int_0^\infty \mu(\tau) e^{-\frac{1}{\alpha}\tau} d\tau$ in equation (2.19), we arrive at the fundamental solution

$$\pi(t) = \frac{1}{\alpha}\int_t^\infty \mu(\tau) e^{-\frac{1}{\alpha}(\tau - t)} d\tau. \tag{2.22}$$

In the following analysis we will find it convenient to refer to the equations for the dynamics of the logarithm of real money balances. Combining equations (2.12), (2.13) and (2.17), we can write

$$\dot{x} = \frac{1}{\alpha}x + \mu. \tag{2.23}$$

The backward-looking solution of equation (2.23) for the initial condition $x(0) = x_0 = -\alpha\pi_0$ and a constant growth rate of base money has a form that is analogous to equation (2.20):

$$x(t) = x^* + (x_0 - x^*)e^{\frac{1}{\alpha}t}, \tag{2.24}$$

where $x^* = -\alpha\mu$ is the stationary log-level of real money balances.

The forward-looking solution for condition (2.25), which is equivalent to condition (2.21):

$$\lim_{t\to\infty} x(t)e^{-\frac{1}{\alpha}t} = 0, \tag{2.25}$$

and for the growth rate of base money, which is variable in the general case, can be written as

$$x(t) = -\int_t^{\infty} \mu(\tau)e^{-\frac{1}{\alpha}(\tau-t)}d\tau. \tag{2.26}$$

The interpretation of the stability of backward and forward-looking inflation dynamics from a technical point of view should not interest us here. However, from a qualitative point of view, we should explain the choice of this or that method for determining the dynamics, as we did above when discussing the interpretation of the budget constraint for the government and the dynamics of the public debt.

In the case of backward-looking dynamics of the money market, in accordance with equation (2.20), if $\pi_0 \neq \mu$, then the economy will face either hyperinflation or hyperdeflation. What is strange is not just the result that an economy with rational expectations is characterized by unstable dynamics. What is even stranger is that if the money market is initially in a steady state and there is a discrete permanent increase of μ, then in accordance with (2.20) the economy will exhibit hyperdeflation. And vice versa, a discrete decrease in μ will bring about hyperinflation. However, regardless of this seeming paradox, this model can nevertheless be explained and should not be written off. This situation can be interpreted from the point of view of how the prices of financial assets are determined. For a given growth rate of base money, inflation taken with a negative sign $-\pi = -\mu_0$ can be considered to be some fundamental characteristic of the rate of return of an asset (in this case, nominal money[24]). If the initial rate of return of the asset is less than the fundamental, i.e. $-\pi_0 < -\mu_0$, then a "negative" speculative bubble will form. Indeed, equation (2.20) can be rewritten as

$$-\pi(t) = -\mu + \left(-\pi_0 - (-\mu)\right)e^{\frac{1}{\alpha}t}. \tag{2.27}$$

In this interpretation, the first item in the right side is the fundamental component, and the second is the bubble[25].

[24] Considering the inverse of the price level as the purchasing power of a nominal money, the level of inflation, taken with a minus sign, determines the profitability of money: $-\pi = \dfrac{\frac{d}{dt}\left(P^{-1}\right)}{P^{-1}}$.

[25] An analogous decomposition can be arrived at for the growth rate of base money. We should note that this bubble, as a particular solution, is one of infinitely many solutions.

In the economic literature the problem of bubbles on the financial market is usually linked to the question about whether the behavior of investors is rational. Avoiding the discussion about the "rationality" of bubbles on the money and finance markets[26], which is not of interest in this research, we should nevertheless comment on the suggested interpretation of unstable dynamics in the model. While standard analysis of the dynamics of rational systems requires the use of the operator of conditional mathematical expectancy, our analysis is based on an extreme case of rational expectations: perfect myopic foresight. Determining inflation exactly for an infinitely small time horizon, economic agents do not take into consideration either the possible dynamics of the system or the actions of monetary and fiscal authorities in the future. Therefore, this is a kind of bounded rationality[27]. Thus, the question about the rationality of unstable dynamics (bubbles) on the money market is replaced by the question of which hypothesis about the behavior of investors should be applied; this question, however, also lies outside our research. However, if we disregard the hypothesis of rationality and we consider the principles by which fiscal and monetary polices can interact and avoid the possibility of any catastrophes on the money or bond markets (hyperinflation or a confidence crisis), we also disregard the possibility that infinitely increasing bubbles are possible. Instead of the condition for the absence of bubbles in this model there are (possibly implicit) conditions for the coordination and choice of policies.

We can also interpret the instability of the solution of equation (2.20) by considering real money balances instead of nominal money. The level of inflation, taken with a negative sign, corresponds to the profitability of nominal money. At the same time, using functions of the type given in (2.11), the level of inflation can be considered to be the price determinant of demand for real money balances. Rewriting (2.13), we can find the following relationship for the level of inflation:

$$\frac{\dot{\pi}}{\pi} + \frac{\alpha^{-1}\mu}{\pi} = \frac{1}{\alpha}. \tag{2.28}$$

The first member of this equation is the sum of increments of the price determinant of demand and the "dividend" for a unit of real money balances. The second member, α^{-1}, is the asymptotic rate of growth of the price determinant (i.e., inflation)[28]. If the norm of the

[26] An overview of this problem can be found Salge (1997). An analysis of bubbles on the money market in the context of Cagan model of hyperinflation is given in the book by Turnovsky (2000, ch. 3). See also Farmer (1984). Empirical tests for the existence of hyperinflationary bubbles are given in Casella (1989), Engsted (1993, 1994), and Funke, Hall and Sola (1994).

[27] We implicitly assume that the inevitability of the interaction between monetary and fiscal authorities in order to avert a crisis on the money and finance markets is a well-known fact. Therefore, lack of information in this case is not a case for the backward-looking behavior of economic agents.

[28] See equation (2.27). Equation (2.28) in essence is not arbitrage, as we are considering only one asset. Nonetheless, it is possible to draw certain parallels with the no-arbitrage condition. The left side of the equation corresponds to the rate of return of the asset with continuously paid dividends. The no-arbitrage condition dictates the equality of the (expected) rate of return of the asset to the riskless interest rate, which in its turn is the asymptotic growth rate of the value of the asset. In this case the asymptotic rate of growth is the inverse semi-elasticity of the money demand.

dividend for a unit of real money balances is less than the asymptotic rate of growth of inflation, which holds if the growth rate of base money is less than the level of inflation and $\mu < \pi$, then the demand for assets (real money balances) falls, while the price of the asset increases: $\pi > 0$.

An argument for choosing the backward-looking dynamics of the money market (bounded rationality of investors) could be the well-known fact that inflationary processes are known to be inertial in economies with both high and low rates of inflation. Depending on the situation, the inertia of inflation and of expected rate of inflation could be explained by either the lack of trust of the population to the efficacy of anti-inflationary measures, or directly by the mechanisms by which inflation spreads in the economy[29]. The latter is closely connected with the principles of the dynamics of the money market that we consider here.

By contrast, the forward-looking solutions (2.22) and (2.26) suppose that the behavior of economic agents is completely rational. In Chapter 4 we analyze fiscal and monetary policy interaction under assumption of backward-looking dynamics of inflation. In Chapter 5 we build our model assuming forward-looking rational behavior of economic agents.

2.4. The fiscal theory of inflation: "Unpleasant monetarist arithmetic"

In the previous section we discussed the basic mechanisms by which monetary policy can influence the rate of inflation; this is what in essence is called "the monetarist theory of inflation". In certain respects it is difficult to disagree with how M. Friedman put it: "Inflation is always and everywhere a monetary phenomenon". From the point of view of traditional monetarism, the growth rate of base money to a significant extent determines inflationary processes, since inflation as a phenomenon is a decrease in the purchasing power of existing money due to the emission of new money.

However, the Cagan model by itself as used for the analysis of inflationary processes, does not take into consideration many important questions. In particular, we are interested in the following problem: can we (and if so, under what conditions) consider only the monetary policy of the central bank as the sole determinant of inflation, without considering the fiscal policy of the government? Can we use only monetary instruments to achieve lower inflation in the short or long run?

This problem arises quite naturally, if we remember that one of the sources of financing the budget deficit of the government is seigniorage, the real income from the emission of the base money, which is collected and controlled by setting the growth rate of base money by the central bank. In this regard monetary policy should not be considered in isolation, but rather in the context of determining fiscal and monetary policy in unison. One of the first to note this were T. Sargent and N. Wallace in 1981 in their famous paper: "unpleasant monetarist

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[29] See, for example, Beckerman (1992), Bruno (1993), Dornbusch (1993), and Heymann and Leijonhufvud (1995).

arithmetic". Their paper laid the foundation for the "fiscal theory of inflation", or FTI. The main result can be given as follows. For a given fiscal policy (for a predetermined trajectory of the primary budget deficit) a tightening of monetary policy (decrease in the growth rate of base money) can bring about a decrease in the rate of inflation in the short run only at the expense of higher growth rates of base money and inflation in the future. Moreover, if the behavior of economic agents is rational and forward-looking, then a tight monetary policy today may bring about high inflation not only in the future, but also in the present.

The logic of this conclusion is based on two main assumptions. First of all, it is assumed that the central bank considers the fiscal policy of the government (the choice of trajectory of the primary budget deficit) as a given. In other words, monetary policy assumes a passive role, and the central bank must provide the government with a volume of seigniorage sufficient to cover the budget deficit (taking into account the existence of an alternative source of financing, namely new borrowings from the government)[30].

Secondly, it is assumed that the interest rate on public debt is greater than the growth rate of output in the economy. As we showed above, it is in this case that the trajectory both of the public debt and of the ratio of government debt to output is unstable, which is an important reason for the existence of the problem of coordinating macroeconomic policies. If the interest rate were less than the growth rate of output, then the ratio of public debt to output would exhibit a stable trajectory, and this would remove many possible questions.

Based on these two assumptions, Sargent and Wallace consider the following theoretical experiment[31]. At the initial point in time the central bank decreases the growth rate of base money, and this brings about a decrease in the volume of seigniorage[32]. For a given (predetermined) trajectory of the primary budget deficit, the less the volume of seigniorage, the higher the public debt at all points in time in the future. Indeed, by compensating for the decrease in the volume of seigniorage, the government is forced to borrow more in order to service the existing debt, and this brings about an increase in the volume of borrowings. However, for many reasons the public debt cannot increase infinitely. According to the argument by Sargent and Wallace, for instance, the increase of public debt is bounded from above by the volume of private savings in the economy, or, what is more likely, by some other, lesser quantity. In order to stabilize the increasing public debt in the future (to fix its volume at a certain point in the future) it will be necessary to have a higher volume of seigniorage, and therefore a higher growth rate of base money and rate of inflation. Modeling the demand for money according to the original quantity theory of money, Sargent and Wallace showed that a lower growth rate of base money (rate of inflation) today will inexorably be replaced by

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[30] There exists, however, a different method of coordination, mentioned but not modeled by Sargent and Wallace. It involves a dependent role for the government, rather than the central bank. In this case monetary policy is independent of the needs of financing the deficit, and the government, taking the flow of seigniorage to be exogenous, is forced to correct the trajectory of the budget deficit in accordance with some principle for managing the public debt. We will return to this case in the following chapters.

[31] We do not give the formal model here. The result of Sargent and Wallace will be seen to be one of the possible cases in the analysis given in the third and fourth chapters.

[32] We will discuss the validity of this conclusion later.

a higher growth rate of base money (inflation) in the future. If, however, the demand for money decreases with an increase in expected rate of inflation (as, for example, for function [2.11]), and these expectations are formed in accordance with the hypothesis of perfect foresight, then the unavoidable increase in the growth rate of base money at a certain point in time will already bring about an increase in inflation even today.

This conclusion can indeed be considered as a "fiscal theory of inflation". In a situation of inevitable policy interaction with the dependent role of monetary policy, the central bank is not able to permanently decrease the growth rate of base money, that is, to conduct long-term policies to bring inflation down. In this sense inflation becomes not only a monetary, but a fiscal phenomenon as well, since influencing it requires not only monetary policy actions, but also fiscal actions that have to do with correcting the budget deficit of the government.

T. Sargent's and N. Wallace's 1981 paper can be termed revolutionary without overstatement; it changed the perceptions of how to conduct macroeconomic policy. The problem it raised about the interaction of fiscal and monetary policy created an interesting discussion in the 1980s. The logic that T. Sargent and N. Wallace suggested can be modified, improved or added to in many directions. At the present time it presents both academic and practical interest.

While the theoretical results were undoubtedly interesting, many economists were skeptical about how realistic the basic assumptions were[33]. Darby (1984) considers that T. Sargent's and N. Wallace's assumption that the interest rate is greater than the growth rate of output does not hold for the economy of the USA and other developed countries. As we noted above, this assumption is indeed critical for all analysis of macroeconomic policy. Answering Darby's criticism, Miller and Sargent (1984) note that the "unpleasant monetarist arithmetic" can (and should) be considered in a wider context, and not just literally. The growth of public debt as a result of a tightening of monetary policies can bring about an increase in the interest rate for a variety of reasons. If so, then Darby's methodology, which included the consideration of the average interest rate for previous periods, could be erroneous[34].

Agreeing that the assumption $r > g_y$ is not incontestable, Bhattacharya, Guzman and Smith (1998)[35] showed that this assumption is not necessary for the existence of "unpleasant monetarist arithmetic". The authors include an extra asset in Sargent-Wallace's model that is available to the private sector and financial intermediaries. In doing so, savings, as an additional asset, conform to the requirement of required partial reservation. It was shown that, taking these additions into account, the "unpleasant monetarist arithmetic" can exist if the

[33] Sargent and Wallace give their analysis based on a somewhat simplified version of the model of overlapping generations. Buiter (1982) notes that one of the drawbacks of the Sargent and Wallace model is the absence of a microeconomic basis for the demand for money. In reality, this is hardly a serious problem. Later papers (which will be discussed shortly) that touch on "monetary arithmetic" as a rule were based on dynamic optimization models. A more interesting point of Buiter's is the following rhetorical, but nonetheless important question: is it possible, by analyzing monetary policy that to a smaller or greater extent controls the money base, to determine its ability to control inflation? We will avoid this (now rhetorical) question.

[34] In this sense, the analysis by Darby (1984) is the subject to Lucas (1976) critique.

[35] See also Bhattacharya and Haslag (1999).

economy contains at least one asset with a rate of return that is greater than the growth rate of output. In the real world such assets, obviously, almost always exist.

Dornbusch (1996) suggests additional considerations that strengthen "unpleasant monetarist arithmetic". First. Tight monetary policy leads to higher interest rates, and thus higher debt service and more rapid accumulation of public debt. Second. Tight monetary policy may worsen fiscal position by lowering tax revenues and increasing unavoidable government spending. Third. Higher interest rates can depress economic growth, thus leading to more rapid growth of the debt to GDP ratio. Although these considerations may be very important in practice, we do not include them into our analysis to be able to concentrate on the "direct" logic of "unpleasant monetarist arithmetic".

In papers by Liviatan (1984) and Drazen (1985) it is shown that the result of "unpleasant monetarist arithmetic" holds only if the economy is characterized by an inelastic demand for money with respect to the nominal interest rate.[36] In Chapters 4 and 5 we will also suggest certain interesting additions to the analysis by Sargent and Wallace.

Seigniorage: is it important for fiscal and monetary policy interaction?

Seigniorage indeed plays a crucial role in the fiscal theory of inflation. However, is it an important part of government revenue, and is this true for all countries and in all times?

In fact, there are three separate questions:

- What is the seigniorage to GDP ratio and is it an important part of government revenue (or spending)?
- Is there empirical evidence for a strong relationship between the budget deficit and seigniorage?
- What is the relationship between the inflation rate and seigniorage?

Let us consider these questions in turn. International statistics show that seigniorage in industrial countries is relatively small, both as a fraction of GDP and as a fraction of government spending. However, it may be an important source of budget revenue in developing countries (see Table 2.1). Fischer (1982) reports the seigniorage to GNP ratios worldwide in 1960—1973 and 1973—1978. More recent evidence for the 1971—1990 period is provided by Click (1998). For the 90 countries in the sample, the average seigniorage to GDP ratio is about 2.5 percent. On average, seigniorage finances 10.5 percent of government spending. Seigniorage is less than 1 percent for a sub-sample of 28 countries, consisting of all industrial countries as well as some that are developing. At the same time, the seigniorage to GDP ratio is more than 5 percent of GDP in 8 countries in the sample. It is interesting to note that seigniorage as a fraction of government spending does not produce the same pattern. For example, seigniorage is 0.4371 percent of GDP in Canada and it is 0.4737 percent in the United Kingdom. At the same time seigniorage as percent of government spending is 2.0144

[36] Velasco (1993) arrived at like results after modifying the Drazen model for an open economy, floating exchange rate and perfect capital mobility.

in Canada, but it is 1.2800 in the United Kingdom. For some developing countries seigniorage is indeed a major source of revenue. For example, seigniorage as a percent of government spending is 18.9687 in Mexico (3.7207 percent of GDP), and it is 62.0003 in Argentina (9.7299 percent of GDP). Seigniorage is important even in some developed countries in the period under consideration: Switzerland, Japan, Spain, Greece, Iceland and Italy have seigniorage well above 5 percent of government spending.

Table 2.1. Average annual rate of seigniorage in selected countries, 1971—1990

Country	Seigniorage as percent of GDP	Seigniorage as percent of government spending	Country	Seigniorage as percent of GDP	Seigniorage as percent of government spending
Denmark	0.3943	1.0512	*Thailand*	1.0872	6.3018
United States	0.4295	1.9552	*Philippines*	1.2251	8.9611
Canada	0.4371	2.0144	*Indonesia*	1.3908	6.8590
United Kingdom	0.4373	1.2800	*Korea*	1.5690	9.6979
Belgium	0.4910	1.0187	*Malaysia*	1.5749	5.2696
Netherlands	0.5352	1.0184	*Spain*	2.0267	7.5584
France	0.5520	1.3863	*Colombia*	2.3178	17.5651
Norway	0.5630	1.4598	*Italy*	2.3572	7.4229
Finland	0.5966	2.1217	*Brazil*	3.0394	13.7132
Switzerland	0.6187	6.7397	*Greece*	3.1291	10.5149
Germany	0.6869	2.3539	*Mexico*	3.7207	18.9687
Austria	0.6940	1.8944	*Argentina*	9.7299	62.0003
Sweden	0.7234	1.9301	*Chile*	10.3001	32.5765
Japan	0.9585	5.6200	*Israel*	14.8424	22.2781

Source: Click, 1998 (extract from Table 1, p. 155).

The most obvious way to test the fiscal theory of inflation is to check for a relationship between government deficit and seigniorage. King and Plosser (1985) check for contemporaneous correlation between money creation and deficits in the USA. They found positive correlation in the 1929—1952 period, but little or no correlation in the 1953—1982 period. This result, however, does not imply weakness of FTI, as long as there is a more general consideration: if fiscal policy is dominant (if the trajectory of the budget deficit is taken as exogenous), then there is a constraint on future monetary policy (future seigniorage revenues). That is, FTI predicts a positive dynamic relationship between seigniorage and past deficits under fiscal dominance. King and Plosser (1985) found that past deficits do predict seigniorage. However, they also found that by adding variables that the Federal Reserve might also respond to (such as the nominal interest rate, the growth rate of output or the unemployment rate) into the regression, the significance of the predictive power of past deficits is reduced. More recent investigation by Fischer, Sahay and Vegh (2002) shows that the relationship between the deficit and seigniorage is strong only in high-inflation countries (during high-inflation episodes).

There are several difficulties in the interpretation of these results. First of all, the testing strategy involves the assumption of fiscal dominance that may hold in some periods but not in others. Secondly, here we again can stress the original point by Miller and Sargent (1984) that "unpleasant monetarist arithmetic" just shows the important consequences of current tight monetary policy for the future alternatives for both fiscal and monetary policy. In particular, we show in the following chapters that there are many possible scenarios of fiscal and monetary policy interaction. Some of them predict inflationary consequences of fiscal deficits, while others do not.

The final question of the inflationary consequences of seigniorage raises little doubts. The most interesting finding in this respect is the nonlinear nature of the relationship between inflation and seigniorage. Fischer, Sahay and Vegh (2002) report the presence of the so-called Laffer curve effect, that is, of a fall in seigniorage as inflation continues to rise. This effect is visible and significant in high-inflation countries. Haslag (1998) provides the evidence on the systematic, positive relationship between a country's monetary policy settings (growth rate of base money in particular) and its reliance on seigniorage. This relationship is nonlinear for OECD countries.

2.5. The fiscal theory of the price level

In the middle of the 1990s yet another interesting approach in the analysis of macroeconomic policy appeared, the "fiscal theory of the price level determination" by M. Woodford and K. Sims[37]. In principle, this theoretical approach is not a direct base for the analysis that we suggest in the following chapters; rather, we will proceed in the context of FTI. However, the existence of certain points where different theories overlap requires that we give a general characterization of this alternative theory, its main assumptions, results and applications. Moreover, if the analysis in this work in certain aspects uses "traditional" monetary logic in constructing models, it would be unfair to pass by a new, interesting (if not generally accepted) theory and its logic in determining macroeconomic policies.

A simplified interpretation of the theory

The Fiscal Theory of the Price Level (FTPL) states that the equilibrium price level is determined by the ratio of the volume of nominal public debt to the present value of real budget surpluses (plus the present value of seigniorage). Indeed, rewriting equation (2.8),

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[37] Woodford (1995, 1997, 1998, 2000, 2001), Sims (1994). See also the earlier investigation by Leeper (1991) and following papers by Bergin (2000), Benassy (2003), and Canzonery, Cumby and Diba (1998), Christiano and Fitzgerald (2000), Cochrane (1999, 2000, 2001), Daniel (2001), Dupor (2000), Gordon and Leeper (2002), Kocherlakota and Phelan (1999), Leeper (2003), Schmitt-Grohe (2000).

$$b(t)=\frac{B(t)}{P(t)}=\int_t^{\infty}\left(S(\tau)-d(\tau)\right)e^{-r(\tau-t)}d\tau \qquad (2.29)$$

for a given accumulated (predetermined) volume of nominal public debt and expected future values of the budget deficit and seigniorage (which are exogenous for this policy) we arrive at the price level for each point in time:

$$P(t)=\frac{B(t)}{\int_t^{\infty}\left(S(\tau)-d(\tau)\right)e^{-r(\tau-t)}d\tau}. \qquad (2.30)$$

Such approaches to the modeling of macroeconomic policies raises many questions or even doubts as to the consistency of the theory.[38] Below we will attempt to understand more fully the essence of FTPL and give the most common points where this theory faces criticism.

The fact that one of the main macroeconomic indexes, namely the price level, is determined from a single equation (2.30), should not disturb us to a great extent. The simplest version of the monetarist approach can also, in essence, determine the price level given only the equation of exchange $MV = Py$. In the context of the principle of neoclassical dichotomy the variable y, real output, is determined in the real sector of the economy, while the velocity of money V is assumed for simplicity to be constant, so that the price level is determined by the amount of money in circulation M. In other words, given the exogenously determined (for this simple and to a certain extent trivial assumptions) variables y and V, the central bank can influence the price level via M. The Cagan model considered above acts in an analogous fashion, and also presents a traditional monetarist approach to the determination of the price level.

Budget constraint for the government or equilibrium condition?

In practice, papers by the founders of FTPL use equation (2.29) in the context of "standard" optimization models[39]. What is different about FTPL is the meaning conveyed by equation (2.29). The traditional approach is to search for a general economic equilibrium (and the majority of "standard" optimization models can be classified as equilibrium models), while equation (2.29) is a budget constraint of the government. The logic of using a budget constraint that is the same both for the private sector as well as the government assumes that the decisions of economic agents must satisfy the budget constraint *for any price level*. Thus,

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[38] Buiter consistently criticizes FTPL in his papers, proclaiming it "logically incoherent". See Buiter (1998, 1999, 2002, 2004). In reality, the dispute over FTPL in academic literature is probably one of the most intense of the last few decades.

[39] Most papers by supporters or critics of FTPL use basic optimization models with money in the utility function, with cash-in-advance constraint, or shopping-time models. There can also be assumptions about the flexibility of prices, or certain other nominal rigidities (Woodford, 1997). In the Appendix to the second chapter we will also consider the Sidrausky model with money in the utility function of a representative agent.

economic agents take the price level as given and base their decisions on it. Based on this, and on the first order conditions and certain other additional conditions, these models determine the equilibrium price level. FTPL, however, considers (2.29) not to be a budget constraint, but rather to be the equilibrium condition itself[40]. In other words, the government must satisfy condition (2.29) not for any price level, but *just for the equilibrium price level*. This is the essence of FTPL.

From the standpoint of the standard macroeconomic approach that is grounded in the principle of sustainable fiscal policy[41], the government and the central bank must conduct their policies so that condition (2.29) is satisfied for given (predetermined) variables $M(t)$ and $B(t)$ and *any* possible price level. In other words, the joint choice of the trajectories $d(\tau)$ and $S(\tau)$ for $\tau \geq t$ cannot be completely exogenous. FTPL states that the government is not at all required to achieve sustainability for its policies at the price level determined by the market. The government itself can influence the price level by conducting certain policies[42].

Government bonds as stocks: an asset pricing interpretation

In the modern world, money issued by the state is not *explicitly* backed ("fiat" or "unbacked" money). In accordance with traditional monetarist theory, the positive worth of money is explained by the demand for it as for a special asset for conducting transactions (given its limited supply). FTPL is based on a different interpretation: money and nominal government bonds have an *implicit* backing as the obligations of the state in the form of future surpluses of the state budget[43]. Thus, Christiano and Fitzgerald (2000) draw a direct analogy between the price determination of assets (they used Microsoft as an example on p. 13) and FTPL. On the stock market the corresponding information about the future determines the value of the firm and, taking into account the number of shares issued, the price for one share. A firm is not required (either in theory or in practice) to conduct a certain policy in the future depending on the current price of its shares. In the opinion of L. Christiano and T. Fitzgerald and other proponents of FTPL, the government is not required to conduct a certain policy based on the size of the public debt for the same reasons. Holders of state obligations (the private sector in the macroeconomic model) determine the equilibrium price level based on the

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[40] Woodford (1995, p. 30) suggest the following interpretation: "It is well-known that when Walras's Law holds (i.e. when individual economic units' budgets can be aggregated to obtain a well-defined present value for aggregate expenditure), the joint requirements that each unit's budget constraint be satisfied with equality and that each market clear contain a redundant equation. (Often this is taken to be one of the market-clearing conditions, so that it is found that it is found that clearing of $N-1$ markets implies clearing of the Nth market as well, but it might equally well be one of the budget constraints that is implied by the others.) Then clearing of all markets implies that if the representative household's present-value budget constraint holds with equality, a similar present-value relation [(2.29)] must hold with equality for the government".

[41] We considered this principle above, and the main part of Chapter 4 will be built upon it.

[42] This, however, does not mean that the government can choose any trajectory for expenditures and taxes. Since the price level cannot be negative, a positive nominal public debt should inevitably be backed by a positive present value of future budget surpluses.

[43] We have already referred above to this interpretation, suggested by T. Sargent. In reality, this interpretation has a very old history. It is one of the possible explanations for the positive value of money, as it is required for paying taxes. See, for example, Starr (1974).

ratio of the nominal volume of the accumulated debt and the real flow of "backing" (present value of the budget surplus and seigniorage), that is, in accordance with (2.30).

It is important to emphasize the following. Parallels are drawn between the determination of the price of shares *based on their number* and the determination of the price level based on the accumulated level of the *nominal* debt. Defending the meaning of (2.30) as of a *"valuation equation"* and answering the critics of the theory, Cochrane notes that FTPL does not at all deny the importance of budget constraints of the private sector and the government in macroeconomic models: "...Government and private sector must obey budget constraints in buying or selling real debt, foreign debt, goods, and any already defined securities, at equilibrium as well as off-equilibrium prices".[44] We will return to the question about the *real* debt later.

In connection with this analogy, J. Cochrane also comes to the following conclusions. The government may issue more bonds without the corresponding increase in the flow of future budget surpluses; this will simply increase the price level[45] (just as the issuance of additional shares without changing expectations about future profits will simply decrease the price of one share). Also, the state is not obligated to react to non-equilibrium prices, unlike, for example, the demand curve, which can be considered only if the budget constraint is satisfied for any prices. Indeed, Microsoft Corporation is not required to increase its dividends by a factor of two if the price of its shares doubles.

The wealth effect as a mechanism by which fiscal policy influences the price level

Again, as in the case of the monetary approach (the quantitative theory), in which the logic of determining the price level based on the exchange equation $MV = Py$ does not undergo principle changes in larger models with a greater number of variables, the FTPL mechanism may be presented in a more formal fashion than simply equation (2.29). Woodford[46] describes the following mechanism: "...an increase in the nominal value of outstanding government liabilities, or in the size of the (appropriately modified) real government budget deficit expected at some future dates, is inconsistent with equilibrium at the existing price level. For either change causes households to believe that their budget set had expanded (assuming no change in the path of the price level), and so they demand additional consumption immediately (as well as planning higher consumption in the future. The consequence would be excess demand for goods (both now and in the future). This forces up prices... Price level determination thus depends upon a wealth effect of price level changes, as in the analysis of Patinkin (1956), but in contrast to Patinkin's analysis of the "real balance effect", I find

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[44] Cochrane (2000), p. 3. There he also explains that, just as in the case of price determination for shares, FTPL does not in any way contradict the logic of constructing models of the Walrasian type. We will return to this question once again later.

[45] Here yet another idea (or comment) inevitably appears. If (2.29) is not a budget constraint for the government, then the transversality condition (2.7) must also not apply to the government. It must apply to the private sector (to its budget constraint).

[46] Woodford (1995), pp. 12—15.

that the effect in question depends upon the value of net outside assets, rather than upon the value of the monetary base", and later in the text: "...changes in [net government liabilities and expectations regarding future government budgets] do affect the equilibrium price level, quite independently of any changes in the path of the money supply that may be associated with them"[47], and "...the expected path of the money supply does *not* matter for price level determination, *except through its consequences for the government's budget*".

Thus, we have two alternative approaches to the determination of the price level: the traditional monetarist approach (the quantitative theory of money) and the fiscal approach (FTPL). How can we explain the emergence of this new (fiscal) approach? Should we apply it in practice? If yes, is it universal, that is, can it replace the usual monetary approach for the description of any situation?

FTPL and the problem of the price level indeterminacy

One of the main reasons why the author of FTPL M. Woodford and his followers consider that the creation of FTPL was "necessary" is an old, but still very relevant problem of the indeterminacy of equilibrium in a wide spectrum of monetary models. First of all, there is the (theoretical) problem about the indeterminacy of the volume of money supply and of the price level if monetary policy as a target uses the nominal interest rate instead of some money aggregate.[48] In M. Woodford's opinion, the set of equilibrium conditions in the traditional approach (the quantity theory) is simply incomplete. In order to remove the problem of indeterminacy and choose a concrete solution for the price level in this class of models, economists often use additional conditions that raise doubts as to how valid or realistic they are.[49] FTPL suggests a new approach: by changing the role of (2.29) and releasing the government of its obligation to "slave" its future policy in order to satisfy (2.29) as a budget constraint (for *any* price level!), we arrive at an additional equilibrium condition that removes the problem of indeterminacy[50].

Translating this problem into the language of macroeconomic policy, we may note the following. Standard monetarist doctrine assumes (in the first approximation), that the price level will be stable if and only if an *independent* central bank upholds an commitment (a policy rule) concerning its targets. In essence, the independence of the central bank and

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[47] The quantity $M(t) + B(t)$ is understood to be the pure nominal obligations of the public sector. For this variable equation (2.29) may be written as $\dfrac{M(t)+B(t)}{P(t)} = \int_t^{\infty}\Big(\big(r+\pi(\tau)\big)m(\tau)-d(\tau)\Big)e^{-r(\tau-t)}d\tau$. Indeed, this equation is also a forward-looking solution of (2.1) given the transversality condition $\lim_{t\to\infty}\big(m(t)+b(t)\big)e^{-rt}=0$. Even though the meaning of this equation is the same as that of (2.29), this form of representing FTPL seems to be more correct to many researches than (2.29) (in particular, to Cochrane).

[48] Classical papers dealing with this phenomenon are Patinkin (1949, 1961, 1965, 1969), Sargent and Wallace (1975), McCallum (1981, 1983, 1986). See also the recent paper by Benassy (2000).

[49] See, for example, Obstfeld and Rogoff (1983). McCallum (1983, 1999) designed the so-called Minimal-State-Variable approach.

[50] In the terminology of McCallum, this problem is that of nominal indeterminacy. In his critique of FTPL, McCallum (2001) notes that in many cases the new theory deals not with the problem of nominal indeterminacy, but with the problem of multiple equilibria (solution multiplicity or nonuniqueness) in the determination of the trajectory of the price level.

the monetary policy rule should be a device for achieving so-called "fiscal discipline"[51]. FTPL, in contrast, is based on the idea that the "correct" monetary policy may be insufficient in order to achieve a stable price level — it is also necessary to conduct a certain ("correct") fiscal policy.

Innovations on the money market and macroeconomic sustainability

Another interesting problem which FTPL can be used to solve, is the appearance (and perhaps even widespread use) of private money as replacement for money that is issued by the central bank. Many proponents of traditional monetarism[52] have expressed concern that the widespread use of money issued by the private sector could make it impossible for the central bank to control the money market and so, in particular, render the price level indeterminate. Again, FTPL predicts that equation (1.29) will uniquely determine the price level. In this case the appearance of private money does not change anything in principle: monetary policy did not directly determine the price level before, and the parameters of fiscal policy such as the flow of future tax revenues or expenditures hardly depend to a great extent on the presence or absence of private substitutes for money issued by the central bank[53]. Objections to use of private money is considered by M. Woodford to be a serious mistake, since (if there is no problem with the indeterminacy of the price level) this takes away many positive aspects of the de-monopolization of the money market from society, such as an increase in the efficiency of the economy and the avoidance (lowering) of inflation[54].

The traditional approach to the analysis of monetary policy assumes that the institute of the money market is stable, that money aggregates and the demand function for money are stable, and that the velocity of money is also stable, which obviously does not conform to reality.[55] Then one may ask the obvious question[56]: how, if money aggregates are unstable, can the central bank achieve its goals with respect to the price level (inflation) by manipulating the base money, the specific volume of which in the modern developed economy is rather small? FTPL is able to remove this problem as well, if the price level (and its stability) are determined not by monetary policy, but by fiscal policy. Moreover, in order to determine the stable price level and achieve it, not only monetary policy but money itself stops playing

[51] The term "fiscal discipline device" is quite a widespread term and presents an interesting area for research. See, for instance, Tornell and Velasco (1998). From the point of view of traditional monetarism, even though the absence of fiscal discipline may entail inflationary consequences, these, as a rule, are considered negligible in economies with low inflation, which have an insignificant level of seigniorage.

[52] See, for example, Friedman (1999).

[53] It is important, however, to note that the appearance of private money may significantly influence the present value of seigniorage. From the point of view of FTPL this, or course, does not mean indeterminacy in of the price level, but rather its value may undergo certain changes, especially if the portion of seigniorage in the economy is high.

[54] See, for example, Hayek (1978). A recent overview can be found in the paper by Cowen and Kroszner (1994).

[55] The necessity of stable institutions of the money market in order to attain macroeconomic stability is often used as an argument against innovations on the financial market.

[56] See Friedman (1999).

a role! This conclusion of FTPL[57] is very timely and relevant in the context of recent discussions about the so-called post-monetary economy[58].

Types of macroeconomic policy and FTPL

In order to determine (distinguish) the classes of situations in which either the traditional monetarist approach or FTPL is applicable, the following definitions of macroeconomic policy have been introduced in the economic literature. The Ricardian type of policy is a macroeconomic policy in which monetary policy plays a dominating role (we will use the term *Money Dominant* (MD) below)[59]. By definition, an MD policy is a macroeconomic policy for which equation (2.29) is satisfied for *any* price level, not just the equilibrium one. Equation (2.29) then becomes the budget constraint for the government in its traditional meaning and does not have a direct relationship to the determination of the equilibrium price level. The equilibrium price level is determined (in line with the monetarist paradigm) by monetary policies, i.e. based on the exchange equation. As an illustration of an MD policy, Woodford (1995) gives the following rule for fiscal policy:

$$T(t) = G(t) - S(t) + \gamma rb(t), \quad 0 < \gamma \leq 1. \tag{2.31}$$

For this fiscal policy, the budget constraint of the government (as an equation for the dynamics of the public debt) reduces to the equation:

$$\dot{b}(t) = (1-\gamma)rb(t). \tag{2.32}$$

Here the rate of growth of the public debt equals $(1 - \gamma)r < r$, so that the no-Ponzi game condition (2.7) is automatically satisfied (for any price level).

Another simple example of an MD policy is provided by the quantity theory of money with an additional assumption about the constant velocity of money[60]. Indeed, in this case,

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[57] Woodford (1998) models an analogous situation in discussing the so-called "cashless limit", in which the portion of transactions in which the use of money is necessary approaches zero.

[58] An overview of the current discussion about the perspectives of the development of an "economy without money" and the modeling of a monetary policy in such a world can be found in Woodford (2000).

[59] The term *Ricardian type of policy* was introduced by M. Woodford, who considers the automatic satisfaction of the budget constraint (2.29) for any price level (the irrelevancy of fiscal policy) a simple extension of the well-known principle of *Ricardian equivalency* (Barro, 1974). Many authors prefer, however, to use different terminology. In an early paper by Leeper (1991) the concept of Ricardian policy in a first approximation corresponding to "passive fiscal policy" (given "active monetary policy"). The terminology used here of MD and FD policies (which we consider more appropriate) is taken from the paper by Canzoneri, Cumby and Diba (2001). It should also be clearly understood that the difference between Ricardian and non-Ricardian policies (between MD and FD policies) does not in any way signify the difference between sustainable and unsustainable fiscal policies.

[60] This assumption is, of course, unrealistic. If we assume that the velocity of money may change depending at least on the nominal interest rate, then we come to a standard model for the dynamics of the price level (a version of the Cagan model), in which an extra condition is introduced in order to find a stable solution;

if the central bank controls the supply of money, then the exchange equation determines the price level. The government is forced to passively correct the parameters of current and future fiscal policies in order that (2.29) is satisfied.

In contrast, a *Non-Ricardian policy* is when the main role in determining macroeconomic equilibrium (in particular, the equilibrium price level) is played by fiscal policy (referred to below as an FD policy, *Fiscal Dominant*). The assumptions and logic of FTPL correspond to this policy, in which the condition (2.29) is satisfied *only* for the equilibrium price level, and does not to be satisfied for non-equilibrium prices; thus equation (2.29) is an equilibrium condition, not a budget constraint[61].

The majority of both proponents and opponents of FTPL agree that the theory is based on the idea that it is possible for the government to choose a behavior that is qualitatively different from that of households. Thus, Kocherlakota and Phelan (1999) characterize an FD policy as a certain *"equilibrium rejection device"*. Indeed, given that equation (2.29) must not necessarily be satisfied for any price level under an FD policy, the government may choose a certain fiscal policy (now or by acting on future expectations) and so reject certain trajectories in the dynamics of the price level (inflation), namely those for which (2.29) is guaranteed to fail. Alternatively, the government can also choose a certain trajectory (make it compatible with equilibrium) in the same way[62].

Cochrane (1999) notes an important difference between FD and MD policies from a dynamic point of view. The FD-type (FTPL) considers in essence the forward-looking dynamics of the public debt: its real value is determined by future fiscal policy, and the equilibrium price level is *forced* to adapt to these expectations. However, MD policies and the traditional monetarist approach use (2.29) as a budget constraint, and though this may be from the standpoint of present value, but nevertheless the public debt itself is determined by its history. Thus for the given accumulated nominal debt and the price level on the money market, the government must adapt its future fiscal policy in order to satisfy (2.29).

What type of macroeconomic policy should we choose? From a theoretical point of view, in M. Woodford's opinion, an MD policy is probably a "special case", not the main one. The opponents of FTPL, however, believe that ignoring (2.29) as a constraint cannot be a basis for any models.

Monetarism and FTPL: different cases of one theory?

As we pointed out above, the standard monetarist approach and FTPL differ in essence only in one aspect — in the interpretation of (2.29) in the macroeconomic model (and this is

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however, the validity of this assumption is doubted by many macroeconomists. See, for example, Cochrane (1999).

[61] Yet there is another possible interpretation of FD-regime. In this case the government conducts its policy as some kind of commitment that does not have anything to do with the volume of debt, while the MD-regime characterizes fiscal policy as a choice of trajectory of the budget deficit *depending* on the volume of real debt. See Christiano and Fitzgerald (2000).

[62] Actually, this idea justifies the terminology "fiscal theory of *determination* of the price level".

what determines the different types of policies described above). This gives many researches[63] reason to consider the monetary model and FTPL as different cases of one theory. Indeed, practically any model for the analysis of fiscal and monetary policy contains a pair of equations[64], one of which determines the demand for real money balances while the other determines the budget constraint of the government (in the usual terminology). For example, this could be the equation of the quantity theory of money and (2.29). Both equations contain the price level $P(t)$ as a variable that needs to be solved for. For the exogenously determined variables of fiscal and monetary policy we therefore naturally come to the problem of over-determined the price level. Therefore, the choice of variables of fiscal and monetary policy must be constrained[65] — the policies must be *coordinated.* Thus, the question of how (2.29) should be interpreted is a problem of how to coordinate the policies and thus gives rise to different theoretical approaches.

In accordance with the monetarist model (with MD-type *coordination* of policies), the central bank is the first to determine the nominal volume of money. The equilibrium price level is then determined from the exchange equation. For a given price level the government is obligated to build its current and future policy so that (2.29) is satisfied as a budget constraint.

In the context of FTPL, "active" fiscal policy determines the price level, and for a given predetermined nominal stock of debt the government chooses a certain trajectory of future budget surpluses. For the price level that is thus determined, the central bank is forced to "passively" adapt the nominal stock of money, $M = \frac{PY}{V}$. As a rule, it is implicitly assumed that the government is able to not only determine the future state of the budget, but to control the future flow of seigniorage[66]. In the context of our further research, this hypothesis cannot be assumed.

Strictly speaking, FTI is also unable to ignore the role of seigniorage in the problem of coordinating fiscal and monetary policy. As we showed above, the logic of "unpleasant monetarist arithmetic" is built about changes in seigniorage and the accompanying consequences for inflation. This to an important degree makes FTI different from FTPL, even though in both cases fiscal policy (by assumption) makes the first move and monetary policy is considered to be exogenously given. We will return to this difference between FTI and FTPL below.

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[63] See, for example, the complete explanation in the paper by Cochrane (2000).

[64] For this reason we analyze a pair of equations in the following chapters, and provide the description of "the rest of the economy", containing this pair, in the Appendix.

[65] The problem of constraints placed on the choice of the fiscal and monetary policy variables, may be modeled in various ways. In particular, the game-theoretic approach can be used for this purpose. Thus, in the papers cited above, T. Sargent and N. Wallace use a description of the coordination of policies as a *game of chicken* (who will be first to compromise — the government or the central bank), though they do not explicitly model it. However, as justly noted by Cochrane (2000), the use of the game-theoretic approach is not only not necessary, but can also result in an incorrect emphasis on the analysis. All that should interest us in the end is a characterization of the macroeconomic policy of the government (it is not important who wins in what games) and what equilibrium price levels are so determined.

[66] Typically, in using FTPL for the analysis of developed market economies, the portion of seigniorage used in the financing of the operational deficit is often considered to be negligible. This consideration, however, cannot be extended to real developing or transitional economies.

The structure of public debt and FTPL

Does the choice of which debt instruments are used in the model influence the results of FTPL? The answer is yes. First of all, what is most important is that FTPL would not exist if we were constructing a model for the economy in which there were only real or indexed government bonds. From a technical point of view, in this case the quantity $B(t)$ in equation (2.29) would not be predetermined, but would change in proportion to the price level $P(t)$ (i.e., be indexed). In simpler terms, the intermediate equality in (2.29) should not be considered, as we should deal only with the real value of debt, $b(t)$. From the point of view of the logic of formulating the macroeconomic model, we may again consider (2.29) to be the budget constraint of the government which must be satisfied for any price level. If the current fiscal or monetary policy, future expectations or any other factors bring about a change in the price level, the government will be *forced* to index the nominal value of its obligations. In this case the present value of budget surpluses (plus seigniorage) cannot in any way determine the price level, but must be determined in accordance with the given *real* volume of public debt. Thus, if FTPL is to be discussed at all, it is necessary that the government have at least some nominal debt instruments (which of course is what we see in reality).

Secondly, the dynamics equation (2.8) in continuous time may be considered to be the limiting case of the model of the dynamics of the one-period public debt in discrete time. What will change in the mechanism of FTPL if we assume the existence of multi-period (long-term) debt? Cochrane (1999, 2001) shows that the main prediction of FTPL about the direct impact of expected fiscal policy on the price level does not change. The mechanism, however, does undergo certain modifications. The existence of long-term bonds means that the total nominal value of issued bonds stops being predetermined. The reason for this is the appearance of relative prices of bonds with different maturity. In this case the results of (for example) an expected increase in the budget deficit could be not only an increase in the current price level, but in the relative price of bonds as well. The last is nothing but an expectation that price levels in the future will increase (as a result of a rise in the budget deficit). Thus, we see the inflationary consequences of an increase in the budget deficit not only (and not as much) now, but in the future. An analysis of the role of policies for the management of public debt (including questions maturity) in order to determine the price level from the standpoint of FTPL can be found in the paper by Cochrane (2001).

Strange predictions or fallacy of FTPL?

Kocherlakota and Phelan (1999) showed that under FD-type policy a temporary (one-time) decrease in the supply of money may bring about hyperinflation, which obviously seems strange. McCallum (2001) came to an analogous result. He showed that one of the possible results of FTPL is a price level trajectory that approaches infinity (i.e., a bubble). In principle, this does not contradict the transversality condition as the level of real money balances approaches zero. Answering this criticism, Cochrane (2000) agrees that this theoretical result is valid, but denies that this in any way means that FTPL does not adequately describe reality, in which an explosive trajectory of price levels is not observed. This simply means that this special policy specification (constant money supply and budget surplus in the paper by McCallum) is not applied in practice.

Another important point in the criticism by McCallum is that under certain (quite general) assumptions, the price level is not explosive, but rather approaches zero. This is what contradicts the transversality condition for real money balances[67], and this means that no well-defined equilibrium exists in the model. In particular, McCallum shows that such a result may be observed if the (initial) level of the nominal public debt is not large enough and/or future budget surpluses are very high. In principle, this does not mean that the theory is completely inconsistent, but does introduce certain additional constraints on macroeconomic policy that are compatible with the logic of constructing FTPL.

Christiano and Fitzgerald (2000) note (and this is quite clear in view of the elements of criticism just considered), that an essential drawback of FTPL is that it is a "fragile theory", in the sense that small changes in the assumptions significantly influence its applications to reality. Indeed, FTPL is built for an entirely FD policy. Therefore, any (realistic) departure from the FD policy will inevitably result in the failure of FTPL to determine the equilibrium price level.

Nonetheless, returning to the discussion above, the most serious problem in the construction of FTPL is the question of interpreting (2.29) as a *budget constraint,* or as a *valuation equation*. Buiter (1998, 1999) insists that the interpretation of (2.29) as a budget constraint (for any price level) is the only one possible, and a refusal of this traditional interpretation makes FTPL internally inconsistent. Cochrane insists no less forcibly that there is another interpretation: "...There are three steps in defining a competitive Walrasian equilibrium: First, one define what the securities *are* — what state-contingent stream of goods is promised for each share or unit of security. Second, one finds demand and supply curves for those securities, as well as demand and supply curves for goods. Third, one finds prices that clear markets. The decision of how much nominal debt and money to issue is a definition of securities. This action occurs without constraint, before the "auctioneer" announces any prices, for government and private issuers alike".[68] In accordance with this interpretation (2.29) is indeed not a constraint, but rather an equilibrium condition for the supply and demand of assets.

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[67] McCallum (2001) formulates the transversality conditions separately for real money balances and public debt, but not for their sum (for example, M. Woodford introduces a combined-asset transversality condition). McCallum insists on the necessity of considering two separate conditions, since the situation when $b(t) \to -\infty$ and $m(t) \to +\infty$ allows for the possibility of infinite credit from the state to the private sector and this obviously seems unreal, and yet does not contradict the transversality condition for $b(t) + m(t)$. Here this consideration becomes important from another point of view: for a combined transversality condition the problem described above of a price level approaching zero does not exist. See footnotes 14 and 15 in the paper by McCallum (2001). In the main text of this work we will follow McCallum and use separate conditions for the real money balances and the public debt.

[68] Cochrane (2000), p. 16.

Theory and empirical evidence

In fact it is impossible to verify the MD or FD hypotheses from an empirical standpoint, as most investigators agree[69]. Therefore, there will probably never be a last point in the question of which theory should be used to formulate macroeconomic policy. Indeed, the differences between MD and FD policies involve whether fiscal policy is adjusted based on the given price level, or if alternatively the price level adjusts towards equilibrium for expected fiscal policy. However, all that we can observe is equilibrium. It is impossible to determine what adjusted to what. Also, if we define an FD policy as a situation in which (2.29) applies only for the equilibrium price level as opposed to any price level (as in the case of MD policy), then we still arrive at the same problem: we do not have statistics for non-equilibrium prices in economics.[70]

The question about which of the hypotheses is more likely to conform to reality should not be solved by a formal test. For example, Woodford (1995) gives the following argument for FD policies (for FTPL): if we take the most widespread view on monetary policy and the specification of demand for money in the economy of the USA, then the equilibrium price level cannot be determined for an MD policy in accordance with quantity theory, and this indirectly confirms the role of (2.29) in determining the price level[71].

Constraints on fiscal policy and the price level stability

The fact that FTPL states that the determination and the stability of the price level depend on fiscal policy could be of theoretical help in the application of the Maastricht Treaty. Indeed, from the point of view of FTPL the instability of the fiscal sphere (for FD policies) will inevitably result in the instability of the price level (and other macroeconomic indicators) *irrespectively* of what monetary policy is pursued[72]. In order to achieve price level stability[73]

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[69] Thus, Kocherlakota and Phelan (1999) note that "...whether the government can follow a non-Ricardian policy is a religious, not a scientific question".

[70] Empirical analysis of the budget constraint (2.8) has a long history. As a rule, these were investigations into the problem of the government's solvency. See, for example, Hamilton and Flavin (1986), Campbell and Shiller (1987). While interesting in themselves, these papers, however, are unable to shed light on the choice between FD and MD macroeconomic policies.

[71] Canzonery, Cumby and Diba (1997, 2001) suggest a test, the essence of which lies in the analysis of the correlation between innovations in the budget surplus and public debt. If an increase in the budget surplus brings about an increase in the real price of bonds, then the economy is characterized by an FD policy; and if it brings about a constant or decreasing real value of obligations, then most likely an MD policy is being observed. The results of the test for post-war USA data seem to support the hypothesis of an MD policy. Cochrane (1999) criticized such approaches from the standpoint of forward and backward-looking dynamics of the debt under different policy regimes (see above in the text). In his opinion, the forecast which determines the sign of the reaction function, demands that various processes which characterize the dynamics of the surplus be determined, and yet does not give any conclusions about the type of policy. He also notes that in reality the quantity theory of money in its pure form does not allow for a direct test either, as from an empirical point of view it is simply a determination of the velocity of money.

[72] Woodford (1997). Here the average (expected) level of inflation could easily be determined by monetary policy, which controls the nominal interest rate. This prediction of FTPL is called "Woodford's *Really* Unpleasant Arithmetic" by Christiano and Fitzgerald (2000).

[73] We should, however, note that from a theoretical point of view the instability of the price level is not always accompanied by a welfare loss. See, for example, Chari, Christiano and Kehoe (1991), Chari and Kehoe

the "right" monetary policy must be accompanied by certain constraints on fiscal policy. While the upper bound of the level of the real public debt and of the level of the budget deficit spelled out in the Maastricht Treaty are probably too strict, it is also true that their existence from the point of view of FTPL is necessary both as a formal requirement and as a credible signal to the private sector that the government (union) will strive to conduct stable policies.

2.6. Concluding remarks

As a conclusion we give an important comparison of FTPL and of the "unpleasant monetary arithmetic" of Sargent and Wallace. One of the interesting points where FTPL and FTI differ is that the latter states that there are possible inflationary consequences for a certain fiscal policy because of its provoking *inevitable* changes in current or future monetary policy[74]. FTPL, by contrast, quite allows for inflation caused by the increase in budget deficit in the *absence* of any changes in the money supply either now or in the future. A certain interpretation of (2.29) does indeed allow for such a scenario. In both cases future fiscal policy will influence the price level (inflation): from the standpoint of FTPL — directly via the level of the budget deficit ($d(\tau)$, $\tau > t$); and from the standpoint of FTI — indirectly, by influencing the level of seigniorage ($S(\tau)$, $\tau > t$) necessary for the sustainability of public debt.

Here there is an interesting quantitative difference. If we consider the mechanism of FTPL, then the *discounted* future values of the budget deficit and of seigniorage determine the current price level. And the discount rate equals to the interest rate of the debt, r (i.e., discount factor equals $e^{-r(\tau-1)}$). If we consider the problem from the standpoint of FTI, then the main role will be played by future values of the base money which are discounted by a rate equal to the inverse of the semi-elasticity of money demand α^{-1} (i.e., discount factor equals $e^{-\frac{1}{\alpha}(\tau-t)}$), as written in the forward-looking solution (2.22) in the Cagan model. By comparing the discount rates r and α^{-1}, we can quantitatively estimate the role of distant changes in the budget deficit in order to determine the price level in the context of FTPL and FTI (which uses the Cagan model as an integral part). Thus, Cochrane (1999), in analyzing data for the US economy, came to the conclusion that FTPL predicts a stronger reaction of the price level than in the Cagan model[75, 76].

(1999). FTPL also allows for the possibility that to a certain extent the instability of the price level may be even desired. Unexpected shocks in the price level act like a tax on holders of nominal public debt (in essence, they act like an inflation tax). From the point of view of optimal macroeconomic policy, this method of absorbing shocks in certain situations may be better than, for example, changes in distortionary taxes.

[74] The classical investigation of hyperinflation episodes by Sargent (1982) gives an important role to the expected stabilization of the fiscal sphere. However, this does not have a direct, but rather indirect influence on the level of inflation — a decrease in budget deficit should bring about a decrease in seigniorage, which leads to a decrease in expected rate of inflation in Sargent's logic.

[75] Building a model for discrete time, Cochrane arrives at the following estimates for the discount factors: 0.15 for the Cagan model and 0.95 for the analog of equation (2.29) in FTPL.

[76] On this basis, Cochrane makes far-going conclusions. If, indeed, the FTI mechanism (or the Cagan model) is weak from a quantitative point of view, then many real economic events (for example, the Asian crisis of 1997, the recent currency crisis in Argentina, the monetary reforms in New Zealand, etc.) in which

We should, however, note that such approaches should be corrected for when changes in fiscal and monetary policy were made; changes in the base money do not have to take place at the same time as changes in fiscal policy. Thus, there are many interesting and diverse forms of coordination of fiscal and monetary policy in the context of FTI. It is this aspect and certain other interesting problems in this area that are dealt with in Chapter 5.

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economists put the fiscal sphere and its problems at the forefront, should be well explained from the standpoint of FTPL. Indeed, an investigation into the nature of the Asian crises by Burnside, Eichenbaum and Rebelo (2001) supports this conclusion. Cochrane notes that FTPL can also be used to interpret the Russian crisis of 1998 (see, also, a general analysis of the default risk in the context of FTPL in the paper by Uribe, 2002). In the following analysis we prefer the interpretation of the 1998 crisis in the framework of FTI, rather than FTPL.

Chapter 3
Nonlinear dynamics of inflation and public debt

3.1. Introduction

We showed in the second chapter that in many cases a high level of inflation can be explained by the nature of the interaction between fiscal and monetary policies; as Milton Friedman noted, "inflation is always and everywhere a monetary phenomenon". Indeed, for most episodes of high inflation in developing countries we can say that the source of inflation is an imbalance in the fiscal sphere. However, is the causality between inflation and the deficit actually so clear?

This question is obviously important. It is hard to not agree with Stanley Fischer when he says that "...given that policymakers do not create inflation out of a clear blue sky, it is almost certain that countries with high inflation rates are countries that are already in trouble for fiscal or other reasons, and thus that it will be either impossible or extremely difficult to deal definitely with the issue of causation".[1] On the other hand, even though an imbalance in the fiscal sphere may be considered to be one of the major reasons for high inflation, statistical data often do not explicitly show a correlation between a decrease in the deficit and a fall in the inflation rate (see, for example, (Bruno, 1993)).

In this chapter we will attempt to elucidate the nonlinear interrelationship between inflation, the budget deficit and public debt, and to demonstrate the role of this nonlinear relationship in determining the interaction between the government and the central bank. Indeed, one of the first reasons that might explain the absence of a simple and clear relationship between changes in the budget deficit and inflation is that economic dynamics are nonlinear. At present most economists agree that in many cases the non-linearity of economic systems can play an important role.[2] A simplified, linear (or linearized) model of economic dynamics may not adequately reflect the nature of economic processes. This general problem is discussed in Bullard and Butler (1993) in the context of modeling the interaction between fiscal and monetary policies. In particular, it is shown that nonlinearity of economic dynamics is a crucial feature of Sargent and Wallace's FTI, and ignoring this may result in incorrect macroeconomic policies.[3]

We will consider two problems in this chapter that may make the interaction between the fiscal and monetary spheres complex and nonlinear. The first is that of the possibility of there being non-unique equilibrium level of inflation at which the money market and the fiscal sphere will be in steady states. If so, changes in the fiscal sphere will have qualitatively differ-

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[1] Fischer (1995), p. 22.

[2] See, for instance, Grandmont (1987), Lorenz (1989), Barnett-Geweke-Shell (1989), Granger-Terasvirta (1993).

[3] Flashel, Franke and Semmler (1997, ch. 9) suggest an interesting nonlinear modification of the Cagan model for adaptive expectations and perfect anticipation presented in the first chapter.

ent effects on the money market depending on which of the equilibria the economy was in. Analogously, changes in monetary policies may also have different effects on the fiscal sphere depending on the equilibrium. This consideration will be at the core of our analysis in this and following chapters.

The second problem that may make the interaction between the fiscal and monetary spheres complex is that of the real effects of inflation. In the general case the real primary budget deficit should not be considered to be exogenous and completely determined by government policies. There are several mechanisms that determine the dependence of real budget income and expenditures on the rate of inflation, even when inflation can be perfectly anticipated. We will show below that the dependence of the budget deficit on the rate of inflation can be either negative or positive. If the budget deficit decreases with an increase in inflation, then the set of steady states and their properties are qualitatively different than if the budget deficit do not depend on inflation.

This chapter has the following structure. In Section 3.2 we present the standard version of the model for the Inflation tax Laffer curve, which considers the financing of the budget deficit by seigniorage.[4] We suggest a modification for this model in the third section to account for the effect of inflation on the real budget deficit. Section 3.4 presents a general model for the budget deficit finance. We consider the dynamic equations for public debt and real money balances. The microeconomic basis for this model is given in the Appendix.[5] Continuing the logic of the second section, we suggest in Section 3.5 a modification of the general model for the financing of deficit to account for the real effects of inflation. The system we arrive at has interesting nonlinear properties. Section 3.6 explores bifurcation in the system of public debt and real money balances. In Section 3.7 we give a qualitative interpretation for the Russian crisis of 1998 as a fold bifurcation in the system of public debt — real money balances. Conclusions are drawn in Section 3.8.

3.2. Monetization of the budget deficit: The inflation tax Laffer curve

Let us again consider the government's budget constraint (2.1), only not from the point of view of public debt dynamics, but from the point of view of inflation. By definition, seigniorage is the real revenue from money emission,

$$S = \frac{\dot{M}}{P} = \dot{m} + m\pi = \mu m. \qquad (3.1)$$

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[4] The version given here is closest to the exposition of the model given in Heymann and Leijonhufvud (1995). A slightly different interpretation of this model can be found in the textbooks by Blanchard and Fischer (1989, ch. 4) or Romer (2001, ch. 10), and also in an article by Bruno and Fischer (1990).

[5] A version of Sidrausky's model can be used as a microeconomic basis. An analogous analysis can be found in papers by Liviatan (1984) and Drazen (1985).

Seigniorage may be further decomposed into two components: the so-called *pure seigniorage* $\dot{m}$ (increase in real money balances), and the i*nflation tax* $m\pi$. Seigniorage can also be written as μm, the product of the growth rate of base money and real money balances. Using (3.1), the government's budget constraint can be written as[6]:

$$\dot{b} + \dot{m} = rb + d - m\pi. \tag{3.2}$$

Now let us return to the macroeconomic policy considered in Section 2.2, which keeps public debt at a steady level: $b(t) = b_0$. Using the definition (3.1), equation (2.6) can be written as

$$\dot{m} = \left(rb_0 + d\right) - m\pi = D - m\pi, \tag{3.3}$$

where the variable D is the operational budget deficit. If the money market is in a steady state, when the rate of inflation is equal to the growth rate of base money ($\dot{m} = (\mu - \pi)m = 0, \quad \mu = \pi$), the operational budget deficit is financed only by the inflation tax; the former completely determines the volume of seigniorage:

$$D = m\pi. \tag{3.4}$$

Just as in (2.6), equation (3.4) is a constraint on macroeconomic policy, indeed a joint constraint on both fiscal and monetary policies. Following the Cagan model, we can consider the real money balance to be a function of expected inflation. We also assume that expected inflation and actual inflation are equal, $\pi^e = \pi$; this is possible if adaptive expectations are steady ($\dot{\pi}^e = 0$) or if expected inflation is determined by the hypothesis of perfect foresight. Equation (3.4) can then be written as

$$D = m(\pi)\pi. \tag{3.5}$$

Further analysis of the condition (3.5) requires a certain assumption about the interaction between fiscal and monetary policies. If fiscal policies are dependent, then (3.5) can be interpreted in the following way: Given the policy of the central bank (for simplicity, given the chosen constant growth rate of base money μ) and given the volume of the public debt b_0, the government is forced to adjust the volume of primary budget deficit d so that

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[6] The right side of (3.2) is interpreted in the Appendix to this chapter to be the increment of a representative agent in real assets: $a = m + b$.

$$d = \mu m - r b_0 \,. \tag{3.6}$$

Note that (3.6) completely determines the volume of the primary budget deficit.[7]

If the monetary policy is dependent, then (3.5) can be understood to mean the following: The central bank must adopt a monetary policy with a growth rate of base money equal to μ, chosen on the basis of the operational deficit D (assumed to be constant for simplicity); D in its turn is determined by the volume of the accumulated debt b_0 and the primary deficit d. In other words, the central bank, being dependent, is forced to set a growth rate of base money so that seigniorage covers the operational deficit of the budget. This model is the basis for the *inflation tax Laffer curve* shown in Fig. 3.1. As in the case of usual taxes, if one makes only the most general assumptions regarding the demand function for the real money balances[8], the inflation tax will exhibit a nonlinear[9] dependence on inflation, which acts as a "tax rate". Indeed, the initially high rate of inflation is associated with a high level of inflation tax; however after a certain point the increase of inflation has to do with the decrease in inflation tax.

Unlike the first case, here the fiscal policy parameter is generally determined only partly by the dominating monetary policy. Equation (3.5) can have up to two steady states for a constant value of d. Stability analysis of the initial equation (3.3) gives the following results[10]. The stability of the two equilibrium states mostly depends on expected inflation. The equilibrium that corresponds to low inflation ($\mu = \pi^L$) will be stable when expectations adapt very slowly. To be more precise, the system will approach this point for any values of inflation less than its value in the equilibrium with high inflation[11] if there are adaptive expectations (2.14) with small values of the parameter θ ($\alpha\theta < 1$, where α is the semi-elasticity of money demand). The equilibrium with high inflation ($\mu = \pi^H$) will be unstable, and for higher values of inflation the system may exhibit hyperinflation, an unbounded increase in the rate of inflation. In this case an increase in the budget deficit, shown by a higher horizontal line D, will be accompanied by an increase in the growth rate of base money and, accordingly, a spurt in inflation.

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[7] However, there is an important problem here that we will return to later: can the government, playing a dependent role, set *any* value of d in accordance with (3.6)? Obviously *not*, if we take into account natural constraints on the expenditure and income items in the budget.

[8] It is necessary for the demand for real money balances (as a function of inflation expectations, or the nominal interest rate in the general case) to have elastic and inelastic parts. Inelastic demand will be observed where the Laffer curve (Fig. 3.1) increases, while elastic demand will be observed where this curve is decreasing. The maximum of the curve corresponds to unit elasticity. It is not difficult, for example, to check that the Cagan function (2.11) satisfies this condition.

[9] Here and below we use the term "nonlinear" not only literally, as in "nonlinear function", but also as a qualitative property of an economic system. For example, the nonlinearity of the system for the Laffer inflationary tax curve model is obviously connected with there being more than one equilibrium.

[10] For more details see Bruno and Fischer (1990), Heymann and Leijonhufvud (1995), Smirnov (1997).

[11] The existence of at least one stable steady state in the economy in this case, and the fact that the dynamics of the public debt will be unstable in accordance with (2.2), agree well with the earlier result of Blinder and Solow (1973). In particular, the dynamics of an economy are stable if the budget deficit is financed by monetary emission, and unstable if it is financed by debt.

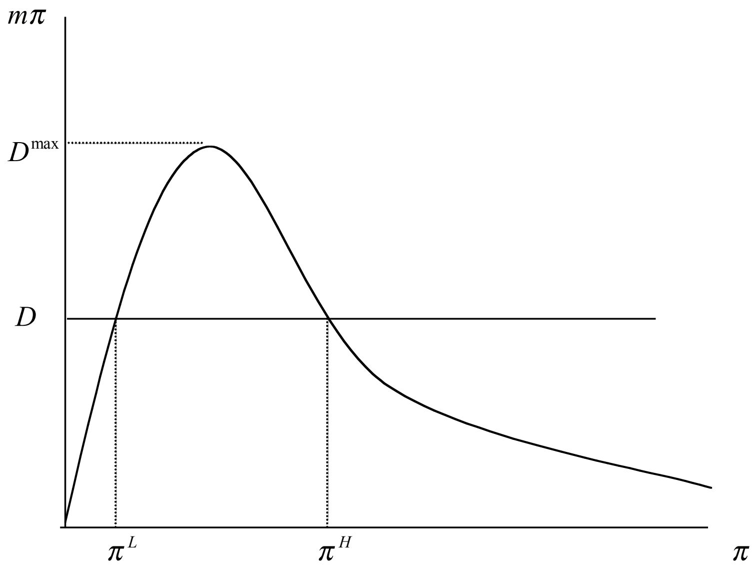

Fig. 3.1. *The inflation tax Laffer curve*

For large values of θ (αθ > 1), and also in cases when expectations satisfy the hypothesis of perfect foresight, the situation is different, and the economy falls into the "high inflation trap". If the system is on the "wrong side" of the Laffer curve, then the increase in the deficit brings about a decrease in the steady level of inflation[12].

It is also important to note that in the general case the inflation tax is bounded from above. There exists a value D^{max} which corresponds to a unique equilibrium growth rate of base money that maximizes the volume of inflation tax. If fiscal policies keep the operational deficit at a level greater than D^{max}, monetary policy will simply not be able to keep the money market in equilibrium. Depending on the properties of inflationary expectations and the parameters of money demand, the economy will face either hyperinflation or hyperdeflation.[13] In its turn, a high level of operational deficit can be determined by either a high level of primary deficit (a problem which the government can alleviate to a certain extent), or a (predetermined) high level of accumulated debt. These considerations underline the importance of constraints on fiscal and monetary policies. We will discuss this problem in detail below.

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[12] These conclusions are very like those of the Cagan model discussed in the first chapter, which is hardly accidental. The dynamics of inflation are determined first of all by the reactions of economic agents who present demand for real money balances.

[13] Formally, this problem can be analyzed as a bifurcation (see Smirnov (1997)). We will return to this later, in the context of a more general system. See also Buiter (1987).

3.3. The effect of inflation on the real primary deficit in the inflation tax Laffer curve model

As we pointed out in the introduction, the assumption that the deficit is exogenous and independent of inflation — and therefore the accompanying assumption that the deficit finance by seigniorage is likewise independent of inflation, which was used implicitly above — is not always realistic. There are many factors that can bring about either a decrease or an increase in the *real* primary budget deficit d under inflation. The first group of factors include the increase of *real* tax revenues for the budget (as a result of applying a progressive income tax scale in *nominal* terms (with discrete indexes) or because of the distortionary nature of taxing the *nominal* interest income; the decrease in the *real* volume of transfers and government expenditures given in *nominal* terms (and with non-continuous indexation), the so-called *Patinkin effect*.[14] The second group of factors should include, first of all, the so-called *Olivera-Tanzi effect*. This effect consists in a decrease of the *real* revenue volume and an increase in the *real* deficit, which takes place because a significant part of the taxes and other budget incomes are determined in *nominal* terms and often reach the budget with a given time lag.[15]

In the general case, of course, it is difficult to determine which factors play the greater role and how the primary budget deficit will depend on the inflation rate in the final analysis. However, the latter can be sometimes observed in practice. For instance, Gavrilenkov (1995) noted a tendency in Russia for a softening of the budget deficit with an increase in inflation. At the same time, the Olivera-Tanzi effect was noted in the analysis of economies in Latin America.[16]

Taking a certain dependency of the primary (and therefore operational) budget deficit on inflation, equation (3.3) can be written as

$$\dot{m} = D(\pi) - m(\pi)\pi. \tag{3.7}$$

If the factors of the first group (i.e. the Patinkin effect) have the greater impact, i.e. $D'(\bullet) < 0$, then the budget deficit curve will have a negative slope. Fig. 3.2 illustrates the simplest case, when the dependence of the deficit on inflation is linear[17]. Up to three steady

[14] Cardoso (1998) refers to it as the "*Patinkin effect*". In exploration of Israel's stabilization program of 1985, Patinkin (1993) stressed the importance of the negative effect of inflation on government spending. Cardoso (1998) states that this effect was dominating in Brazil in last decades.

[15] This list of factors, of course, is not meant to be complete. All of the factors in essence are distortional effects of inflation, determined by so-called nominal state institutions. A brilliant overview of the real effects of inflation can be found in the paper by Fischer and Modigliani (1979).

[16] Olivera (1967), Tanzi (1977).

[17] The assumption that the dependence of the deficit on inflation is linear is obviously *ad hoc*. Its simplest explanation is given in Smirnov (1997). If the dependence $D(\pi)$ is nonlinear, then the system may have even more than three steady points. We do not consider this case, firstly because it is "exotic", and secondly because the main properties of the system due to its *nonlinearity* can be demonstrated for the simpler case shown in

states are possible. For instance, if the inflation expectations satisfy the hypothesis of perfect foresight, the states with low or very high inflation will be stable (points *A* and *C*). Equilibrium at point *B* will be unstable. An important feature of this system, which arises from its non-linearity, is the following: the equilibrium that the system will approach, either point *A* (low inflation) or point *C* (high inflation), depends on the initial inflation expectations. Therefore, monetary policy plays an important role; it can, by influencing inflation expectations, bring the economy with a given budget deficit to point *A*, to a state with low inflation.[18]

If the Olivera-Tanzi effect is dominant in the economy and $D'(\bullet) > 0$, then the budget deficit curve will have a positive slope. Figure 3.3 illustrates a possible situation. It seems most likely that the Olivera-Tanzi effect will not affect the principal result, namely that there are two steady states, the stability of which can be determined just as in the basic case.[19]

3.4. Basic model of the dynamics of public debt and inflation

We will use the following model as the basis for studying the interaction of fiscal and monetary policies in both this and later chapters:

$$\begin{cases} \dot{b} = d + rb - \mu m, \\ \dot{m} = \left(\mu - \pi(m)\right)m. \end{cases} \tag{3.8}$$

The first equation of this system, which is simply equation (2.1), describes the dynamics of public debt. As in Section 2.2, we will consider equation (2.1) to be the budget constraint for the government and the equation for the dynamics of public debt. The second equation in system (3.8) is equation (2.13), which describes the dynamics of real money balances (and, implicitly, inflation). From this point on we will analyze the dynamics of the money market based on the hypothesis of perfect foresight when forming inflation expectations. Then, using hypothesis (i) in Cagan's model, we can use the inverse function theorem to write the level of inflation as a monotonic decreasing function of real money balances: $\pi = \pi(m)$, $\pi'(m) < 0$. The second equation in (3.8) characterizes monetary policy.

Fig. 3.2. It is more important that, unlike the inflation tax Laffer curve model, equilibrium always exists for the case shown in Fig. 3.2; in other words, for any fiscal policy the central bank is able to keep the money market in a steady state, possibly with a very high rate of inflation. However, again, if the dependence $D(\pi)$ is nonlinear, then it is theoretically possible that there will be no steady states of the system for high budget deficits. The analysis given below of the singularity and bifurcation of the system is for the simple case shown in Fig. 3.2. This is sufficient to arrive at the major results.

[18] In this respect, the conclusions that can be drawn from this model are close to the so-called problem of coordination failure in models with multiple equilibriums suggested by the New Keynesian economics. An overview of the problem can be found in the textbook by Romer (2001, ch. 6).

[19] As above, a nonlinear specification of $D(\pi)$ can hypothetically result in a system with a greater number of steady states. But, again, this would be "exotic". For example, in Dornbusch, Sturzenegger and Wolf (1990) the following specification of the Olivera-Tanzi effect is suggested: $d = G - \left[T/(1+\sigma\pi)\right]$, where *G* is government expenditures, *T* is the tax revenue and the parameter $0 \le \sigma < \infty$ characterizes the extent to which the Olivera-Tanzi effect influences the economy (its absence corresponds to a value of zero). It is not difficult to see that for this reasonable specification the system will have two steady states.

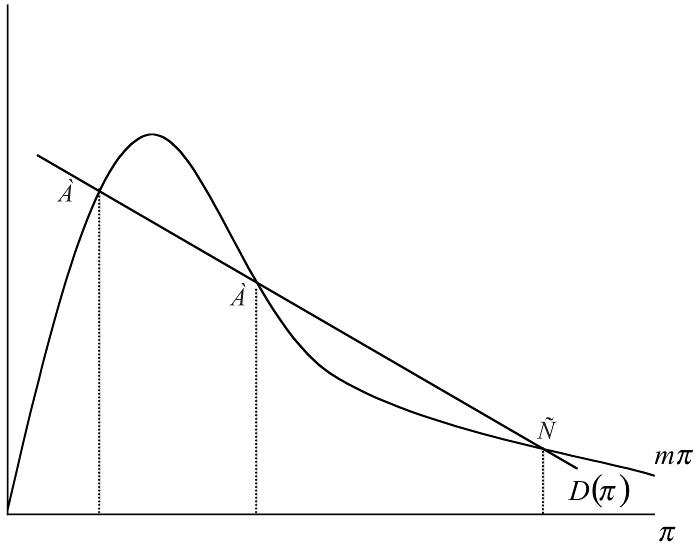

Fig. 3.2. *Steady states in the inflation tax Laffer curve model for* $D'(\bullet) < 0$ *(the Patinkin effect)*

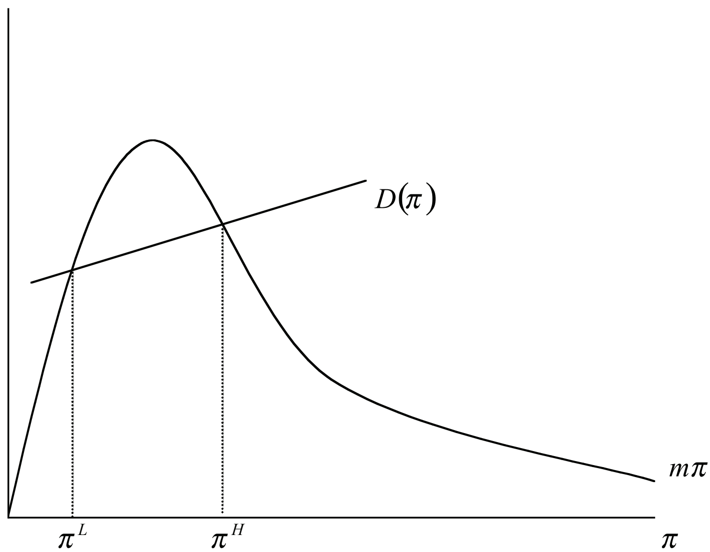

Fig. 3.3. *Steady states in the inflation tax Laffer curve model for* $D'(\bullet) > 0$ *(the Olivera-Tanzi effect)*

We should make an important point. Formally, writing the system (3.8) as we have implicitly assumes that the monetary policy of the central bank and the fiscal policy of the government are independent of each other. Even though the government uses seigniorage as one way of financing the budget deficit (the last item in the right side of the first equation of the system), the dynamics of the real money balances, which are determined by the second equation of the system, is not in any way connected with the volume of real public debt. However, as we pointed out in Section 2.2, the first equation of the system should be considered to be a *joint* constraint on fiscal and monetary policies. We will return to this fundamental consideration later.

System (3.8) is a standard starting-point for the analysis of fiscal and monetary policies.[20] This system allows for many interpretations, depending on the assumptions that are made with regard to the specification of fiscal and monetary policies and how they interact. We will start by characterizing the stability of the system, assuming that the variables have backward looking dynamics.[21] The linearized system at an equilibrium point (b^*, m^*) for constant values of the fiscal and monetary policy variables, d and μ, can be written as

$$\begin{pmatrix} \dot{b} \\ \dot{m} \end{pmatrix} = \begin{pmatrix} r & -\mu \\ 0 & -\dfrac{\mu}{\varepsilon^*} \end{pmatrix} \begin{pmatrix} b - b^* \\ m - m^* \end{pmatrix}. \tag{3.9}$$

This system shows that the steady state is an unstable node.[22] The eigenvalues of the Jacobi matrix for the steady state are positive, one of them is equal to the interest rate, and the other is the reciprocal of the modulus of the semi-elasticity of the demand function with respect to the real money balances: $\lambda_1 = r$ and $\lambda_2 = -\dfrac{\mu}{\varepsilon^*} = -\dfrac{1}{\alpha}$, where $\varepsilon^* = \dfrac{\pi(m^*)}{\pi'(m^*)m^*} < 0$ is the elasticity of money demand with respect to inflation expectations (or, in the general case, to the nominal interest rate).

The set of steady states of real public debt and real money balances is determined by the following equations:

$$\dot{b} = 0, \qquad b = \frac{\mu m - d}{r}, \tag{3.10}$$

$$\dot{m} = 0, \qquad \pi(m^*) = \mu. \tag{3.11}$$

[20] See Drazen (1985), and also Heymann and Leijonhufvud (1995).

[21] In other words, we consider system (3.8) with the additional initial conditions $b(0) = b_0$ and $m(0) = m_0$. An interpretation of the backward looking dynamics of public debt and real money balances was given in the first chapter. An analysis of the possible interactions of fiscal and monetary policies under backward looking dynamics of b and m will be considered in the next chapter. In this chapter we will only consider the foundation for further analysis as well as a few other questions.

[22] Distance from the point of equilibrium will hardly change the qualitative behavior of the system. In particular, the sign of the trace of the Jacobi matrix guarantees the absence of periodic solutions according to the Bendicson criteria. See, for example, Lorenz (1989).

The money market will be in a steady state ($\dot{m} = 0$) if the rate of inflation is equal to the growth rate of base money: $\pi(m^*) = \pi^* = \mu$. No matter what the situation is in the fiscal sphere, there is a unique equilibrium value for the volume of real money balances m^* for every value of the money policy parameter. This result is depicted by the horizontal line *MM* in Fig. 3.4, the phase diagram for system (3.9).

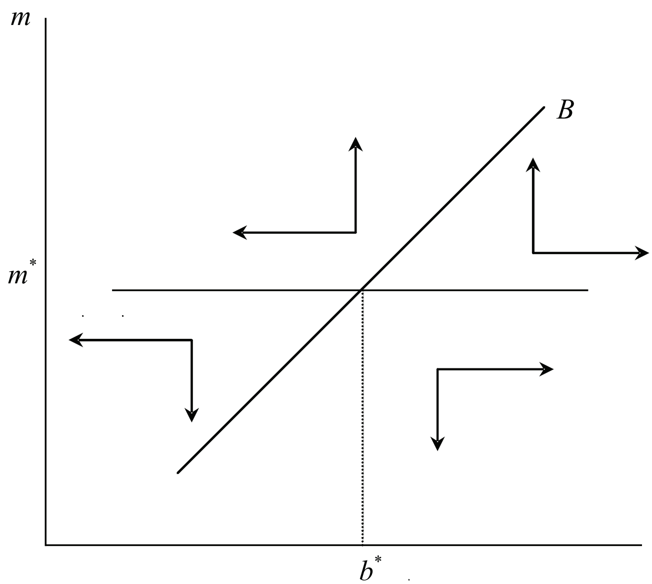

Fig. 3.4. *Phase diagram for public debt and real money balances*

As we discussed in Section 2.2, a steady volume of public debt requires that the payments for servicing the public debt should be equal to the seigniorage minus the primary deficit: $rb = \mu m - d$. The slope of the corresponding line *BB*, which is equal to $b'_m = \dfrac{\mu}{r}$, depends on the growth rate of base money. If the central bank does not issue additional money and $\mu = 0$, then *BB* will be a vertical line. On the other hand, for sufficiently high values of μ, the line *BB* will be rather flat. In essence, this means that the steady states of the public debt are not sensitive to the state on the money market in an economy with low inflation (with low values of μ), but will be sensitive to it in an economy with high inflation (with high values of μ). This fact can be easily explained by referring to the shape of the standard inflation tax Laffer curve shown in Fig. 3.1. For a low level of inflation (which would be equal in the steady state to the growth rate of base money) even a large change in the operational deficit, one that would require the same increase in the volume of seigniorage, could be affected by a small change in μ (the inflation tax curve is rather steep in this case). The opposite is true for high rates of inflation (growth rates of the money base).

An analogy for the inflation tax Laffer curve can be seen if we consider the set of steady states in the fiscal and monetary spheres ($\dot{m} = 0,\ \dot{b} = 0$) for various values of the parameter μ. Using the condition for a steady state on the money market in the first equation of system (3.8), we arrive at the equation for the *SS* curve:

$$b(m) = \frac{\pi(m)m - d}{r}. \tag{3.12}$$

The *SS* curve, shown in Fig. 3.5, is concave to the vertical axis and has a maximum (for the volume of government debt) that is achieved only for unit elasticity of the demand function for real money balances, i.e. $\varepsilon^* = -1$; this is the same behavior we observe in the inflation tax curve. Changes in the fiscal policy parameter *d*, the primary budget deficit, influence only the curve *BB*. An increase in the primary deficit shifts this curve, and therefore the *SS* curve as well, to the left.

As shown in Fig. 3.5, in the general case there could be up to two steady values for the growth rate of base money and the demand for real money balances for a given volume of debt. However, what is important is that this system, unlike the reduced model considered above for the financing of the budget (the inflation tax Laffer curve model), does not exhibit any principle difference in terms of stability for equilibria with high or low inflation; both equilibria are unstable.

A comprehensive analysis of the various forms of interaction between fiscal and monetary policies based on this dependence will be given in later chapters.

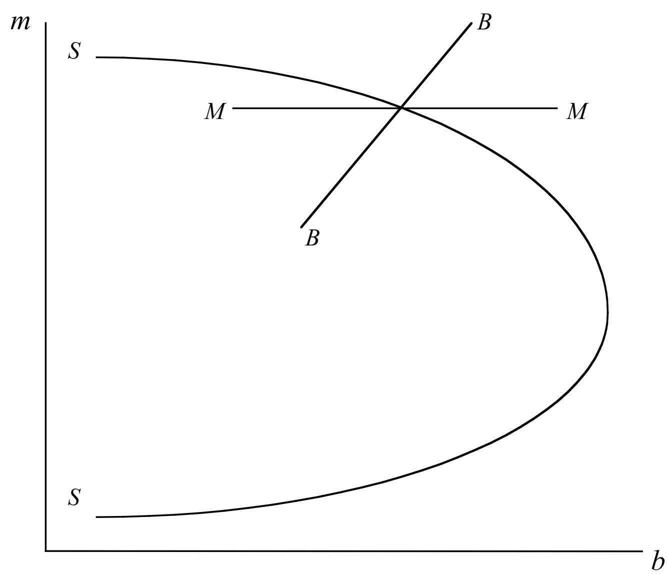

Fig. 3.5. *The set of steady states of public debt and real money balances for various values of the growth rate of base money*

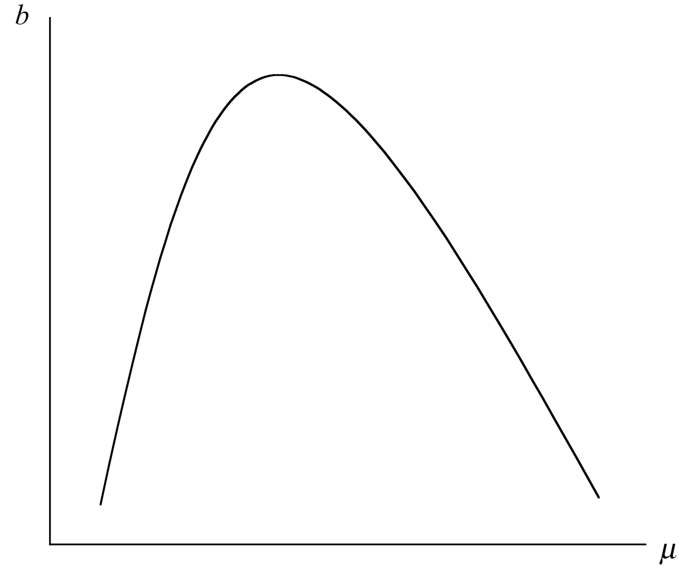

Fig. 3.6. *Public debt and the growth rate of the base money in the steady state*

3.5. A model for the dynamics of public debt and inflation with real effects of inflation

As in the inflation tax model, the assumption that the primary deficit depends on inflation will also significantly influence the properties of system (3.8) in the model for the dynamics of public debt and inflation.

Let us consider the case of a negative dependence of the budget deficit on the rate of inflation (the Patinkin effect). As before, we consider the following simple linear specification:

$$D(\pi) = d_0\left(1 - \pi(m)\right) + rb, \tag{3.13}$$

where d_0 is the "design primary deficit", or the deficit that we would have if there were no inflation effects.[23] System (3.8) could then be written as

$$\begin{cases} \dot{b} = d_0\left(1 - \pi(m)\right) + rb - \mu m, \\ \dot{m} = \left(\mu - \pi(m)\right)m. \end{cases} \tag{3.14}$$

[23] Cardoso (1998) calls it the "*virtual deficit*". She proposes the non-linear dependence of actual primary deficit on inflation: positive when inflation is low and negative when inflation is high. It seems to quite prominent to incorporate this idea into our model, but we shelve it.

It is not hard to see that the stability of the equilibria will not qualitatively change in comparison with system (3.8).[24] The principle change with respect to the basic model is that the shape of the *SS* curve (the set of steady points for various values of the monetary policy parameter) critically depends on the primary budget deficit:

$$b = \frac{\pi(m)m - d_0(1-\pi(m))}{r}. \tag{3.15}$$

To illustrate, consider for instance the demand function for real money balances defined as

$$m^d = \frac{1}{1+\left(\pi^e\right)^2}. \tag{3.16}$$

The *SS* curve will assume a *Z* shape for positive, comparatively small values of the calculated deficit (see Fig. 3.7). Indeed, in this case the derivative of the function of real debt with respect to real money balances has two zeroes[25]:

$$\begin{aligned} &b(m) = \frac{1}{r}\left[m\sqrt{\frac{1}{m}-1} - d_0\left(1-\sqrt{\frac{1}{m}-1}\right)\right], \qquad 0 < m < 1. \\ &b'(m) = \frac{-2m^2+m-d_0}{2rm^2\sqrt{\frac{1}{m}-1}} = 0, \qquad m_{1,2} = \frac{1 \mp \sqrt{1-8d_0}}{4}, \qquad d_0 < \frac{1}{8}. \end{aligned} \tag{3.17}$$

As we see from Fig. 3.7, in this case there is no maximum possible steady value of public debt. We suggest the following possible explanation. If the government is able to achieve a primary surplus by increasing inflation (the growth rate of base money), then it can also increase the volume of borrowing by having a source for the servicing of the debt. In addition, this model demonstrates, analogously to Smirnov's model (1997), that for certain values of the public debt there exist three values of the growth rate of base money that correspond to the steady states of the system. The nonlinear dependence of the steady states of public debt on the growth rate of base money is given in Fig. 3.8.

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[24] Linearization of the system (3.14) in a neighborhood of the equilibrium point shows that the steady state is still an unstable node. Moreover, the eigenvalues of the Jacobi matrix remain the same in the steady state. This is obvious, since the second equation in (3.14) remains independent of b, just as in system (3.8).

[25] The choice of the functional form (3.16) in this paper is justified by the possibility to find the zeros of the derivative in (3.17) analytically. Numerical investigation of the Cagan function (3.11), carried out by the author using MathCad® 2000 Pro, gave qualitatively the same results for reasonable values of the parameters in the Cagan function. It should nevertheless be pointed out that the results of the model to a certain extent depend on the parameterization of the model. However, as noted above, this analysis is not meant to arrive at the most general results possible, but rather we aim to elucidate the potentially important role played by the nonlinearity of the system in order to explain the complex interactions of the parameters of fiscal and monetary policy.

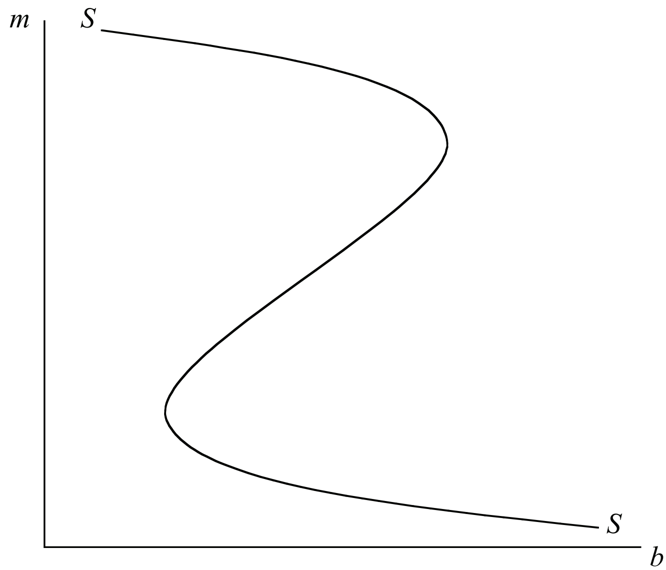

Fig. 3.7. *The set of steady states of public debt and real money balances for low values of the designed budget deficit*

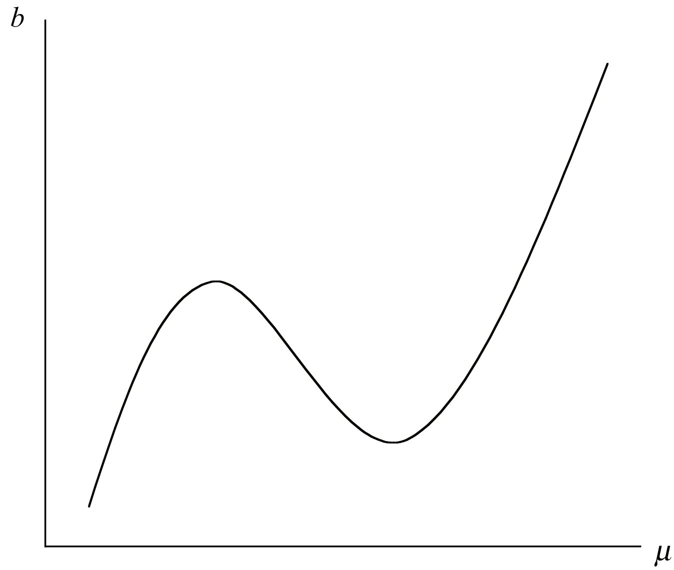

Fig. 3.8. *The interconnection between public debt and the growth rate of base money in the economy's steady state for low values of the designed budget deficit*

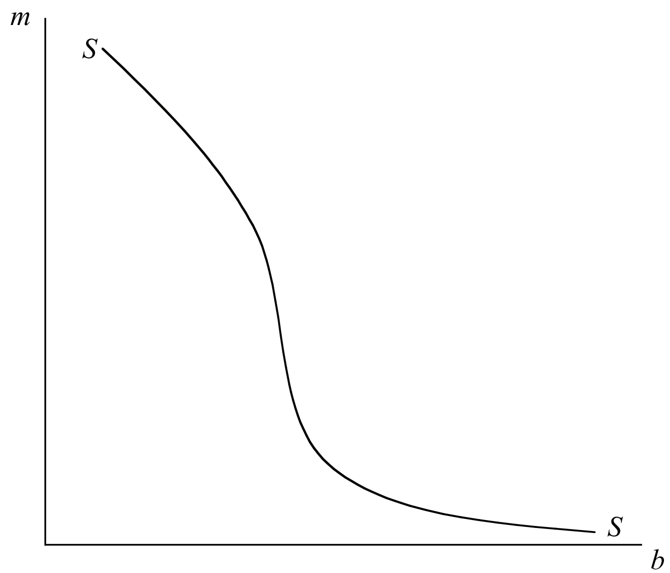

Fig. 3.9. *The set of steady states of public debt and real money balances for high values of designed budget deficit*

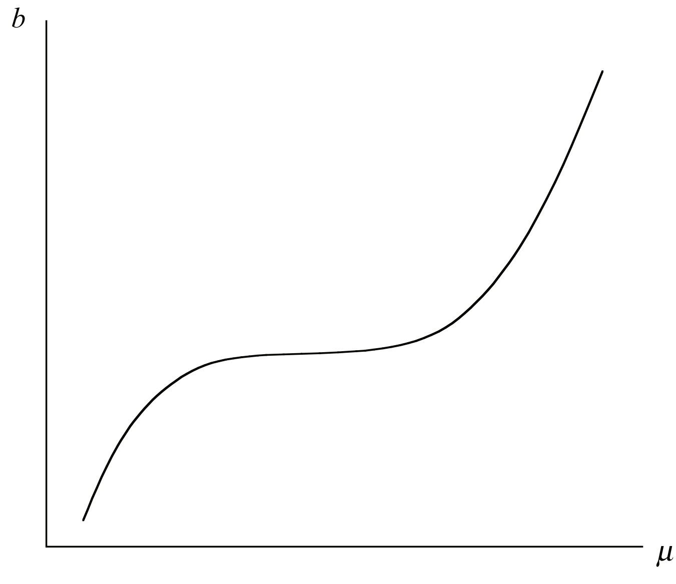

Fig. 3.10. *Interconnection between public debt and the growth rate of base money in the economy's steady state for high values of the designed budget deficit*

For sufficiently high values of the calculated deficit (d_0 > 1/8 for the demand function [3.16]) the derivative in (3.17) is always less than zero and the *SS* curve has a negative slope (see Fig. 3.9). In this case the steady volume of the public debt always increases with an increase in the growth rate of base money (see Fig. 3.10). However, is should be pointed out that the steady values of debt are less sensitive to changes in the rate of growth of the base money for mid-range values of the latter.

If we consider a positive dependence of the budget deficit on the rate of inflation (the Olivera-Tanzi effect) in a simple linear specification,

$$D(\pi) = d_0\left(1 + \pi(m)\right) + rb, \tag{3.18}$$

we will see that just as in the inflation tax Laffer curve model, our modification of the system (3.8) does not qualitatively change its properties. The set of steady points of the *SS* curve for the demand function for real money balances (3.16) and the zeroes of the corresponding derivative can be written as

$$\begin{gathered} b(m) = \frac{1}{r}\left[m\sqrt{\frac{1}{m} - 1} - d_0\left(1 + \sqrt{\frac{1}{m} - 1}\right)\right], \qquad 0 < m < 1. \\ b'(m) = \frac{-2m^2 + m + d_0}{2rm^2\sqrt{\frac{1}{m} - 1}} = 0, \qquad m_{1,2} = \frac{1 \mp \sqrt{1 + 8d_0}}{4}, \qquad m_1 < 0. \end{gathered} \tag{3.19}$$

Equations (3.19) show that the set of steady states has the same shape as in Fig. 3.5.

3.6. Analysis of bifurcations in the system of public debt and real money balances

The macroeconomic dynamics in the system of real money balances and public debt can be investigated in a way that allows one to avoid the problem of unstable steady states in system (3.8). In addition, the analysis given below, which is analogous to the models that were discussed in Section 3.2, can be used to describe the qualitative differences in the consequences of changing macroeconomic policy depending on the inflation regime.

Consider the set of steady values of the debt as the fiscal policy parameters. The central bank, by conducting monetary policy via open market operations, is able to choose (perhaps non-uniquely) the growth rate of base money that corresponds to the economy's steady state for any possible value of the public debt.

The functional dependence of the steady values of the growth rate of base money on the fiscal policy parameters (the volume of the public debt b and the primary deficit d) for system (3.8), which does not account for the effect of inflation on the primary deficit, can be written as

$$\mu = \frac{d + rb}{m}. \tag{3.20}$$

Inserting this expression into the second equation of the system (3.8), we get a functional description of the vector field of the dynamics of real money balances for various values of the fiscal policy parameters (the volume of the public debt *b* and the primary deficit *d*) and the servicing rate of public debt *r*:

$$\begin{aligned} \dot{m} &= F(m, D), \qquad D = d + rb, \\ F(m, D) &= D - \pi(m)m. \end{aligned} \tag{3.21}$$

An investigation of the singularity and stability of the steady states of (3.21) results in several conclusions. The system has two steady states (one stable and the other unstable), if the value of the operational deficit D[26] is less than the maximum of the inflation tax $\pi(m)m$. The steady state is unique if the maximum inflation tax equals the operational deficit, and does not exist if the operational deficit is greater than the maximum inflation tax. Therefore, the system has a catastrophe point of the "fold bifurcation" type[27]. The vector field and bifurcation diagram for the demand function for real money balances (3.16) are shown in Fig. 3.11 and 3.12.

Diagrams with the same qualitative properties result for the system modified to account for the Olivera-Tanzi effect; this follows from the uniqueness of the extreme in (3.19) on the feasible set.

We are mostly interested in investigating the system in which an increase in the rate of inflation results in a decrease in the primary deficit. Using the parameters of fiscal policy to express the steady value of the growth rate of base money and putting this expression into the equation for the dynamics of the real money balances, we find

$$\mu = \frac{d_0\left(1 - \pi(m)\right) + rb}{m}. \tag{3.22}$$

$$\begin{aligned} \dot{m} &= f(m, d_0, b), \\ f(m, d_0, b) &= rb + d_0\left(1 - \pi(m)\right) - \pi(m)m. \end{aligned} \tag{3.23}$$

---

[26] Analysis of the bifurcation of this system allows us to consider the operational deficit as a single parameter without paying undue attention to its components (the primary deficit and the servicing of the debt). Indeed, an increase in the primary deficit shifts the *SS* curve in Fig. 2.5 to the left, while an increase in the stationary volume of the public debt simply means a shift of the vertical level line to the right.

[27] An analogous results was arrived at in Smirnov (1997). The bifurcation point corresponds to the peak of the *SS* curve (or to the peak of the inflation tax Laffer curve), where the elasticity of money demand is equal to −1. See a classification of bifurcations in economic systems in, for instance, Azariadis (1993) or Lorenz (1989).

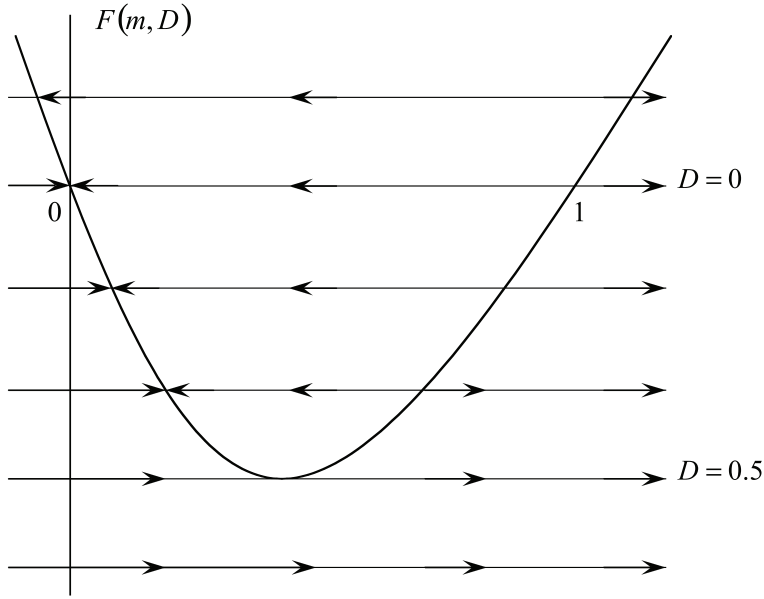

Fig. 3.11. *The vector field for the model without inflation effects on the budget deficit*

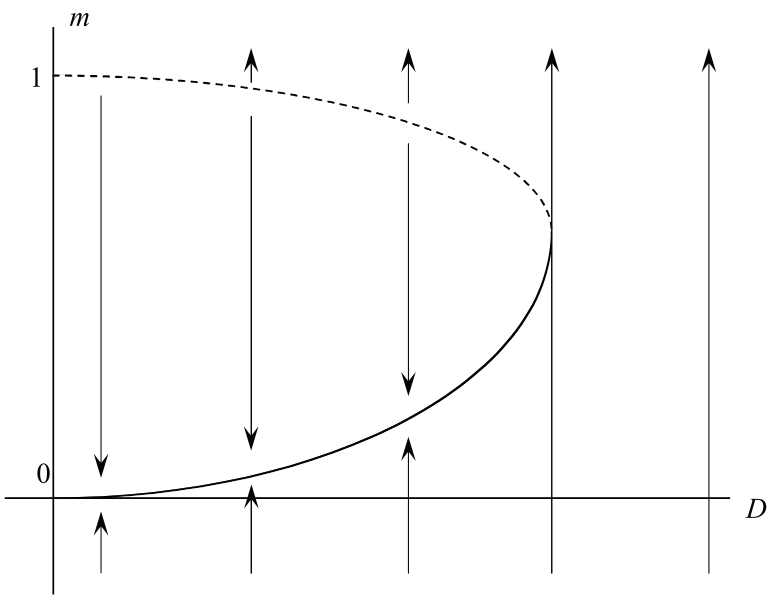

Fig. 3.12. *Bifurcation diagram in the model without inflation effects on the budget deficit*

In this case we have a first-order system with two parameters, changes in which (unlike (3.21)) should be considered separately. Changes in the steady volume of public debt b, keeping the designed primary deficit d_0 constant, result in a shift in the vertical level line in Fig. 3.7. On the other hand, an increase in the (positive[28]) value of the designed primary deficit d_0 will "straighten" the Z-shaped curve SS, and it will finally assume the shape shown in Fig. 3.9.

We will consider first the effect of increasing the steady volume of the public debt for the chosen value of the designed primary deficit d_0 for the range where the set of steady states SS has a Z-shape (i.e., $0 < d_0 < 1/8$ for the demand function (3.16)). As we pointed out in the previous section, there are in the general case three steady values for the volume of demand for real money balances for a fixed level of public debt, and therefore there are three corresponding values of the growth rate of base money and rate inflation. An investigation of the singularity and stability of the steady states brings us to the following conclusions. The equilibria with high or low inflation are stable, and the equilibrium for the mid-range rate of inflation is unstable. In addition, system (3.23) has two catastrophe points of the "fold bifurcation" type with respect to the parameter b. The corresponding vector field and bifurcation diagram are given in Fig. 3.13 and 3.14. The bifurcation diagram shows that the dynamics of the system will exhibit hysteresis. Consider the situation when the system is initially on the top (stable, in this interpretation) branch of the SS curve. If the government increases the volume of the accumulated debt[29] and the central bank conducts the correct operations on the open market, the steady growth rate of base money should be increased; this will bring about a decrease in the steady demand for real money balances. An increase in the volume of public debt along the top branch of the SS curve will be accompanied by a relatively smooth increase in the rate of inflation. The situation will catastrophically change when the system reaches the singularity point (the point of the top extreme). An increase in public debt will bring about a sharp increase in the equilibrium rate of inflation and a decrease in the demand for real money balances; the system jumps to the lower branch of the SS curve, and movement (to the left) along this curve represents hyperinflationary processes in the economy. The dynamics of the system that is initially on the lower branch of the SS curve can be described analogously. A decrease in the volume of public debt should be associated here with a tightening of monetary policy and an increase in the demand for real money balances. This type of financial stabilization at a certain point in time will bring about an instant improvement in the situation, and the system will move to a low-inflationary state[30].

Investigation of the steady dynamics of the economic system that is initially on the middle, unstable branch of the SS curve (for instance, at point A), brings us to some interesting

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[28] It should be pointed out that the specification of our model for the deficit finance, which takes into account the negative effect of inflation on the budget deficit, is not symmetric with respect to the fiscal policy parameters, and does not allow us to consider negative values of the designed primary deficit; however, there is no point in doing so anyway.

[29] For a given level of the designed primary deficit, this could be because of the necessity of servicing the existing public debt.

[30] Here we consider b as a parameter and analyze the movement of the equilibrium point following changes in this parameter. See technical discussion of this bifurcation in Azariadis (1993, p. 146—147).

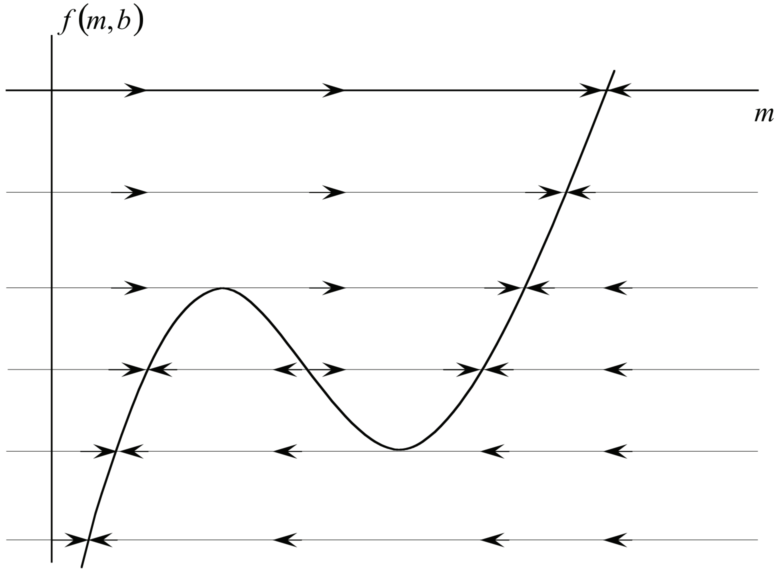

Fig. 3.13. *Vector field (with respect to the parameter b) for the model with a negative influence of inflation on the budget deficit*

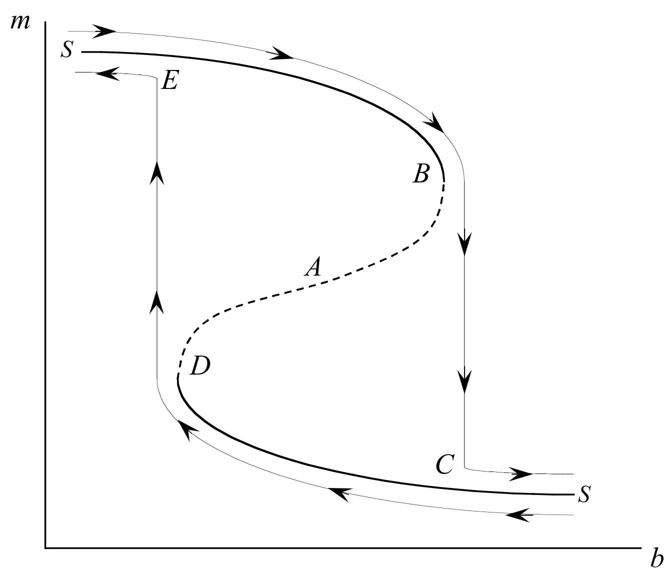

Fig. 3.14. *Bifurcation diagram (with respect to the parameter b) for the model with a negative influence of inflation on the budget deficit*

results. Here an increase in public debt (again assuming that the designed primary deficit remains unchanged) must be accompanied by a decrease in the growth rate of base money and a visible monetary stabilization of inflation (a shift from point A to point B). However, after arriving at the singularity point B, the system will undergo a catastrophe: a vanishingly small increase in the debt will bring about a shift to the hyperinflationary branch (the system will jump from point B to point C). On the other hand, a tightening of fiscal policy (a decrease in the steady public debt) will initially result in forced expansionary monetary policy and an increase in inflation (a shift from point A to point D). However, after arriving at point D, bifurcation will ensue and the economy will shift to the low-inflation branch (the system will jump from point D to point E). The character of coordination between fiscal and monetary policy will qualitatively change: stabilization of the public debt in equilibrium must be affected with a monetary stabilization of inflation, and the system will move to the left along the top branch of the *SS* curve[31].

A deeper economic interpretation of these equilibrium processes for a transitional economy will be given below. Let us turn now to an investigation of the bifurcation of the system if the second parameter of fiscal policy changes, namely the designed primary deficit d_0[32]. Assume that the volume of public debt b is fixed at a level where three possible equilibrium values of the growth rate of base money are possible. Analysis of the stability and singularity of the system (3.23) gives us a bifurcation that is principally different from the one considered above. In this case the dynamics of the system will not be of the "fold bifurcation" type; the dynamics will display a catastrophe akin to the "pitchfork bifurcation" type. An increase in the designed primary deficit will, as noted above, bring about a "straightening" of the *SS* curve in Fig. 3.7. The top steady state for real money balances will move down, and the bottom steady state will move up. A change in the position of the middle (unstable) steady state will be different depending on the volume of public debt. If the latter is relatively small, then the middle steady state will move down, and at a certain point it will coalesce with the bottom state and both will disappear; the system will jump to the top (low-inflation and stable) branch. This catastrophe is shown on the bifurcation diagram (Fig. 3.15). A further increase in the designed primary deficit d_0 brings about an (asymptotic) increase in the steady value of the growth rate of base money (a decrease in the volume of demand for real money balances) up to the level that corresponds to the maximum volume of inflation tax revenue $\pi(m)m$ (given the functional form (3.16), the maximum of inflation tax is equal to 1 and it is achieved at $\mu = 0.5$). As can be seen

[31] Note that if parameter b changes for the constant growth rate of money when economy stays at point A, then it will jump to the stable branch (upper or lower part of *SS* curve). But we actually suggest a little bit different interpretation, assuming that an increase in b is accompanied by a decrease in the growth rate of money just to move economy from one unstable steady state to another (this is done continuously or step by step to move economy from point A to B). As economy is posited in the steady state, no matter it is stable or unstable it will be kept there (if there is no shock, of course). This way of modeling was suggested in the original paper by Drazen (1985). It may seem artificial, but it helps us to stress the potential danger of conducting tight monetary policy at the time when public debt is rising.

[32] This analysis was also carried out using MathCad® 2000 Pro.

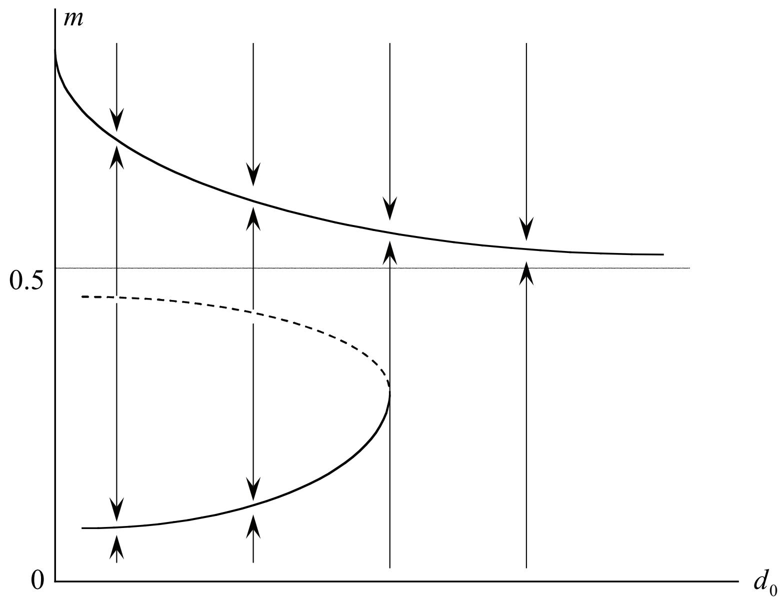

Fig. 3.15. *Bifurcation diagram (with respect to the parameter d_0) for a low volume of public debt*

from (3.15), the real budget deficit, which takes into account the negative influence of inflation, will adjust the present value of inflation tax in order to provide for the corresponding level of public debt. The factor $(1 - \pi(m))$, which characterizes this effect, approaches zero and decreases the real primary deficit to the level at which the volume of inflation tax is close to its maximum and sufficiently high to support the existing volume of public debt without requiring further borrowing.

Figure 3.16 gives the bifurcation diagram for relatively high volumes of public debt (as before, we assume that three steady states exist). Here the middle equilibrium value of demand for real money balances increases, and at a certain point coalesces with the low inflation equilibrium; the system jumps to the high-inflation branch. A further increase in the designed deficit d_0 brings about a decrease in the steady value of the growth rate of base money (an increase in the volume of demand on real money balances) to the level that corresponds to the maximum inflation tax revenue $\pi(m)m$. In this case we observe a real primary surplus, which is a second resource for keeping the public debt at the given level (the first resource is the inflation tax, which is close to its maximum value).

Figure 3.17 shows the hypothetic intermediate situation, when all three equilibria coalesce at one point, i.e. the system has a pure "pitchfork bifurcation". Analysis of an increase in the designed primary deficit gives results that are analogous to those given above.

Consider now the values of the fiscal policy parameter (public debt b) for which there is only one steady state of the money market. An increase in the designed primary deficit should

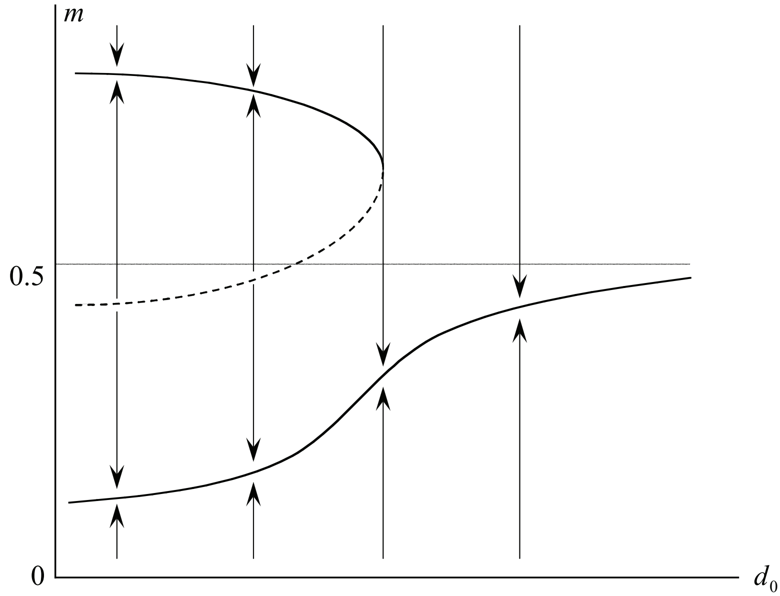

__Fig. 3.16.__ Bifurcation diagram (with respect to the parameter d_0)
for a high volume of public debt

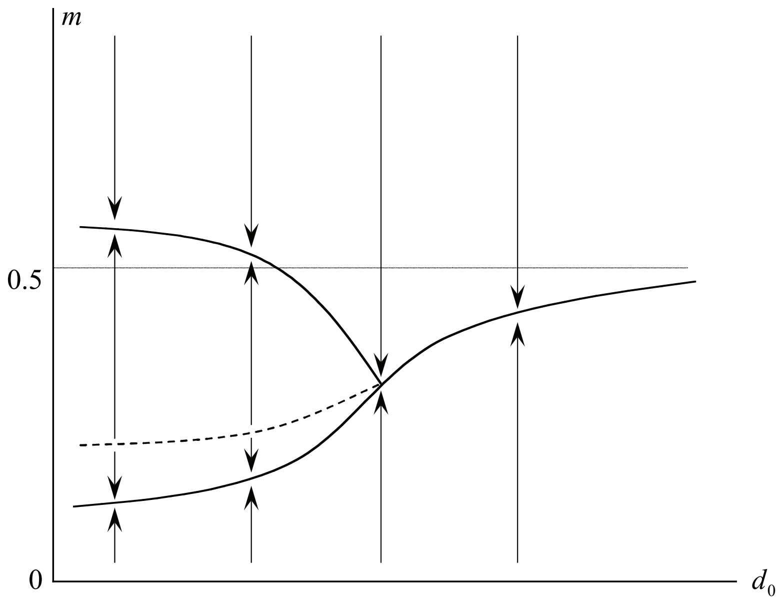

__Fig. 3.17.__ Bifurcation diagram with respect to the parameter d_0).
"Pitchfork bifurcation"

be associated with an increase in the growth rate of base money for low values of the debt, and a decrease for high values of the debt. In the first case the steady volume of demand for real money balances decreases, and in the second it increases; as before, this steady volume will approach the level that is determined by maximum inflation tax revenue.[33]

3.7. The Russian crisis of 1998 as a fold bifurcation

On August 17, 1998, in the face of adverse conditions the Central Bank of Russia (CBR) was forced to devalue the ruble. While on August 14 one US dollar was worth 6.29 rubles, a few weeks later, on September 9, it became worth more than 21 rubles. At the same time, the Russian Federal Government imposed a moratorium on the repayment of part of its debt and announced an intention to restructure it; this was *de facto* a default. By the end of the year, there was a significant increase in the annual rate of inflation: it was well below 10 percent before the crisis, and it increased to 84 percent after the crisis.

While the nature of the 1998 crisis is rather complex, it seems possible to partly interpret it from the point of view of bifurcation theory within the framework of our analysis, as a kind of fiscal-monetary coordination failure.

Figure 3.18 shows the monetary situation before and after the crisis. In the period before the crisis, monetary policy was tight. While the average monthly growth rate of money was 2.2 percent in 1997, in the first seven months of 1998 it was just 0.3 percent. Inflation was also rather moderate or even low: the average monthly growth rate of CPI was 0.9 percent in 1997, and 0.6 percent in the period from January to July 1998. The official target level of annual inflation was 8 percent in 1998.

At the same time, the fiscal situation remained remarkably bad (both for that period and in perspective as well). Table 3.1 illustrates this point.

For several years, the Government had failed to meet the announced target level of operational deficit. The dynamics of public debt was in fact dramatic. While primary deficits were persistently high, a substantial squeeze in seigniorage and rising interest payments led to rapid debt accumulation.[34, 35] Figure 3.19 shows the dynamics of internal Russian public debt in market instruments (GKO and OFZ — federal bonds).

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[33] The next step in our investigation should be the analysis of the joint bifurcation when the fiscal policy parameters d_0 and b change. However, given the complexity of the theoretical classification of possible catastrophes and the difficulties illustrating them graphically, we will leave this for further study. A possible effect of changes in the volume of public debt and the calculated primary deficit, either in the same direction or not, could be the acceleration or delay of the approaching catastrophe, as well as amplification (or damping) of the nonlinear effects of the influence of fiscal policy on the equilibrium of the money market.

[34] The seeming stabilization in the debt to GDP ratio is merely a result of an appreciation in the real exchange rate. See details in Kharas, Pinto, and Ulatov (2001).

[35] While interest rates on GKO's were double-digit, the growth rate of GDP was negative (only in 1997 was it positive, and close to zero). As was discussed in Section 2.2, this fact is important for the stability properties of the debt to GDP ratio dynamics.

Table 3.1. Fiscal and monetary policy indicators, 1995—1997

Year	**1995**	**1996**	**1997**
Operational deficit (actual, percent of GDP)	5.7	8.4	7.0
Operational deficit (target, percent of GDP)	6.0	4.2	3.2
Primary deficit (actual, percent of GDP)	2.2	2.5	2.4
Interest payments (percent of GDP)	3.6	5.9	4.6
Government debt (percent of GDP)	50	48	50
Government debt (billions USD)	170	201	218
Seigniorage (percent of GDP)	3.62	1.26	1.36
Real GDP growth (percent a year)	–4.0	–3.4	0.9
Inflation rate (percent a year)	131	22	11
Real exchange rate appreciation (percent)	10	22	6

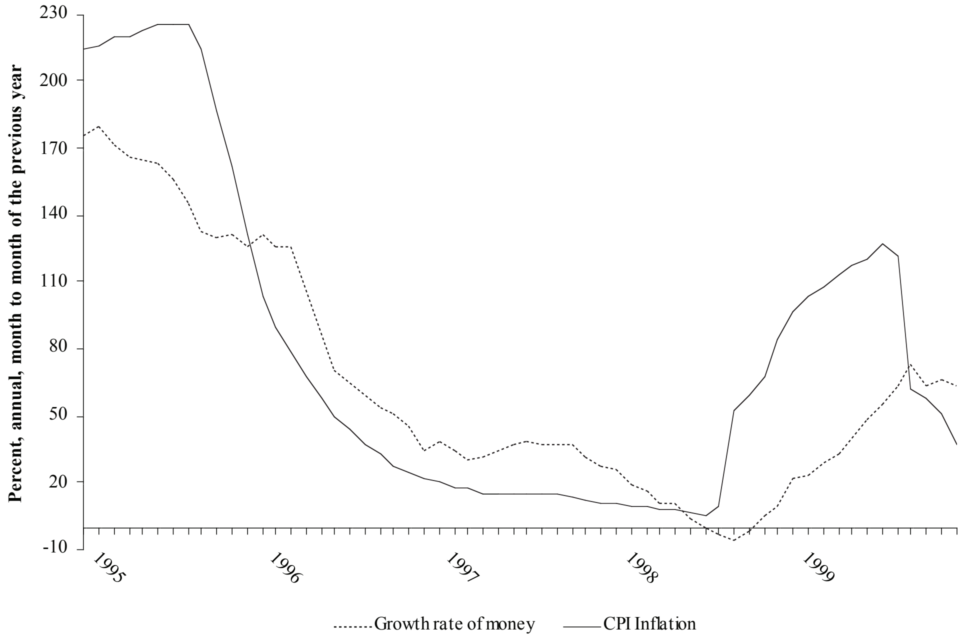
Source: Kharas, Pinto, and Ulatov (2001).

For a constant budget deficit, we can interpret the simultaneous monetary contraction and the rise of public debt in 1997—1998 in terms of equations (3.22)—(3.23) and Fig. 3.14, which illustrates the hysteresis effect. Assume that the economy is initially in a state of moderate inflation (point *A* in Fig. 3.14). An increase in the accumulated public debt is accompanied by a decrease in the growth rate of money and, therefore, in the rate of inflation. However, after the debt achieves a certain critical value (point *B* in Fig. 3.14), the economic system bifurcates and jumps to a state with high (hyper) inflation (point *C* in Fig. 3.14), in which a further increase in the volume of accumulated debt is accompanied by an increase in the steady level of inflation. What is especially noteworthy is that near the bifurcation point *B* the system shows a gradual adjustment of the public debt and a rather rapid decrease in the growth rate of money; these may give the erroneous impression of macroeconomic stabilization. This result agrees with the phenomenon noted in Vavilov (1999), when there seemed to be a stabilization in Russian debt during the last months before the crisis that corresponds to a logistic equation (see also Fig. 3.19).

Limitations

Our explanation of the nature of the August 1998 crisis is based on the mechanism of the interaction between fiscal and monetary policies and disregards many important aspects of that event. First of all, as it often happens, the Russian crisis was a combination of government default, currency devaluation, and a banking crisis. Many authors (in particular, Montes and Popov, 1999) agree that the most important part of the general financial crisis was a speculative attack on the ruble that can be best described by first-generation models of currency crises.[36] Indeed, a remarkable tightness of monetary policy and its success in fighting inflation before the crisis was a result of the specific exchange rate policy of the CBR — roughly speak-

[36] Krugman (1979), Flood and Garber (1984).



Source: CBR; HSE Economic Journal, Statistics (various issues).

Fig. 3.18. *Growth rate of money and inflation in Russia, 1995—1999*

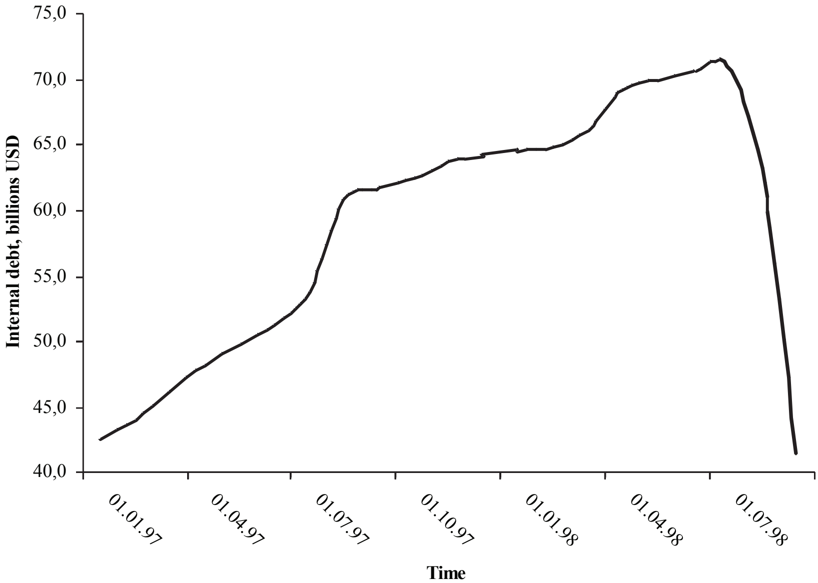
ing, a fixed exchange rate regime.[37] In this respect, one should also stress an additional factor that was important both for the collapse in the exchange rate and for the debt confidence crisis: the Asian crisis of 1997 led investors to scrutinize Russian exchange and public debt markets (as well as the vulnerable Russian banking sector) more carefully.

Second. Our simple model does not account for the debt structure. In particular, it is the maturity structure that is important here. A substantial volume of the government debt was in the form of short-term ruble treasury bills (called GKOs) that bear a high rollover risk. In fact, as Table 3.1 shows, the debt to GDP ratio was indeed high, but not extremely high (from a historical perspective). One element of the stabilization package implemented just before the crisis was a swap out of GKOs into long-term Eurobonds. However, this was done far too late and did not help prevent the crisis.[38] Thus, very poor debt management policy may also be seen to be a source of the crisis.

Third. The rollover risk along with the devaluation risk led to extremely high real interest rates on short-term debt. They were on average higher than 50 percent in the period of

[37] Central Bank of Russia announced a target level of 6.2 rubles for the USD with a 15 percent band for the period of 1998—2000.

[38] In general, there is theory and evdince that debt swaps do not avert crisis when an open economy approaches default. See, i.g., Velasco and Lorrain (1993), and Aizenman, Kletzer and Pinto (2002).



Source: CBR; Bureau of Economic Analysis.

***Fig. 3.19.** Internal debt in market instruments (GKO-OFZ) in Russia, 1997—1998*

1995—1997, and even higher (and rising) a month before the crisis. This factor simply makes the problem of fiscal-monetary coordination more acute, as rising interest rates lead to a more rapid growth of public debt.[39]

Fourth. Chapters 3 and 4 of this thesis provide an analysis of fiscal and monetary policy interactions assuming backward-looking dynamics of the system. In practice, it is difficult to judge what factors were of major importance for the crisis: the current state of the system (large fiscal deficits and accumulated public debt in 1998), or the expectations that the Russian Government would not be able to meet its obligations in the near future by providing sufficient surpluses and that it would therefore be forced to monetize the outstanding debt. We will return to this point in Chapter 5.

3.8. Conclusion

Let us return to the question posed at the beginning. Are we able to positively state that there is unique, positive (linear) interrelation between the deficit and the debt on one hand, and forced monetary expansion and inflation on the other? The investigation presented here seems to give a negative answer. The dependence is non-linear, and it depends on the infla-

[39] Drazen and Helpman (1990) provide an example of an analysis of fiscal and monetary policy under conditions in which there is uncertainty about the future stabilization policy mix. In their paper, the interest rate includes a risk premium that depends on the instantaneous probability of a future policy switch.

tionary regime of the economy. Changes in the primary deficit and the volume of accumulated debt may have completely different effects on inflation.[40]

We have considered in this chapter a model for the financing of the operational budget deficit in which we assume that there is a negative relationship between the real primary deficit and inflation. This approach removes the problem presented by the existence of maximum volumes of the deficit and of the public debt for steady financing. If the economy is initially in a state with low inflation or with high (hyper) inflation, an increase in the steady volume of the public debt requires an increase in the growth rate of base money. In the case of low inflation the system will inevitably come to a catastrophe and jump from the low-inflation branch to the hyperinflation branch. This process, as noted above, displays hysteresis. If the economy accumulates inflationary potential in the form of an increasing government debt, then sooner or later the money market will undergo sudden changes.

On the other hand, this model more or less realistically describes the process of stabilization of hyperinflation; one of the conditions for this is a decrease in the real value of the accumulated public debt[41]. This process must first be accompanied by a gradual decrease in the steady growth rate of base money. After reaching the singularity state the economy will bifurcate — the steady level of inflation jumps to a lower level, and the economy will move to low inflation regime.

At the same time even a significant increase in the designed primary deficit that is financed without additional government borrowings, can have less severe implications for inflation. Depending on the initial state, the economy may undergo either an increase or a decrease in the equilibrium rate of inflation; however, a further increase in the designed budget deficit stabilizes inflation expectations at a moderate level. This allows the central bank to achieve inflation tax revenues close to the maximum possible, and the government to bring the real primary deficit (surplus) to a level that is compatible with the steady state of the public debt.

Appendix. Microeconomic basis for the dynamics

The analysis given in this and following chapters is based on the system of equations (3.8), which describes the dynamics of public debt and real money balances. It assumes the existence of a demand function for real money balances that decreases with inflationary expectations, for example the Cagan function (2.11) or (3.16). Here we give the micro foundations for the main analysis, based on the standard intertemporal optimization problem for a representative agent. In particular, we explain the interconnection between the budget constraints of the government and of a representative agent, derive the demand function for real money balances and introduce the assumptions necessary for money to be superneutral[42].

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[40] See also Bruno (1995) on the importance of non-linearity in inflation dynamics.

[41] See, for example, Bruno (1993), Sargent (1993).

[42] The model considered here belongs to a class of monetary growth models, or models with money in the utility function. It was first suggested in a paper by Sidrauski (1967). In this exposition the model is closest

Consider a representative agent with an infinite time horizon who maximizes the lifetime utility from consumption and real money balance. Including the latter in the utility function presupposes that money eases transactions, and allows us to derive the demand function for money[43].

$$\max_{c,m} \int_0^\infty u(c,m) e^{-\rho t} dt. \tag{A3.1}$$

Here c is real consumption, $m = \frac{M}{P}$ is the real money balances, ρ is a subjective discount rate, $u(c, m)$ is the instantaneous utility function with the standard properties $u'_c, u'_m > 0,\ \ u''_{cc}, u''_{mm} < 0$. The budget constraint is given by the following equation:

$$Pc + \dot{M} + \dot{B} = Py + RB - PT, \tag{A3.2}$$

where P is the price level, y is the real labor income, which we assume for simplicity to be constant, T is the real lump-sum taxes, B is the nominal public debt, and R is the nominal interest rate on public debt. The representative agent spends his total disposable nominal income on consumption and savings. The latter consists of increments in the money base and in government obligations. The initial values of the nominal assets are given by $M(0) = M_0$, $B(0) = B_0$. The budget constraint (A3.2) can be written in terms of real variables for convenience:

$$c + \dot{m} + \dot{b} = y + rb - T - \pi m, \tag{A3.3}$$

where $b = \frac{B}{P}$ is the real public debt, π is the rate of inflation, and $r = R - \pi$ is the real interest rate on public debt[44]. Denoting $a = m + b$, the real assets of a representative agent, the budget constraint can also be written in the form of a dynamics equation:

$$\dot{a} = \dot{m} + \dot{b} = y + rb - c - \pi m - T = y + ra - c - (r + \pi)m - T. \tag{A3.4}$$

---

to the version used in Drazen (1985). A canonical representation of the model can be found, for example, in Blanchard and Fischer (1989), Turnovsky (2000), Walsh (1998).

[43] This assumption is central in a class of models that include money in the utility function. Alternative methods for deriving demand for money in macroeconomic dynamics models are the classes of models "shopping time", "cash-in-advance constraint", as well as monetary versions of models with overlapping generations. Under certain assumptions the first two classes are equivalent to models with money in the utility function (see, for example, McCallum-Goodfriend (1987), Feenstra (1986)). Elucidation of the model of a representative agent is justified by the main goals of our investigation. We should, however, point out that an analysis based on the model of overlapping generations would probably give additional interesting results. See, for example, Weil (1987, 1991).

[44] Just as in the main part of the thesis, we assume that inflationary expectations satisfy the hypothesis of perfect foresight.

Monetary policy is characterized by a constant (or piecewise constant) growth rate of base money equal to $\frac{\dot{M}}{M} = \mu$. The money market is in equilibrium and at each point of time the dynamics of real money balances can be described by the equation

$$\dot{m} = \left(\mu - \pi\right)m. \qquad \text{(A3.5)}$$

The government finances the operational budget deficit (which is defined as the government expenditure, G, minus net taxes, T, both taken for simplicity to be constant, plus debt service) by new public borrowings and seigniorage. The later is comprised of pure seigniorage and inflation tax, $\frac{\dot{M}}{P} = \dot{m} + \pi m$. The budget constraint of the government in terms of real variables can be written as

$$G - T + rb = \frac{\dot{M}}{P} + \dot{b}. \qquad \text{(A3.6)}$$

The budget constraint of a representative agent (A3.3) and the budget constraint of the government (A3.6) together form the fundamental macroeconomic identity:

$$y = c + G. \qquad \text{(A3.7)}$$

Given the formulated problem of intertemporal optimization,

$$\max_{c,m} \int_0^{\infty} u\left(c,m\right)e^{-\rho t}dt \quad s.t. \quad \dot{a} = y + ra - c - (r+\pi)m - T,$$

we write the Hamiltonian function

$$H(t,c,m,b,\lambda) = u(c,m)e^{-\rho t} + \lambda e^{-\rho t}\left[y + ra - c - (r+\pi)m - T\right],$$

where the co-state variable λ characterizes the shadow price of an increase in real assets (the opportunity cost of savings) in terms of marginal utility of foregone consumption. The first order conditions are:

$$\frac{\partial H}{\partial c} = 0, \qquad u'_c(c,m) = \lambda, \qquad \text{(A3.8)}$$

$$\frac{\partial H}{\partial m} = 0, \qquad u'_m(c,m) = \lambda\left(r+\pi\right), \qquad \text{(A3.9)}$$

$$\frac{\partial}{\partial t}\left[\lambda(t)e^{-\rho t}\right] = -\frac{\partial H}{\partial a}, \qquad \dot{\lambda} = \lambda(\rho - r), \tag{A3.10}$$

$$\lim_{t\to\infty} \lambda(t)e^{-\rho t} = 0. \tag{A3.11}$$

Condition (A3.8) gives the optimal consumption choice, in which the marginal utility equals the shadow price of a unit of savings. Condition (A3.9) equates the marginal utility from an additional unit of real money balance to the opportunity cost of savings (the nominal interest rate) in units of utility from consumption. Finally, condition (A3.10) determines the dynamics equations of the co-state variable. Considering the Hamiltonian function to be a generalized utility function, this condition requires the increment in utility (indirectly) resulting from an increase in assets, taken with a negative sign, to equal the increase of the shadow price of savings over time. Condition (A3.10) guarantees that the rate of growth of the co-state variable will be determined by the difference between the subjective discount rate and the interest rate. Condition (A3.11) is the standard no-Ponzi game condition for such problems. Taking (A3.9) and (A3.9) together, we can write a combined first order condition:

$$\frac{u'_m(c,m)}{u'_c(c,m)} = r + \pi. \tag{A3.12}$$

This condition gives in an implicit form the demand for real money balances as a function of the nominal interest rate and consumption. In order to write the demand function in an explicit from and to analyze the dynamics of the money market, it is necessary to introduce the following important assumption. We assume that the function of current utility is additively-separable with respect to its arguments:

$$u(c,m) = v(c) + w(m). \tag{A3.13}$$

For this functional form, the first order condition (A3.8) can be written as

$$v'_c(c) = \lambda. \tag{A3.14}$$

Using the macroeconomic identity (A3.7) and assuming that labor income and government expenditures are constant, we find the constant level of consumption; taking into account (A3.14) we also find the constant value of the co-state variable. Using (A3.12), money demand can be determined as a function that decreases with respect to the nominal interest rate[45]:

[45] This follows from the standard assumptions we made concerning the instantaneous utility function.

$$w'_m(m) = \lambda(r+\pi). \tag{A3.15}$$

In addition, a constant co-state variable allows us to use condition (A3.10) to determine the constant level of the real interest rate:

$$r = \rho\,. \tag{A3.16}$$

Finally, using the results given above, we can describe the dynamics of the public debt and real money balances:

$$\begin{cases} \dot{b} = rb + (G-T) - \pi m, \\ \dot{m} = \left(\mu + r - \dfrac{w'_m(m)}{\lambda}\right)m. \end{cases} \tag{A3.17}$$

System (A3.17) is a prototype for the system (3.8) which we consider in the main text of this chapter. It is not difficult to see that the corresponding steady state of the system is an unstable node for the given initial values of public debt and real money balances. The Cagan function for the demand for real money balances that is used in the analysis,

$$m^d = Ae^{-\alpha\pi^e} \tag{2.11}$$

corresponds to the utility function

$$w(m) = m\left(\alpha_1 - \alpha_2 \ln m\right),\ \ \alpha_1, \alpha_2 > 0\,, \tag{A3.18}$$

where $A = e^{\left(\frac{\alpha_1}{\alpha_2}-1\right)}$, $\alpha = \dfrac{\lambda}{\alpha_2}$ [46].

In conclusion, it is necessary to make certain important comments concerning the methodology of constructing this economic model and its properties. First of all, the economy has the property of a neoclassical dichotomy, and money is superneutral. Indeed, consumption and the real interest rate are determined by conditions (A3.7) and (A3.16), which do not contain nominal variables or the growth rate of base money. Changes in monetary policy (changes in the growth rate of base money) affect the demand for money only via inflation expectations, not by changing the real interest rate. An assumption that is of significant importance for this result is that of additive separability of the current utility function[47].

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[46] We should point out that in this specification the semi-elasticity of demand for money, α, is determined by the co-state variable λ, which in its term depends on consumption.

[47] For a more general form of the utility function, the economic system dichotomizes and will be accompanied by the superneutrality of money only in a steady state. See, for example, Blanchard and Fischer (1989), Turnovsky (2000), Walsh (1998).

Second. The considered version of the monetary growth model, unlike the canonical model by Sidrauski, presupposes constant labor income and does not consider the accumulation of capital. The assumption that income is constant can be weakened (without significant complications or changes to the main results), for instance by replacing it by assuming a constant growth rate of output[48]. Introducing physical capital in the model does not change the main results either. We will have an additional first order condition, in accordance with which the interest rate on government bonds must be equal to the marginal productivity of capital. The properties of neoclassical dichotomy and the superneutrality of money are also based on the hypothesis of additive separability of the instantaneous utility function. Monetary policy, as before, does not affect the interest rate; however, during the transitional dynamic the latter is not constant anymore, and it is determined by the accumulation of capital. The interest rate is constant and equal to the subjective discount rate only on the balanced growth trajectory; this is equivalent to the assumption that the growth rate of output is constant. Consideration of a variable interest rate (i.e., the accumulation of capital on the transitional trajectory) is of course interesting in the analysis of macroeconomic policy. However, this would to a significant extent complicate the model and also move our topic of discussion — that of the interaction between fiscal and monetary policies — to the background both because it would become impossible to arrive at the necessary analytical solutions to the model, and because of the difficulties in analyzing dynamic systems higher than the second order[49]. For these reasons we do not include the labor market in our analysis, nor do we include labor in the utility function and we do not introduce the corresponding production function[50].

[48] It would perhaps be more logical to consider variables as shares of output in this version of the model. We will consider this question in the third chapter.

[49] An analysis of this sort can be found in the book by Turnovsky (2000). The author indeed considers the influence of macroeconomic policy for the deterministic case, and also for optimal stochastic dynamic models with a more complete specification then that given here. He considers, however, a completely different class of problems, not the interaction of fiscal and monetary policies.

[50] In particular, it is well known that inclusion of the labor market in the Sidrauski model guarantees that money will not be superneutral in transitional dynamics even for additively separable utility functions.

Chapter 4
Fiscal and monetary policy interaction I: The role of constraints

4.1. Introduction

Two important problems which both developing and developed countries face are *inflation bias* and *deficit bias*. Researchers believe that the main reason for inflation bias in developing countries (and in countries with a transitional economy) is significant financing of the budget deficit by seigniorage[1]. This implies that inflation bias can be explained by deficit bias in many cases, especially in high-inflation economies.[2]

Over the last few years *the new political economy* has become a popular avenue of research. Positive analysis that explains deficit bias is based on the actual mechanisms for forming the government budget. Politicians' and society's imperfect understanding of optimal policies or of strategic interaction during the political process can be potential sources of inefficient fiscal policies that lead to an undesirably high deficit. Overviews of studies in this area are given in Drazen (2000) and Persson and Tabellini (2000). The analysis presented in this chapter is devoted to a different problem. Considering the deficit bias problem to be a given, the following questions arise: Can the inflation bias problem be avoided if the deficit bias problem is present? Can chronic inflation be brought under control only by following tight monetary policies that are formally independent of fiscal needs? How can stabilizing monetary policies be developed? What measures should be taken first, and which measures might turn out to be premature and result only in a waste or resources?

The stabilization of the economies in Latin America, Israel and of the transitional economies in Eastern Europe — economies with high inflation — over the last decades shows that it is important to not only adopt the appropriate measures, but to do so in the correct order. Even though it goes without saying that the dynamics of each of these economies had its distinctive features, it is still possible to discuss the rules for conducting monetary and fiscal stabilization policies that have been worked out in practice; these rules concern the type, sequence and timing of policies. One of the main conclusions that we come to after the analysis

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[1] This does not mean that any episode of undesirably high inflation in a developing country can be explained by seigniorage, though the latter is indeed a typical reason. The statistics are that while seigniorage to output ratio is very low in developed countries (less than 1%), it is rather high in developing countries (see, for example, Agenor (2000, ch. 3)). One of the most common reasons for inflation bias in developed countries is the dynamic inconsistency of low-inflationary policies (Romer, 2001, ch. 10). On the other hand, one of the most plausible explanations for the fact that a significant part of the budget deficit is financed by seigniorage in developing countries is that the internal financial market is underdeveloped and that access to international financial markets is limited.

[2] Fischer, Sahay and Vegh (2002, p. 855) note that: "...no obvious long- or short-run relationship between inflation and fiscal balance is found for the low inflation countries or during the low inflation episodes in the high inflation countries. The relationship, however, is quite strong in the high-inflation during the high inflation episodes". See also the empirical study of this problem in Catao and Terrones (2001).

of historical cases when inflation was stabilized is that of the impossibility of stopping high inflation even in the middle run by using only monetary policies that were not first supported by stabilization in the fiscal sphere. Coordinated fiscal and monetary policies are needed for stabilization of the economy.

The analyses given in this chapter and in the next have a common goal. By considering various ways in which fiscal and monetary policies interact, we wish to determine the general principles for developing policies that would stabilize the fiscal and monetary spheres. We also wish to explain the nature of the mistakes we observe in stabilization programs. Following the logic suggested in Section 2.2, we will first analyze the policies that can be used to move the fiscal sphere and monetary market from one steady state to another. Afterwards, in Chapter 5, we will provide a general analysis of a macroeconomic policy that is inherently sustainable. From a technical point of view, the analysis in this chapter is based on a backward-looking dynamics. The fifth chapter considers the forward-looking dynamics of the economy.

This chapter has the following structure. In the second section we return to the general model for the dynamics of the public debt and real money balances given in Chapter 2. An analysis of the interaction between fiscal and monetary policies will be given on the basis of this model. We additionally consider the dynamic stability of the public debt to output ratio, and the ratio of real money balances to output. If the interest rate on public debt is less than the growth rate of output, then the steady state of the economy becomes stable. It is shown that this imposes several constraints on the interaction between fiscal and monetary policies. If the interest rate on public debt is higher than the growth rate of output, then the characteristics of the dynamics of public debt and real money balances do not qualitatively differ from the characteristics of the dynamics of the shares of the corresponding variables in the output.

Section 4.3 considers the possibility of lowering the inflation rate by using only monetary policies. It is shown that tight monetary policies may not be able to bring the economy back into equilibrium; indeed, it may even bring about an increase in inflation rather than a decrease. On the other hand, the analysis given in Section 4.4 shows that fiscal policies are able to independently improve the situation in the fiscal sphere, decreasing the size of public debt and thus making it possible to increase spending (or to lower taxes). This must be done at the expense of decreasing the budget deficit (or of increasing the budget surplus), while the state of the money market will not change. In Section 4.5 we show that monetary policies aimed at decreasing the steady level of inflation need to be supported by the government in the form of a decrease in the budget deficit that will help to decrease seigniorage. Sections 4.6 and 4.7 provide historical examples of loose monetary policy and tight fiscal policy that decrease inflation. We review and interpret macroeconomic policies in Russia in 2000—2003 and in United States in mid-1980s. Section 4.8 studies the situation, where changes in the fiscal sphere require coordinated changes in monetary policies.

We turn to the classical work of Sargent and Wallace in Section 4.9. The model we consider also shows “unpleasant monetarist arithmetic”. Moreover, a tightening of monetary policy is not only unable to decrease inflation, but also requires a tightening of fiscal policy to stabilize the economy. Section 4.10 considers further feasible constraints on the interaction of fiscal and monetary policies. In reality, a situation in the economy could arise in which even coordinated fiscal and monetary policies will not be able to avoid a debt crisis and hyperinflation. Macroeconomic policies should be determined keeping this in mind and the situation should never be allowed to approach this dangerous point.

We draw final conclusions in Section 4.11. The examples of interaction between fiscal and monetary policies that were considered earlier can be used to give one possible explanation for the nature of the mistakes in macroeconomic policy in Russia that made the 1998 crisis inevitable. Other considerations, however, underline the future advantages that current policies make possible. The Appendix to this chapter contains further material of a technical nature, which deals with the analysis of the dynamics of an economical system.

4.2. Stability of the backward-looking dynamics and macroeconomic policies

Let us return to the basic model for the dynamics of public debt and real money balances:

$$\begin{cases} \dot{b} = d + rb - \mu m, \\ \dot{m} = \left(\mu - \pi\left(m\right)\right) m. \end{cases} \tag{4.1}$$

As was shown in the previous chapter, if we linearize (4.1) in a neighborhood of the equilibrium point (b^*, m^*), then the system

$$\begin{pmatrix} \dot{b} \\ \dot{m} \end{pmatrix} = \begin{pmatrix} r & -\mu \\ 0 & -\dfrac{\mu}{\varepsilon^*} \end{pmatrix} \begin{pmatrix} b - b^* \\ m - m^* \end{pmatrix} \tag{4.2}$$

will have an unstable steady state (an unstable node[3]). The eigenvalues of the corresponding Jacobi matrix are $\lambda_1 = r$ and $\lambda_2 = -\dfrac{\mu}{\varepsilon^*}$. Taking into account that the second equation in the system does not explicitly contain b, it is not difficult to describe the dynamics of real money balances and public debt[4]:

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[3] It should be pointed out that it is theoretically possible that $\mu = -r\varepsilon^*$, and the two roots will be equal. The system will then bifurcate, and an equilibrium of a node type will become a diacritical node. Assuming that the demand function for money is concave to inflation expectations ($\pi''(m) > 0$), either the bifurcation point will be unique (if it exists), or, for a Cagan function with constant semi-elasticity ($\varepsilon = \alpha\pi$), any equilibrium will be a diacritical node if $\alpha r = 1$. However, this bifurcation does not seem to be of interest itself, and we will not consider this case.

[4] Equations (4.3)—(4.4) were found from the linearized system (4.2). The dynamics of real money balance and public debt far from equilibrium may be somewhat different. However, as we pointed out in the previous chapter, the presence of the limiting cycle for the system is unlikely.

$$m(t) = m^* + (m_0 - m^*)e^{-\frac{\mu}{\varepsilon^*}t}, \tag{4.3}$$

$$b(t) = b^* + (b_0 - b^*)e^{rt} + \frac{\mu\varepsilon^*}{\mu + r\varepsilon^*}(m_0 - m^*)e^{-\frac{\mu}{\varepsilon^*}t}. \tag{4.4}$$

As was pointed out above, the very fact that the system (4.1) is dynamically unstable creates certain difficulties and demands further elucidation of the character of macroeconomic policies. Practically the entire analysis in Chapter 3 was conducted under the assumption that monetary policies were dependent — we considered the dynamics of the money market and forced changes in the rate of increase of the money base for exogenous fiscal policy parameters d and b for both the inflation tax Laffer curve model and the following study of the bifurcation of the system. It was possible to avoid the problem of instability of the system (4.1) mostly because of the fact that in most cases stable or unstable equilibria on the money market exist for these parameters of fiscal policy.

It is, however, quite obvious that the assumption that monetary policies are dependent is possible, but hardly universal. This means that we need to consider the problem of instability of (4.1) for a more general case. As we have pointed out above, the second equation of system (4.1), which describes the dynamics of the money market, does not explicitly depend on the fiscal variables. However, as we discussed in Section 2.2, the first equation in the system should be considered to be a *joint* constraint on fiscal and monetary policies. This brings us to two important conclusions. First of all, the money market can be stabilized by using monetary policies alone. However, this (formal) conclusion is tempered by the fact that stabilization of the money market itself, given the unstable dynamics of the fiscal sphere, cannot be considered to be a satisfactory result of macroeconomic policies. Secondly, the interaction of fiscal and monetary policies are determined by the first equation of (4.1) (the equation for the dynamics of public debt and, at the same time, the budget constraint for the public sector). For this reason possible suggestions for dealing with the instability of (4.1) should be qualitatively the same as the possible solutions to eradicating the instability of the backward looking dynamics of public debt discussed in Section 2.2, i.e. one should consider the dynamics of the debt to output ratio, develop a macroeconomic policy that would keep the fiscal sphere and money market in a steady state, and finally develop a sustainable macroeconomic policy. Analysis of a sustainable macroeconomic policy is considered in Chapter 5. In this chapter, before moving to the analysis of fiscal and monetary policies that would keep m and b at a steady state, we will investigate how considering the variables as fraction of output changes the qualitative properties of the system.

Using the results of Section 2.2 (the transition to [2.4] from [2.1]) and considering the dynamics of real money balances as a fraction of output instead of (2.11), system (4.1) can be rewritten as

$$\begin{cases} \dot{b}_y = \left(r - g_y\right)b_y + d_y - \mu m_y, \\ \dot{m}_y = \left(\mu - g_y - \pi\left(m_y\right)\right)m_y, \end{cases} \tag{4.5}$$

where, as in Section 2.2, $m_y = m/y$. Linearization of this system in a neighborhood of the steady state (b_y^*, m_y^*) gives an interesting, albeit predictable result.

$$\begin{pmatrix} \dot{b}_y \\ \dot{m}_y \end{pmatrix} = \begin{pmatrix} r - g_y & -\mu \\ 0 & -\pi'(m_y^*)m_y^* \end{pmatrix} \begin{pmatrix} b_y - b_y^* \\ m_y - m_y^* \end{pmatrix}. \tag{4.6}$$

The stability of the steady state now depends on the sign of the first eigenvalue of the Jacobi matrix, $\lambda_1 = r - g$, which can be either positive or negative. The second eigenvector is positive, as before: $\lambda_2 = -\pi'(m_y^*)m_y^* > 0$.

If the growth rate of output is higher than the interest rate, i.e. $\lambda_1 = r - g_y < 0$, the equilibrium point (b_y^*, m_y^*) will be a saddle-point. The set of steady states *BB* and *MM* can be described by the equations:

$$\dot{b}_y = 0, \qquad b_y = \frac{\mu m_y - d_y}{r - g_y}, \tag{4.7}$$

$$\dot{m}_y = 0, \qquad \pi\left(m_y^*\right) = \mu - g_y\,. \tag{4.8}$$

Unlike the curve described by equation (4.10), here the set of steady states of b_y, the curve *BB* in Fig. 4.1, has a negative slope. As for system (4.1), the dynamics equation for m_y (the second equation in [4.5]) does not depend on b_y and the current fiscal policy. It is not difficult to show that in this case the saddle path coincides with the set of steady states of the second equation, the curve *MM*. The latter is horizontal, as before.

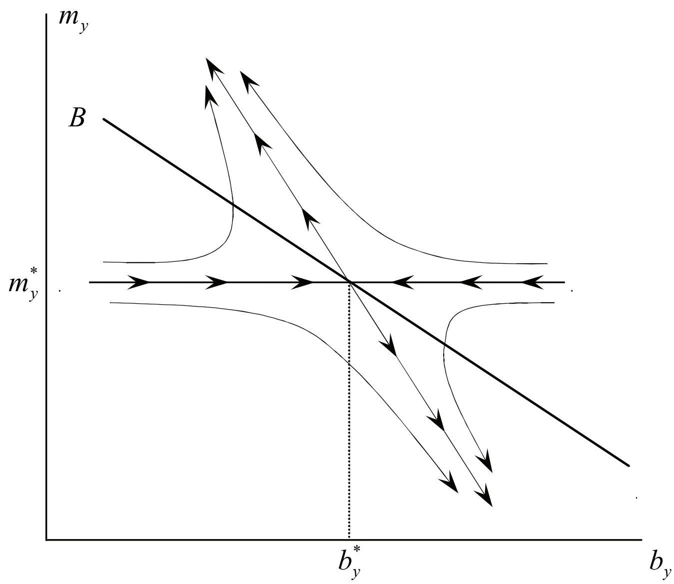

Fig. 4.1. *Phase diagram for b_y and by if $r < g_y$*

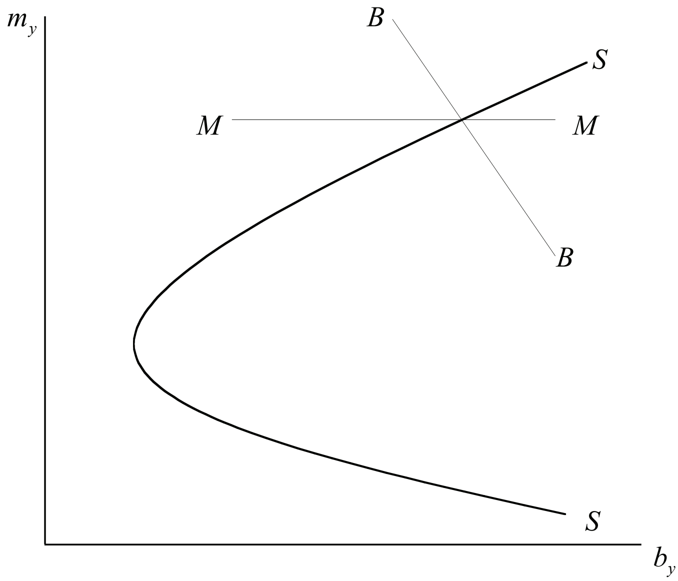

Fig. 4.2. *Set of steady states of b_y and m_y for various values of* μ *if $r < g_y$*

If the central bank sets the growth rate of base money to be equal to the sum of the inflation rate and the growth rate of output in accordance with the initial level $m_y(0)$: $\mu = g_y + \pi(m_y(0))$ (in other words if the economy is initially in the steady state of the money market), then the system will follow the saddle trajectory to equilibrium. The government can allow the volume of real debt to grow, as the ratio of debt to output will approach the equilibrium level. On the other hand, the central bank may choose an arbitrary growth rate of base money and, by conducting the appropriate open market operations, it can put the economy on the saddle path (or directly into equilibrium).

The set of steady states for the system (4.5) for various values of μ can be described by the equation

$$b_y\left(m_y\right) = \frac{\pi\left(m_y\right)m_y - d_y}{r - g_y}. \tag{4.9}$$

In this case the curve *SS* (shown in Fig. 4.2) has a different shape than in Fig. 3.5 in Chapter 3, and we see a limit below which there are no equilibrium values for the growth rate of base money that would be compatible with the size of real public debt. However, this fact is not so important, as the central bank can, by adopting the correct policy, induce the economy to reach equilibrium from any point on the plane. For an economy with high inflation that can be described by system (4.5) — as far as our model is applicable considering our assumptions — a larger size of real public debt should be associated with higher values of the growth rate of base money. This is shown by the lower branch of the *SS* curve in Fig. 4.2. In contrast, if there is low inflation, then higher growth rates of base money correspond to lower steady volumes of public debt. The connection between the steady volume of public debt (as a share of output) and the growth rate of base money in the terms of this model is shown in Fig. 4.3.

These results support the main ideas of Section 2.2. Indeed, if the interest rate is less than the growth rate of output, then the problem of the interaction between fiscal and monetary policies disappears in the framework of this paper (i.e. in the form of a joint budget constraint given by [2.1]). The fiscal sphere is able to independently achieve stable equilibrium given any initial size of public debt. The problem standing before monetary policy is in this case is very much simplified — its only goal is to keep the money market stable. And even if we consider the hypothetical goal of coordinating fiscal and monetary policies in order to achieve some predetermined equilibrium, then, given the analysis given above, attaining this goal is trivial.

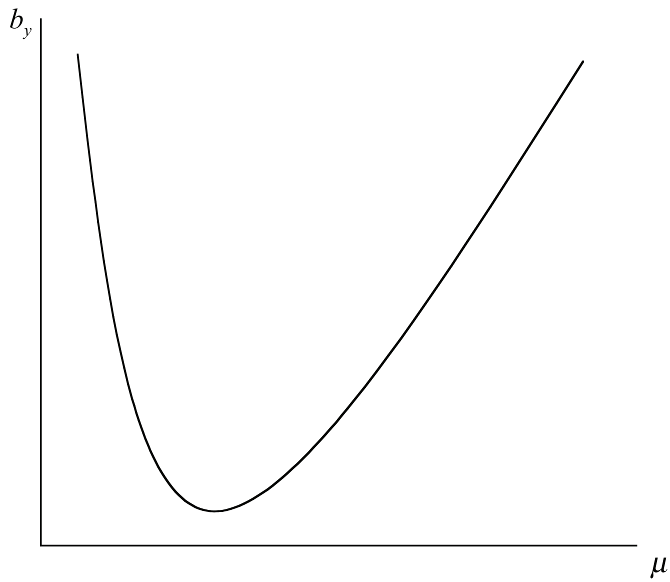

Fig. 4.3. *The connection between b_y and μ in the steady state of the economy if $r < g_y$*

If the interest rate is higher than the growth rate of output, then the system (4.5) will qualitatively have the same properties as system (4.1). It is then evident that there is no principle difference between analyzing the systems (4.1) and (4.5). We will then consider system (4.1) in order to keep notation simple.

We will now turn to the problems that are directly connected with the interaction (coordination) of policies in a situation where the dynamics of real money balances and public debt are unstable. In other words, in analyzing system (4.1), we will consider a macroeconomic policy that keeps the fiscal sphere and money market in a steady state, and further consider the consequences of not keeping to this policy. We will consider several cases that describe the potential of conducting unilateral or coordinated monetary or fiscal policies, as well as the constraints that macroeconomic policies must satisfy.

4.3. Unilateral monetary policy

In a steady state, the rate of inflation is equal to the growth rate of base money. However, as shown in Section 2.3, a decrease in the growth rate of base money in a money market with backward looking dynamics will destabilize the system and bring about the emergence of a bubble and an (unstable) increase in inflation. An increase in inflation will in its turn affect the volume of seigniorage and, consequently, bring about changes in the fiscal sphere. Depending on the initial position of the system on the inflation tax curve, the volume of inflation tax may at first either increase or decrease. However, after achieving the maximum of the inflation tax curve the volume of inflation tax (and seigniorage) will begin to fall[5]. In such a situation the government will be forced to borrow more funds, and the volume of public debt will increase.

Various possible scenarios of how events will unfold for the economy are shown in Fig. 4.4, depending on whether the economy was initially on the "right" or "wrong" side of the inflation tax Laffer curve (the upper and lower branches of the *SS* locus). Initially, the system is in steady state E_0, determined by the intersection of the curves MM_0 and BB_0[6]. A decrease in the growth rate of base money shifts the equilibrium to point E_1, which is determined by the intersection of MM_1 and BB_1. The ensuing dynamics of the system depend on the branch of the *SS* curve and the relative sizes of the parameters of the model: changes in the real money balances and public debt may be either to the left or to the right of the *SS* curve (proof of this fact for small changes in the growth rate of base money is given in the Appendix to the chapter[7]). Fig. 4.4 gives the possible trajectories E_0E_2, E_0A, E_0C, E_0D.

For an economy that was initially functioning at a low rate of inflation (the upper branch of the *SS* curve), a decrease in the growth rate of stationary money base will certainly eventually bring about a decrease in the volume of real money balances, an increase in public debt and in the rate of inflation — the system will come to the region to the bottom and to the right of the intersection of MM_1 and BB_1, from which it cannot escape. If the vector of increments of the variables is left of the *SS* curve, then the system will sooner or later (depending on whether inflation is low or high) re-cross the *SS* curve (trajectory E_0E_2 in Fig. 4.4). If the system begins its movement in the region to the right of the *SS* curve, it may in principle never again re-cross it (trajectory E_0A in Fig. 4.4).

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[5] It should be pointed out that, as the system is not in equilibrium, the volumes of seigniorage and inflation tax are different. In the case we are considering the pure inflation tax is $\dot{m} < 0$. Therefore, the directions of change of seigniorage and inflationary tax may be different.

[6] Note, that it does not mean that economy jumps to point E_1. It keeps staying in point E_0, that is now out of steady state. New vector field corresponds to the new steady state E_1. Analysis in all theoretical experiments in this chapter follows exactly the same logic.

[7] The system is nonlinear and cannot be investigated analytically far from a steady state. The scenarios we consider seem to be plausible to us, but require additional numerical analysis.

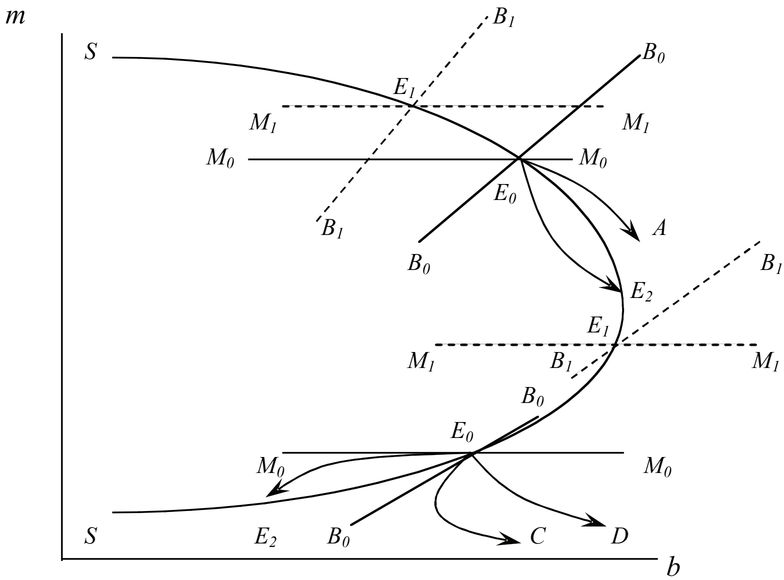

Fig. 4.4. *The consequences of unilateral monetary policy actions (decrease in the growth rate of base money)*

An economy that is initially functioning at a high rate of inflation may face either a decrease (trajectories E_0E_2 and E_0C in Fig. 4.4), or an increase in the volume of public debt (trajectory E_0D in Fig. 4.4) with a decrease in the real money balances and an increase in the rate of inflation[8]. This behavior will be determined by the initial state of the system with respect to the intersection of the curves MM_1 and BB_1. Indeed, the lower left region, which corresponds to a decrease in the debt volume, does not preclude the system from moving to the right region, where the debt will increase[9] (trajectory E_0C in Fig. 4.4). As in the first case, the trajectory E_0E_2 allows the system to return to the *SS* curve, while trajectories E_0C and E_0D do not.

The conclusion is that tight monetary policies which destabilize the economy may not be able to independently (without making changes in the fiscal sphere) return the system to any steady state. (trajectories E_0A, E_0C and E_0D on Fig. 4.4). This kind of tight money policy will bring about an undesirable increase in inflation and, most likely, an increase in public debt as well. The central bank can in principle return the system to equilibrium for trajectory E_0E_2, at the price of increasing the growth rate of base money, and with it the steady level of inflation[10].

[8] This can be explained by the fact that the SS curve is concave with respect to the vertical axis, and that the curve BB_1 has a larger slope than the curve BB_0.

[9] Hyperinflation with an infinitely decreasing volume of public debt is theoretically possible, but hardly likely. The reason is that hyperinflation requires the government to have a public debt that is close to zero or negative in the initially high or hyperinflationary state.

[10] Analogously, the central bank can bring the system to a state where $\dot{m} > 0, \dot{b} < 0$ for the trajectories E_0A, E_0C and E_0D. However, the shape of the *SS* curve and the relative magnitudes of the model's parameters do not always guarantee a return to one of the steady states. We will return to this problem later.

4.4. Unilateral fiscal policy

Unlike monetary policy, fiscal policy is always able to shift the economy from one steady state to another. This can be explained by the fact that monetary policy in this model is formally independent of the government's needs, and changes in the fiscal sphere do not have any *direct* influence on the money market. In its turn, this means that fiscal policy by itself cannot shift the system from one point on the *SS* curve to another. A change in the fiscal policy parameter *d*, the initial budget deficit, will bring about a parallel shift of the *BB* and *SS* curves, and the economy will move along the *MM* curve.

Let's consider the following example. Imagine the government wishes to have a higher level of government expenditures (i.e. a greater initial budget deficit or smaller initial budget surplus) given a certain level of tax (common and inflationary) revenue, and to keep this new expenditure compatible with a steady public debt volume. The only way for the government to achieve this goal independently, even in the future, is to lower the budget deficit (or increase the budget surplus). This kind of fiscal policy will allow the volume of public debt to decrease with time, and with it the size of the resources needed to service it will also diminish. This will let the government increase its expenditures.

This scenario is illustrated in Fig. 4.5. The economy is initially in steady state E_0 on the SS_0 curve. The initial decrease of the primary budget deficit will shift the equilibrium to point E_1 on the SS_1 curve. The money market will remain in its steady state described by the *MM* curve. The volume of public debt will begin to decrease (trajectory E_0E_2 on Fig. 4.5), and after achieving a certain level the government will be able to move the economy to a steady state on the curve SS_2 after increasing the primary budget deficit level. It is important to understand the essence of this change. In reality, this fiscal policy does not change the volume of the *operational* budget deficit, which remains equal to the volume of inflation tax in equilibrium. The reason is that the steady state of the money market does not undergo any changes, and in the final analysis the public debt remains fixed at a new steady level. The government simply changes the structure of the budget expenditures; by decreasing the servicing of the debt, it can increase the *primary* budget deficit. Decreasing the public debt increases the possibilities of the government in the future.[11]

The choice of the size of the initial decrease of the deficit is determined by simple considerations. On one hand, the greater the decrease of the deficit, the faster the public debt will decrease and the sooner the government will be able to allow itself a higher budget deficit. On the other hand, the initial decrease in the budget deficit may be extremely painful for the government both from a political and an economic point of view. Therefore, the government

[11] The opposite is true as well: an accumulation of public debt narrows the alternatives available to fiscal policies in the future. This is the consideration that is the base for the model of strategic debt accumulation in political economy, where a politician in power at a certain time can influence the actions of the politician that will replace him simply by leaving behind a large public debt. See the fundamental works by Persson and Svensson (1989), Tabellini and Alesina (1990), and also Romer (2001, ch. 11), Drazen (2000) and Persson and Tabellini (2000).

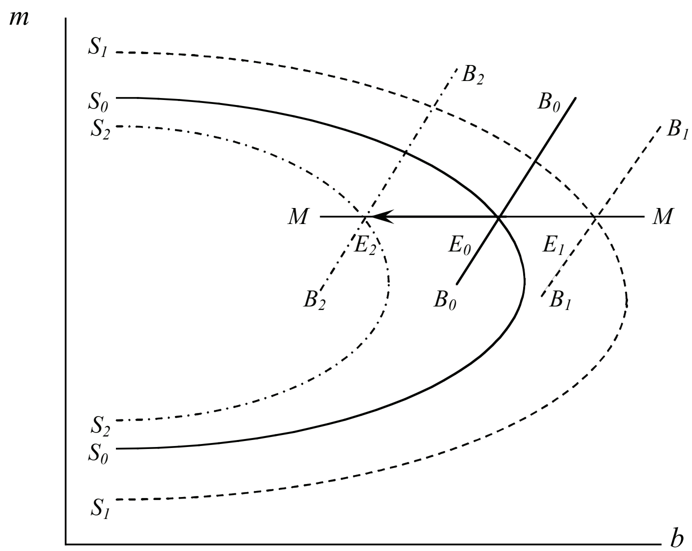

Fig. 4.5. *The consequences of unilateral fiscal policy actions (a decrease in the steady volume of public debt and an increase in the primary budget deficit level)*

faces a problem of optimal choice between the size of the debt today and the time that it will have to wait until it will have a higher deficit, compatible with the steady debt, in the future. This is the same as, given certain assumptions, the government choosing a high budget deficit now or in the future[12].

4.5. Anti-inflationary monetary policies that requires a decrease in the budget deficit

It was shown above that monetary policy that destabilizes the economy under certain conditions is not able to independently return the money market and fiscal sphere to any steady state. We will consider a possible scenario, in which anti-inflationary policies of the central bank require additional actions of a fiscal nature.

Suppose the economy is initially in equilibrium E_0 on the upper branch of the curve SS_0. The final goal of the central bank is to decrease steady inflation from the level of the curve MM_0 to the level of the curve MM_2. Fig. 4.6 shows one of the possible ways to coordinate fiscal and

[12] We do not consider this problem of dynamic optimization. It is qualitatively close to the problem of optimization for a representative agent. The difference is only in that the representative agent, who maximizes his consumption utility, must save more (i.e. increase his assets) in order to have the possibility of consuming more in the future, while the government must decrease its debt (i.e. liabilities) in order to allow itself a higher level of primary deficit (government expenditures) in the future. Or, as it is more often presented in macroeconomics, the government's goal may be to decrease taxes, which is what management of the public debt is used for. See Barro (1979, 1995).

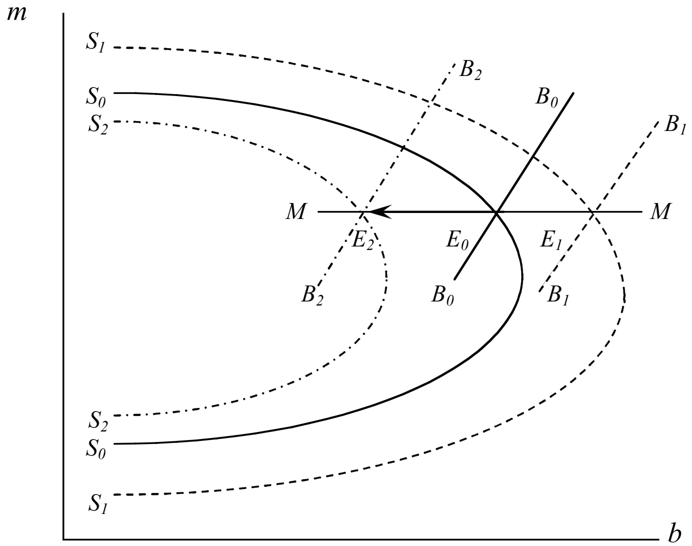

Fig. 4.6. *An anti-inflationary monetary policy that requires a decrease in the budget deficit*

monetary policies[13]. The initial increase in the rate of increase of the money base shifts the equilibrium to point E_1 (while economy keeps staying in point E_0) and brings about an increase of the real money balances and a decrease in the size of public debt: $\dot{m} > 0, \dot{b} < 0$ (trajectory E_0E_2 in Fig. 4.6[14]). Coordination of policies in the simplest case may result in the system coming to point E_2, which corresponds to the target value of steady inflation. In doing so the central bank decreases the growth rate of base money, and the government is forced to decrease the volume of primary budget deficit[15] — and the economy is on the new curve SS_1. The necessity of decreasing the primary deficit after decreasing the servicing of the debt is explained here by the decrease in the volume of inflation tax on the "correct" branch of the inflation tax curve.

4.6. Loose monetary policy and fiscal surpluses in Russia after the crisis, 2000—2003

A year after the August 1998 crisis, Russian macroeconomic policy was rethought. As shown in Section 3.7, the period before the crisis was characterized by a tight monetary policy and large fiscal deficits. In 1996 the growth rate of money was equal to 37.6 percent, while in 1997 it was reduced to 25.8 percent. For the first seven months of 1998, the growth

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[13] We again do not consider the optimality of the chosen scheme; we simply give it as one possible approach.

[14] If the trajectory E_0E_2 was left of the curve SS_0, then the central bank would be able to independently decrease inflation without the help of the government.

[15] Otherwise, a unilateral monetary policy would result in an increase in public debt.

rate of money even became negative and was equal to –3.2 percent. At the same time, the government had been running operational deficits from the beginning of economic reforms in 1992. In 1996 and 1997 the operational deficit was equal to 8.4 and 7.0 percent of GDP respectively.

The policy turnover can be seen starting from 2000. Table 4.1 reports the data on the federal government's operational budget balance, which became positive in 2000. At the same time, just after the crisis, monetary policy became largely loose. In 1999 the annual growth rate of money was equal to 57.5 percent, and in 2000 it was 61.5. Later on, it was decreased, but it nevertheless remained higher than in the pre-crisis period (39.7, 32.4, and 50.5 percent in 2001, 2002, and 2003 respectively). Despite this obviously loose monetary policy, the inflation rate decreased drastically in the second half of 1999 from very high to quite moderate values. Moreover, it continued to slowly decrease thereafter. Figure 4.7 illustrates this fact.

Table 4.1. *Federal government operational budget surplus (percent of GDP), 2000—2003*

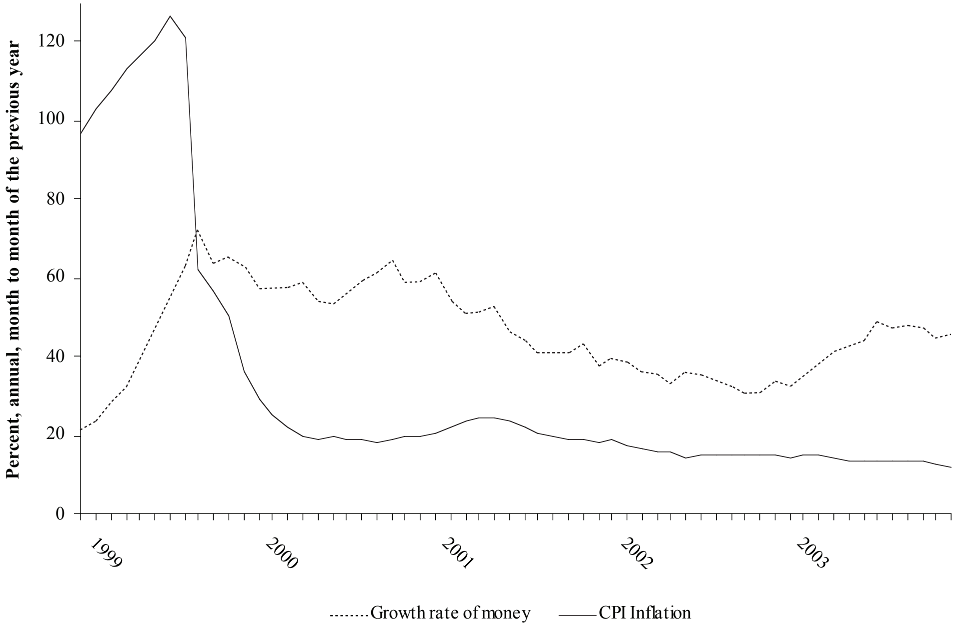
	3 months	**6 months**	**9 months**	**year**
1997	–4.3	–4.3	–3.8	–3.3
1998	–3.5	–3.9	–3.0	–3.2
1999	–2.5	–2.5	–2.5	–1.5
2000	2.1	3.3	3.0	2.5
2001	2.6	3.3	2.7	2.9
2002	5.0	6.3	2.4	1.4
2003	3.1	5.9	6.5	1.7

Source: HSE Economic Journal, Statistics (various issues).

In the fiscal sphere, the turnover in fiscal balance led to a rapid decrease in the value of public debt. Figures 4.8 and 4.9 illustrate this point. After the default, internal government debt (in form of the market instruments GKO and OFZ) was quite low and more or less stable. At the same time, large fiscal surpluses allowed the government to significantly reduce its external debt.

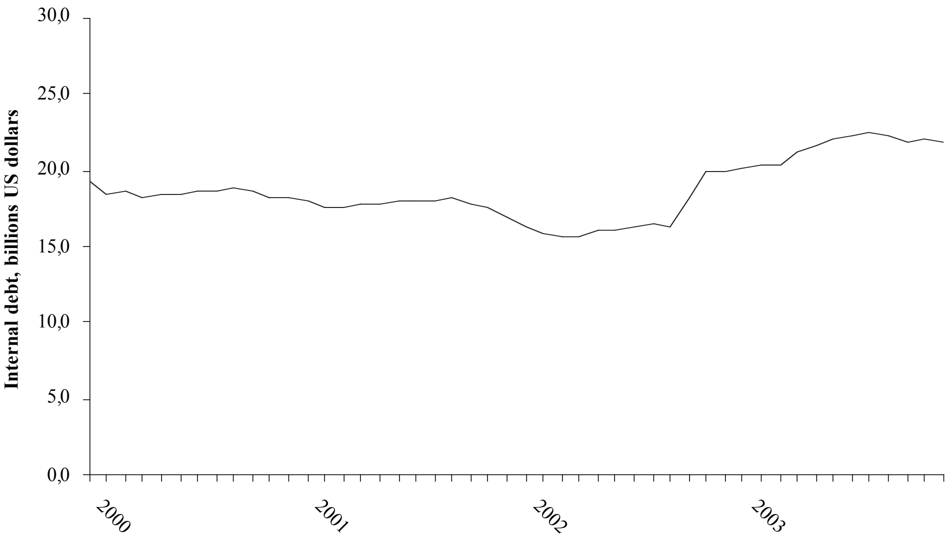
This historical example supports the theory given in Section 4.5.[16] An initial increase in the growth rate of money followed by a decrease in the budget deficit (or an increase in the budget surplus) produces transitory dynamics along the line E_0E_2 in Fig. 4.6. In the new equilibrium E_2 the inflation rate and the public debt both are at lower levels in comparison with the initial state E_0.

[16] In addition, the interest rate was higher than the growth rate of GDP in the period after the 1998 crisis despite the positive and rather high growth rates of Russian GDP.



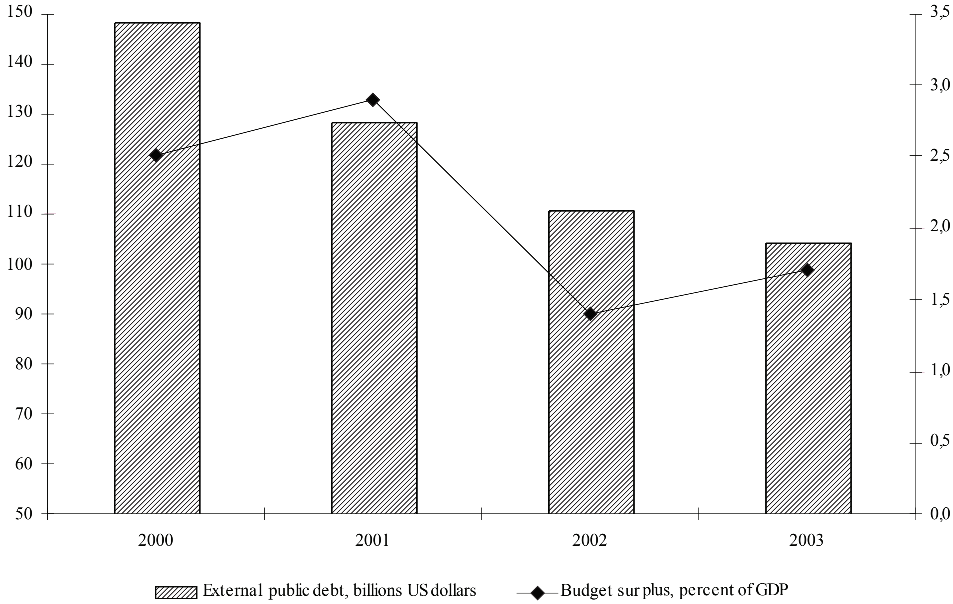
Source: CBR; HSE Economic Journal, Statistics (various issues).

Fig. 4.7. *Growth rate of money and inflation rate in Russia, 1999—2003*



Source: CBR.

Fig. 4.8. *Internal debt in market instruments (GKO-OFZ) in Russia, 2000—2003*



Source: CBR; HSE Economic Journal, Statistics (various issues).

Fig. 4.9. *External public debt and federal government budget surplus in Russia, 2000—2003*

Limitations

Several considerations weaken the illustrative validity of this historical example. First. Why should this period be considered? In fact, fiscal surpluses were positive not only for the period of 2000—2003, but in subsequent years as well. Nevertheless, we restricted our example to this period. This is due to the extraordinary events in the fiscal and monetary spheres that took place in 2004. The first event was that, starting from January 1, 2004 the Russian Government began to accumulate the Stabilization Fund, which has reached more than 70 billion US dollars by the end of 2006. This Fund partly acts as a mechanism for pumping out excess liquidity resulting from a large net export that, in its turn, stems from favorable (for Russia) world oil prices and from the CBR's intervention aimed at keeping a high US dollar's exchange rate. This implies a quite different mechanism for the interaction of fiscal and monetary policies, in which the central bank creates inflation via foreign exchange market operations, rather then via open market operations with government liabilities. Moreover, quite in contrast, fiscal policy is engaged in quasi-monetary activities to sterilize loose monetary policy. It is interesting to note that there seems to be no sizeable success in further reducing the inflation rate for the period 2004—2006 — it has been stuck at levels slightly higher than 10 percent per annum. The second event was the real threat of a banking crisis in Russia in July-August of 2004. The panic was provoked by certain real facts as well as rumors about a number of banks in trouble with their balance sheets. The CBR was forced to inject liquidity into the banking sector by decreasing its discount rate (the "refinancing rate", in Russian terminology) and by decreasing the required reserves ratio. This is an obvious outlay for our analysis. And this is something that is not considered in our models.

Second. Returning to Russia in 2000—2003, one should not view this period as an example of an *active* contractionary fiscal policy and a *purposely* pro-inflation monetary policy. In fact, these were simply a response to a huge positive trade balance and a growing export sector starting from 2001. However, as we are not concerned with the real sector of the economy — treating taxes, government spending and money supply as exogenous with the respect to the other components of the economy (but not to each other, of course) — and we do not consider the structural budget surplus, this fact is not important here.

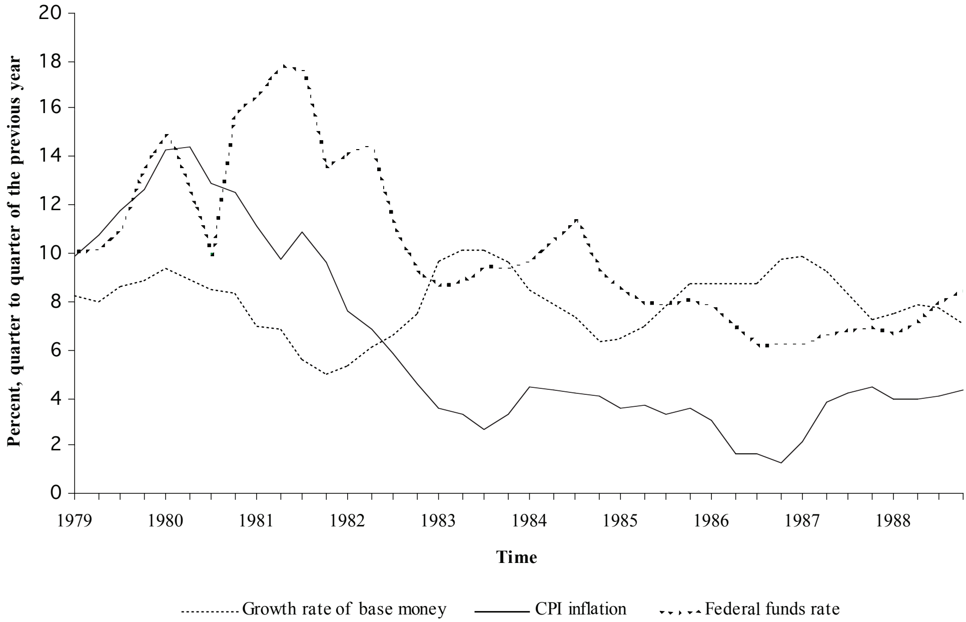
Third, and the most important. The fact that monetary policy in Russia after 2000 operated mostly through the foreign exchange market creates obvious difficulties in interpreting this historic episode in support for the theory developed in Section 4.5. Throughout our analysis, we assumed that new money is created as the central bank exchanges base money for government debt. The tremendous growth rates of money after the 1998 crisis, reported in Fig. 4.7, resulted from the exchange of base money for foreign currency (mainly the US dollars). This represents the huge international reserves accumulated by the CBR for that period: while it was approximately \$12.5 billion at the beginning of 2000, it increased to \$76.9 billion by the end of 2003 and continued to rise. Nevertheless, while one should interpret data on loose monetary policy in Russia after 1999 only in view of its open-economy aspect, we still believe that this episode may support our theoretical example, as long as some smaller part of the increase in base money was provided via open market operations with government bonds.

4.7. Reaganomics I: A backward-looking interpretation

Macroeconomic policy in the U.S. in the 1980s provides a prominent historical episode. In the absence of any hint of currency crisis, it is much easier and more straightforward to interpret public debt and inflation dynamics in a purely fiscal-monetary framework. Moreover, given that research in the field of macroeconomic policy coordination was inspired by the original paper by Sargent and Wallace, which was in its turn motivated by U.S. policy in the beginning of the 1980s, it is quite natural to analyze this episode by means of the model studied in this chapter.

Indeed, Paul Volcker's attempt to decrease the inflation rate and Reagan's deficits have attracted quite a lot of attention in the literature.[17] Figures 4.10 and 4.11 illustrate the monetary and fiscal stance of the U.S. economy in the period between 1978 and 1988. In October 1979, soon after Paul Volcker became chairman of the Federal Reserve, a sharp change in monetary policy was announced. While technically it was a shift from interest rate targeting to monetary base targeting, the conceptually new policy was meant to resolve the inflation problem: inflation was well above 10 percent per annum during the late 1970s. Despite the

[17] On the main insight into the subject and reviews, see Feldstein ed. (1994).



Source: International Financial Statistics, IMF.

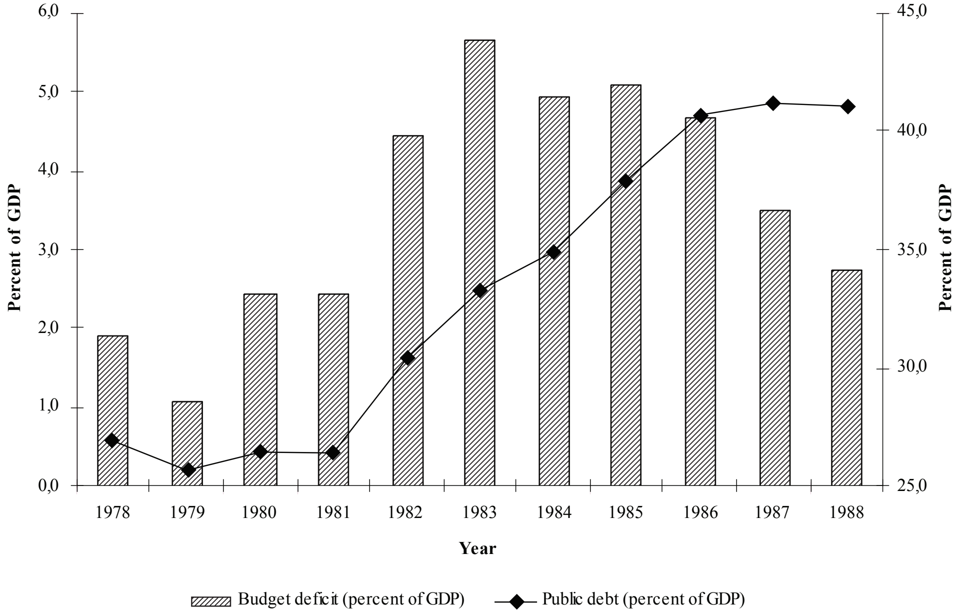
Fig. 4.10. *Monetary policy and inflation in the U.S., 1979—1988*

high unemployment cost of this program, despite the widely held view that the policy was not credible lasted at least until the end of 1980, and despite the fact that the policy was indeed inconsistent (see the non-successive behavior of the federal funds rate and the monetary base in Fig. 4.10), the main goal was achieved: inflation was brought down to single-digit range and remained well below 5 percent annually by the end of 1982 (see Fig. 4.10).[18] At the same time, the period of Reagan's administration was characterized by very high budget deficits and a sharp increase in the U.S. debt with a slowdown only in the late 1980s (see Fig. 4.11).

The question that we are trying to answer, and that was originally raised by Sargent and Wallace (1981), is whether this fiscal-monetary policy mix was credible (or sustainable). And if the answer is negative, then what policy options are available to stabilize the economy after the period of tight monetary policy and budget deficits? As was briefly discussed in Section 2.4, the "unpleasant monetarist arithmetic" gives a negative answer to the first question.[19] Later, Sargent (1985, 1986) suggested an interpretation of the non-credibility of disinflation in the face of ongoing fiscal imbalances as a "game of chicken" between fiscal and monetary authorities (which was originally orally proposed by Neil Wallace). In order to stabilize the

[18] See a discussion of the policy in Brimmer (1983) and Blanchard (1984) for early critiques, and modern discussion in Clarida, Gali and Gertler (2000), Sargent, Williams, and Zha (2004), Friedman (2005), and Goodfriend and King (2005), among others.

[19] We will discuss whether this policy mix is inevitably incredible later in Chapter 5.



Source: International Financial Statistics, IMF.

Fig. 4.11. *Budget deficit and public debt in the U.S., 1979—1988*

public debt dynamics, either the administration or the Federal Reserve must "chicken out". That is, either the government needs to reduce the budget deficit, or the central bank needs to ease its monetary policy and provide more seigniorage for the government's need.

Sargent notes that in fact the Federal Reserve gave in first in August, 1982. Specifically, it decided to reduce the federal funds rate after the Mexican crisis that posed a threat to financial stability inside the U.S. However, as one can easily see from Fig. 4.10, despite this policy shift and a substantial increase in the growth rate of base money from late 1981 to the middle of 1983, the inflation rate continued to fall until the middle of 1983. After another, rather modest increase in 1983, the inflation rate continued to decline further. Even if we take into account some reasonable lags in the response of inflation to monetary policy, it seems that inflation was falling at the same time when monetary policy was loose. To complete the description, we should note that in the period from 1982 until 1986 budget deficits were notably high. During this period the public debt to GDP ratio increased by more than 10 percent points (see Fig. 4.11). A certain stabilization can be noted to have taken place after the deficit reduction in 1987 and 1988.

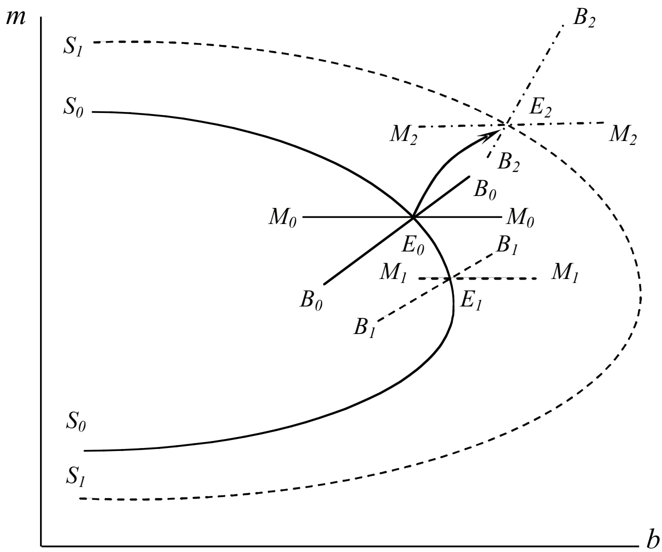


Fig. 4.12. *Disinflation and the rise of public debt following the ease in monetary policy*

Here we propose an explanation of this episode in the framework of the analysis in Section 4.5.[20] Consider again the dynamics of public debt and real money balances following an increase in the growth rate of base money as shown in Fig. 4.6. The trajectory E_0E_2 is such that both inflation and public debt are declining (while real money balances are rising). But this is not the only possibility in this case. Figure 4.12 demonstrates that after an increase in the growth rate of base money, public debt may decrease while inflation decreases (real money balances are rising). The vector field associated with the new (temporal) steady state E_1 allows this scenario as well as a decrease in public debt depicted earlier in Fig. 4.6. The system may remain fixed in the new steady state E_2 if the government cuts its budget deficit (so that the curve SS shifts to the right to the new position SS_2). And indeed, as we see in Fig. 4.11, that was the fiscal policy adjustment that took place at the end of the disinflation program of the 1980s.

4.8. The policy of increasing the primary deficit by temporarily increasing the volume of seigniorage

We will now consider the case in which the government is forced (perhaps permanently) to increase the volume of the primary budget deficit. If the central bank does not interfere, this will give rise to an unsustainable growth of the public debt. Can a change in monetary policy bring the economy to a steady state that is compatible with the new level of primary

[20] In Chapter 4 we suggest another explanation that is based on forward-looking considerations and is closer to the original idea of Wallace's "game of chicken".

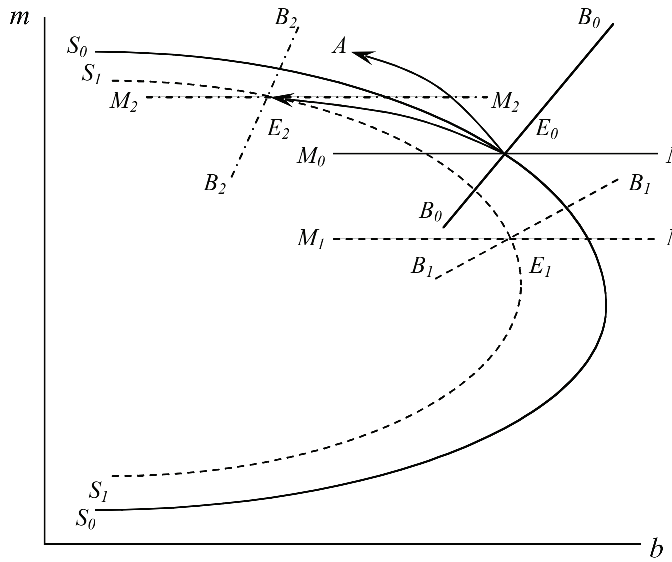


***Fig. 4.13.** The policy of increasing the primary deficit by increasing the volume of seigniorage*

debt? The answer to this question depends on how much the deficit changes and on the relative magnitudes of the parameters of the model.

Figure 4.13 shows a possible scenario for events to unfold. The system is initially in equilibrium E_0 on the curve SS_0. An increase in the primary budget deficit brings about a shift in the set of steady states onto curve SS_1. The volume of public debt will increase for the old growth rate of base money (curve MM_0) as a result of the inadequacy of the old volume of inflation tax for covering the increased operational deficit. A possible way out of this situation is an increase in the volume of seigniorage by increasing the growth rate of base money. This corresponds to shifting the equilibrium to point E_1 on the curve SS_1 as shown in Fig. 4.13 (while economy keeps staying in point E_0). The economy is then in a state where $\dot{m} > 0, \dot{b} < 0$ with respect to the new steady state. However, the ensuing dynamics of the system may either bring (trajectory E_0E_2) or not bring (trajectory E_0A) the economy to a steady state on the curve SS_1. In the first case, the central bank at a certain moment must fix the growth rate of base money at a level corresponding to equilibrium E_2 (locus MM_2). In the second, monetary policy by itself cannot return the economy to any steady state without tightening policies in the fiscal sphere.

4.9. Consequences of "unpleasant monetarist arithmetic" for fiscal policy

Using the results of Section 4.3, we can consider the results of a temporary decrease in the growth rate of base money using assumptions analogous to those of Sargent and Wallace (1981). Initially, when the central bank decreases the growth rate of base money, the

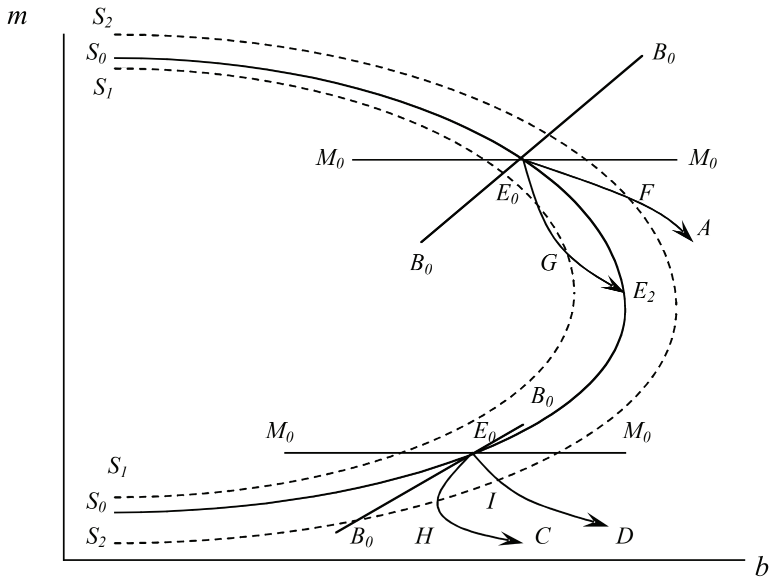


***Fig. 4.14.** The consequences of decreasing the growth rate of base money: "unpleasant fiscal-monetary arithmetic"*

economy is in equilibrium at point E_0. Depending on the where the economy is on curve SS_0 and the relative values of the model's parameters, the system will move along one of the possible trajectories E_0E_2, E_0A, E_0C, or E_0D[21] (see Fig. 4.14). Assume that at a certain moment T in the future the economy will be at a steady state. The characteristics that the new state will have in comparison with the initial state depend on the trajectory of the transitional dynamics of the system.

It is obvious that for any transitional trajectory, the growth rate of base money that is compatible with the new steady state must be greater than it was initially. This also means a higher level of steady inflation, which is what we call the "unpleasant monetarist arithmetic" of Sargent and Wallace. If the economy turns out to be on trajectory E_0E_2, and the time interval $[0, T]$ is sufficiently small, then the new steady state G will correspond to a higher level of primary budget deficit. Even given an increase in the steady level of the volume of public debt, this can be considered from a certain point of view to be an improvement in the government's position.

If the system begins to move along the trajectories E_0A, E_0C, or E_0D, then the corresponding new steady states F, H, and I will be on the curves SS_2[22], where the value of the primary budget deficit is higher in comparison with SS_0. Here the states F and I are characterized by

[21] The trajectory E_0E_2 on the lower branch of the curve SS_0 is not considered, as it is unlikely

[22] The points F, H and I are shown to lie on one curve in Fig. 4.14 for clarity. This is possible if we choose varying time intervals $[0, T]$ for each of the corresponding trajectories.

a higher volume of public debt, while the new steady state for trajectory E_0C may correspond to a decrease in the steady volume of the debt. Such a situation can be characterized not only as "unpleasant monetarist arithmetic", but also as "*unpleasant fiscal-monetary arithmeti*c" — the government turns out to be in a worse situation than it was initially.

4.10. Feasibility constraints on the interaction of fiscal and monetary policy

The previous examples may give the incorrect impression that it is always possible to use fiscal and monetary policies to fix the economy in a steady state, if not bring it to a predetermined desirable state. However, this is not true even given the backward looking behavior of economic agents and a developed market of government bonds.

First of all, this is because of a limitation from below (and, possibly, from above) of an instrument of fiscal policy — the primary budget deficit. Unlike the parameter of monetary policy μ, which can assume practically any value, the magnitude of the primary budget deficit (surplus) is bounded from below (above). From a formal point of view, the volume of government expenditures cannot be negative and tax revenues has a maximum defined by the standard Laffer curve. In real life, the government is hardly interested, even in the face of a debt crisis, to decrease expenditures below a certain positive level or "squeeze" the maximum possible taxes from the economy for obvious economic and political reasons. Therefore, even if the government is able to create primary budget surplus, its magnitude will have a natural upper bound[23]. In this situation one can say that fiscal policy has a *feasibility constraint*[24]. Denote the minimum volume of primary deficit[25] to be d_{min}. The existence of d_{min} means that after the public debt has achieved a certain critical value the government will be unable to independently stop the further unsustainable growth of the debt.

Secondly, as we showed above, monetary policies are not always able to independently bring the economy to any steady state. Even though the central bank can change the direction of change of the real money balances and secure a decrease in public debt by providing an arbitrarily high volume of seigniorage given backward looking dynamics of the money market, the system may not return to the equilibrium curve *SS*.

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[23] It would be logical, however, to suppose the existence of an upper bound for the budget deficit as well, one that would be defined by a maximum level of government expenditures, among other things. The problem here is that of determining the optimal level of government intervention in the economy (see, for example, Leslie (1995, ch. 1)) and of other considerations as well. However, this does not of principle importance for our investigations.

[24] See, for example, Agenor (2000). We should point out here one shortcut of our analysis. The fact that we consider the interaction of fiscal and monetary policies apart from general equilibrium in the economy means that we completely ignore the following important problem. Changes in macroeconomic policy now or in the future can bring about changes in the feasibility constraint. For example, macroeconomic policy may change the maximum possible volume of tax revenue. Of course, this line of investigation is interesting, but it would significantly complicate our analysis and would not influence our key results.

[25] If there is a budget surplus, this value will be negative. Possibly this boundary, like the other variables and parameters of the model, should be defined relative to emission; however, as pointed out above, this is not of principle importance for our further investigations.

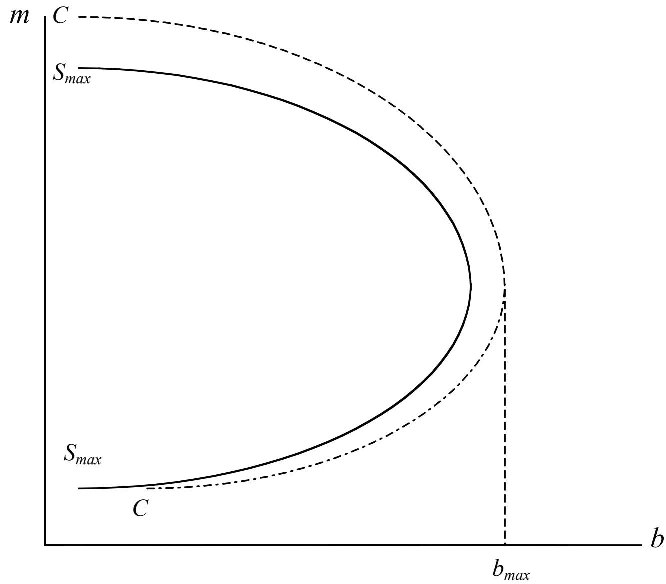

Fig. 4.15. *Constraints on the interaction between fiscal and monetary policies*

From a formal point of view, having d_{min} gives rise to constraints for the existence of steady states of the system for any rates of growth of base money. There exists a boundary curve SS_{max},[26] to the right of which no equilibrium is possible (see Fig. 4.15). This curve in the first approximation can be considered to be the boundary, to the right of which there is a region that monetary and fiscal polices, even working together, are not able to move the economy out of, nor are these policies able to stabilize the economy. Actually, it is more probable that the boundary of this "crisis region" should lie somewhat more to the right (for example, curve *CC* in Fig. 4.15). Given the existence of μ (see the Appendix to this chapter), this boundary may coincide with the curve SS_{max} on a certain interval. The nonlinear character of the system being considered does not allow one to derive an equation for this boundary using analytical methods. General considerations, however, seem to indicate that it will be a curve concave to the vertical axis, and it will determine the maximum allowable value of the public debt b_{max}[27].

In light of our results, the interaction of fiscal and monetary authorities has a necessary limitation — their policies cannot let the economy approach the "crisis region", where the dynamics of public debt at the very least will be unstable[28]. We should point out that, by its

[26] In other words, equilibria located to the right of the curve SS_{max} correspond to *infeasible* fiscal policies.

[27] This value may exceed or be equal to the limitation determined by fiscal policy alone.

[28] Given the assumptions of the model, the central bank can always bring the money market back to a steady state by setting the growth rate of base money.

very essence, this limitation that has appeared on the interaction between fiscal and monetary policies is a consequence of the feasibility constraints imposed on fiscal policies.

4.11. Summary and conclusions

The conclusions that can be made by considering this model are based on the assumptions regarding the inertial character of the backward looking dynamics of the money market. However, even though this hypothesis can hardly be considered universal or indisputable, the results of our analysis mostly agree well with the experience of macroeconomic stabilization.

The first interesting result is that unilateral monetary measures may not be able to bring the economy back into equilibrium, while the government (if this does not violate the limitations on the variables of fiscal policy) can always shift the volume of public debt from one steady state to another without changing the inflation rate. If inflation has a significant inertia, then the reaction of economic agents to assurances that monetary stabilization is forthcoming may be weakened. In this case the dynamics of inflation may to a significant extent be determined by the prehistory of the process, rather than expectations concerning future conditions. This conclusion agrees well with the experience of stabilizing high inflation economies. As a rule, all attempts to stabilize an economy by applying orthodox (purely monetary) policies have met with failure. Researches currently agree[29] that heterodox stabilization should be of foremost interest both in terms of importance, and in terms of sequence of actions. Heterodox stabilization consists first in the balancing of the fiscal sphere and in moving it out of the crisis. A second important conclusion is that in a situation where the government is at the limits of its possibilities and it may not be able to stem the unstable increase in public debt, the central bank may also be unable to bring the system back to any equilibrium. Therefore, in most cases the government must move after the central bank, so that the economy can return to a steady state. At the same time, if the government is operating within the region of feasible values of the fiscal policy parameters, then its actions, which do not influence the monetary sphere, may not require a response from the central bank.

We believe that these general conclusions agree well with the results of macroeconomic policy that can be observed in Russia. One of the factors that made the crisis of 1998 unavoidable was the doomed attempt to stabilize the financial system (and, in particular, inflation) by applying tight monetary policies that were not supported by tight fiscal policies, namely by the balancing of the budgetary sphere. Even if we suppose that investors in 1996—1998 perceived the government's fiscal policy to be stable (which is doubtful), then the obvious mistake of both the government and the central bank was that they allowed the fiscal sphere to approach the dangerous boundary of feasible policies. Indeed, the default could have been avoided if the government had been able to at least temporarily tighten fiscal policy and de-

[29] See, for example Beckerman (1992), Bruno (1993), Dornbusch (1993), Heymann-Leijonhufvud (1995).

crease the primary deficit. But such possibilities can be discussed only in the subjunctive, if only because a stable policy turned out to be impossible.

On the other hand, the fact that the Russian government has been able in the last few years to form a budget surplus and achieve a decrease in public debt means that the government has improved the set of alternatives available to macroeconomic policy in the future.

The remaining results may be summed up as follows.[30] If monetary policy turns out to be unable to independently shift the economy to a new steady state with a lower level of inflation, then the government's actions should be aimed at decreasing the primary budget deficit. For an economy with low inflation, the decrease in the inflation tax turns out to be greater than the decrease in the public debt service. In an economy with high inflation, on the contrary, an increase in revenues from issuing money may not be enough to cover the increased interest payments on the debt.

A government which faces the necessity of increasing the primary budget deficit but does not want its debt to spiral out of control, should count on a temporary increase in seigniorage. Under low inflation this will require an increase in the growth rate of base money, and under high inflation the growth rate of base money should be decreased. The new equilibrium (with low or high inflation) will be characterized by a lower volume of inflation tax and an increased primary deficit, which will be compensated by decreased payments for servicing the debt.

Sargent and Wallace's result, the principle of "unpleasant monetarist arithmetic", under certain ratios of the parameters of the model and of the experiment can be amplified. A decrease in the growth rate of base money given no change in the fiscal sphere can not be perpetual. A temporary decrease in the growth rate of base money can bring about not only an increase in inflation both on the transitional trajectory and at the new steady state, but it can also bring about a necessity in tightening fiscal policies — the volume of the primary budget deficit must be decreased in the new steady state.

Appendix. Analysis of the transitional dynamics of the system

Consider the following theoretical experiment. At time the growth rate of base money is $\mu = \mu_0$. The economy is in a steady state, where $m(0) = m_0^* = m_0$, $b(0) = b_0^* = b_0$ and $\mu_0 = \pi(m_0)$. At time $t = t_1$ the central bank changes the growth rate of base money, so that $\mu = \mu_1$. The equilibrium of the system shifts to a new position, $m_1^* = m^*$, $b_1^* = b^*$, in which $\mu_1 = \pi(m^*)$ and the elasticity of demand is $\varepsilon_1^* = \dfrac{\mu_1}{\pi'(m^*)m^*}$.

[30] We have discussed only what we consider to be the most interesting examples, while in fact the model can be used to analyze the possibilities and consequences of the entire spectrum of possible interactions between the government and the central bank. The difficulties of carefully analyzing the transitional dynamics of the system means that further investigation of the scenarios we consider here can be done only by numerical methods.

Suppose that the change in the growth rate of base money is infinitely small, and consider the dynamics of the system in a neighborhood of the new equilibrium. We can express the size of public debt as a function of real money balances by using the dynamic equations (4.3) and (4.4)[31]:

$$b(m)=b^*+\left(b_0-b^*\right)\left[\frac{m-m^*}{m_0-m^*}\right]^{-\frac{r\varepsilon_1^*}{\mu}}+\frac{\mu_1\varepsilon_1^*}{\mu_1+r\varepsilon_1^*}(m-m^*). \tag{A4.1}$$

From here we can calculate the derivative of public debt with respect to the size of the real money balances on the trajectory of the variables' increments in a neighborhood of the equilibrium point:

$$b'(m)=-\frac{r\varepsilon_1^*}{\mu_1}\frac{b_0-b^*}{m_0-m^*}\left[\frac{m-m^*}{m_0-m^*}\right]^{-\frac{r\varepsilon_1^*}{\mu_1}-1}+\frac{\mu_1\varepsilon_1^*}{\mu_1+r\varepsilon_1^*}, \tag{A4.2}$$

and in the initial condition of the system:

$$\begin{aligned} b'(m=m_0)&=-\frac{r\varepsilon_1^*}{\mu_1}\frac{b_0-b^*}{m_0-m^*}+\frac{\mu_1\varepsilon_1^*}{\mu_1+r\varepsilon_1^*}=\\ &=-\frac{\varepsilon_1^*}{\mu_1}\frac{\mu_0 m_0-\mu_1 m^*}{m_0-m^*}+\frac{\mu_1\varepsilon_1^*}{\mu_1+r\varepsilon_1^*}. \end{aligned} \tag{A4.3}$$

Here we used the fact that $b(m)=\dfrac{\mu m-d}{r}$ in the steady state.

Now consider the limit as $\mu_1 \to \mu_0 = \mu$ (or $m^* \to m_0$). We get the slope of the dynamic trajectory for any initial condition lying on the curve *SS*:

$$b'_m\big|_D=-\varepsilon\left(1+\frac{1}{\varepsilon}\right)+\frac{\mu\varepsilon}{\mu+r\varepsilon}, \tag{A4.4}$$

where, using the equality of steady inflation and growth rate of base money, we have $\varepsilon=\varepsilon(\mu)=\dfrac{\mu m'(\mu)}{m(\mu)}$.

We can calculate the slope of the curve *SS* from equation (3.12) for every possible value of the growth rate of base money:

$$b'_m\big|_{SS}=\frac{\mu}{r}\left(1+\frac{1}{\varepsilon}\right). \tag{A4.5}$$

[31] As noted above, we do not consider the case $\mu = -r\varepsilon^*$(or $\alpha r = 1$ for the demand function with constant semi-elasticity), when the equilibrium of the system becomes a diacritical node.

It is not difficult to see that the difference between the slopes of the dynamic trajectory and the curve *SS*,

$$\Delta(\mu) = b'_m\Big|_D - b'_m\Big|_{SS} = \frac{\mu\varepsilon}{\mu + r\varepsilon} - \frac{\mu + r\varepsilon}{r}\left(1 + \frac{1}{\varepsilon}\right), \tag{A4.6}$$

can be either positive or negative. In other words, the dynamics of the system may head either to the right or to the left of the curve *SS*.

In particular, for the Cagan demand function (2.11) with constant semi-elasticity, $\varepsilon(\mu) = -\alpha\mu$, we have

$$\Delta(\mu) = \frac{1 - \alpha r}{\alpha r} - \frac{\alpha r + (1 - \alpha r)^2}{r(1 - \alpha r)}\mu. \tag{A4.7}$$

In this case there is a unique value $\mu = \left(\alpha\left[1 + \frac{\alpha r}{(1 - \alpha r)^2}\right]\right)^{-1}$ for which the function $\Delta(\mu)$ equals zero. The value of μ may assume either small or large values, depending on the value of the semi-elasticity of money demand and the interest rate.

Chapter 5
Fiscal and monetary policy interaction II: The role of expectations, inflationary and fiscal regimes

5.1. Introduction

In Chapter 2 we considered one of the basic approaches to the formulation of macroeconomic policy, namely the principle of a sustainable fiscal policy. This principle states that at every point in time the volume of public debt must be backed by the real value of the pure income of the government, which is generally determined as the sum of the primary budget surplus and seigniorage. In this chapter we will investigate unilateral and joint actions of the government and central bank that will keep the public debt on a sustainable path. It is of principle importance that the central bank is able to control the flow of seigniorage for given values of the primary budget deficit (surplus). This consideration is obviously of great practical importance for countries in which seigniorage is a significant source of financing the budget deficit.

The model suggested below allows us to widen the principle of T. Sargent's and N. Wallace's "unpleasant monetarist arithmetic" (considered in Section 2.4) in certain aspects. First of all, a decrease in the growth rate of base money may bring about either a decrease or an increase in the steady level of seigniorage depending on the rate of inflation prevalent in the economy (on the active branch of the inflation tax Laffer curve).[1] The logic and results of the Sargent and Wallace model are true only for the "right side" of the inflation tax Laffer curve, that is, for low inflation (for the section of the demand curve for real money balances that is inelastic with respect to inflation expectations).

Second. The direction of the transitional dynamics of seigniorage may differ from the direction of change in its steady level. An important role is played here by the expectations of economic agents. We assume that expectations are forward-looking, and we additionally allow for the possibility that information about changes in macroeconomic policy becomes available before they are actually implemented. As can be seen from the analysis given in Section 2.3, in this case the expected decrease (increase) in the growth rate of base money will bring about an increase (decrease) in the demand for real money balances even before the actual changes in monetary policy. Here we should remember that seigniorage may be represented as the product of the *actual* growth rate of base money and the volume of real money balances, the demand for which decreases with an increase in the *expected* future actual growth rate of base money. Therefore, both the current volume of seigniorage and the present value of future seigniorage flow may change even before switches in macroeconomic policies are implemented. This factor, beyond any doubt, plays a very important role and, as

[1] This fact was first noted in connection with the principle of "unpleasant monetarist arithmetic" in the papers by Liviatan (1984) and Drazen (1985). See also Liviatan (1986, 1988). The analysis in the second and third chapters also used this very important consideration.

we will show later, may violate the principle of "unpleasant monetarist arithmetic" even in a low-inflation economy.[2]

Third. When formulating either fiscal or monetary policy, one should note that the interest rate on the public debt can also be important; it determines, in essence, the discount factor when calculating the present value of future budget surpluses and of seigniorage. *Ceteris paribus,* a high interest rate makes distant changes in macroeconomic policies less important and forces the government and central bank to concentrate more on their short-run policies. By contrast, a low interest rate will give greater weight to long-run policies. If it is the real value of budget surpluses and seigniorage that is considered by the principle of sustainable fiscal policy, then the value of the interest rate will significantly influence the choice of how fiscal and monetary policies will interact.[3]

This chapter has the following structure. In the second section we determine joint forward-looking dynamics for real money balances, rate of inflation, and public debt. In Sections 5.2—5.10 we study several possible ways in which fiscal and monetary policies may interact. In particular, Sections 5.5, 5.7, 5.9 and 5.10 provide historical experience of the United States, Latin American and Asian countries that serve as counterparts to theoretical scenarios. We show that under certain assumptions monetary policy may be permanently tightened under unchanged fiscal policies, thus avoiding the "unpleasant monetarist arithmetic" of Sargent and Wallace. The examples we discuss do not come close to exhausting all possible types of macroeconomic policy; they do, however, allow us to determine three factors that we consider to be of major importance in choosing how fiscal and monetary policies should interact, namely: (i) future expectations of changes in policies, (ii) inflationary regime (elasticity of the demand for real money balances), and (iii) the interest rate on public debt.

In Sections 5.11—5.13 we consider the consequences of uncertainty about the timing and type of changes in macroeconomic policies. In Section 5.14 we return yet again to the problem of the sustainability and feasibility constraints for macroeconomic policy. In the final section, 5.15, we generalize our results.

The nonlinear character of the inflation and of public debt dynamics does not allow us to investigate the economic system by purely analytical means. The Appendix at the end of

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[2] The role of expectations of future changes in macroeconomic policy (the expectation of future stabilization) was considered extensively. See, for example, Calvo (1988), Drazen and Helpman (1988), Bental and Eckstein (1990), Miller, Skidelsky and Weller (1990), Bertola and Drazen (1993), Sargent (1993), Miller and Zhang (1997), Sutherland (1997), Rankin (1998), Elder (1999), Ruge and Murcia (1999). Our research concerns problems that are closest to those considered by Drazen and Helpman (1990).

[3] As a rule, special attention is paid to the value of the interest rate on the public debt as it determines the associated costs of debt service. See a general overview of this problem by Missale (1999). In considering in essence the same problem, we transfer the analysis to the context of the interaction between fiscal and monetary policies. It should also be noted that we consider the interaction of fiscal and monetary policies under the assumption that the latter determines the growth rate of base money. However, in reality the central bank often pays most attention not to the money base, but rather to the interest rate. In many countries after World War II, monetary policies kept the interest rate at a rather low level, thus decreasing the costs of servicing the public debt. This is an important example of the logic of the interaction of fiscal and monetary policies; however, in this research we consider a monetary policy that controls the money base, not the interest rate.

the chapter contains some numerical values of the parameters in the model and the results of theoretical experiments that confirm the most important results that we arrived at in the chapter.

5.2. Sustainable macroeconomic policy

As in the previous chapter, we will consider here the problems of formulating a common fiscal and monetary policy by using the standard pair of equations that describe the dynamics of the public debt and of real money balances:

$$\begin{cases} \dot{b} = d + rb - \mu m, \\ \dot{m} = \left(\mu - \pi\left(m\right)\right)m. \end{cases} \tag{5.1}$$

However, unlike our previous analysis, in this chapter we will consider the forward-looking dynamics of the variables:

$$x(t) = -E_t \int_t^{\infty} \mu(\tau) e^{-\frac{1}{\alpha}(\tau - t)} d\tau \,, \tag{5.2}$$

$$\pi(t) = \frac{1}{\alpha} E_t \int_t^{\infty} \mu(\tau) e^{-\frac{1}{\alpha}(\tau - t)} d\tau \,, \tag{5.3}$$

$$S(t) = \mu(t) e^{-E_t \int_t^{\infty} \mu(\tau) e^{-\frac{1}{\alpha}(\tau - t)} d\tau} \,, \tag{5.4}$$

$$b(t) = E_t \int_t^{\infty} \left(S(\tau) - d(\tau)\right) e^{-r(\tau - t)} d\tau \,. \tag{5.5}$$

In order to simplify our analysis, and in order to be able to arrive at analytical solutions, we will base our approach on the Cagan function for the demand for real money balances (2.11). As in the case of the backward-looking solution (4.3), the second equation's independence of the public debt and of the parameters of fiscal policy allows us, by using the results of our analysis in Section 2.3, to find the forward-looking solution (5.2) for the logarithm of real money balances. The Cagan function (2.11) gives us $x = \ln m = -\alpha\pi$, and this allows us to automatically arrive at the equation for the dynamics of inflation (5.3). Thus, using the definition of seigniorage $S = \mu m$ and the fact that $m = e^x$, we find the volume of the monetization of the operational budget deficit (5.4). Finally, equation (5.5) describes the dynamics of the public debt in the case of conducting sustainable fiscal policies. As we discussed in Section 2.1, equation (5.5) characterizes the intertemporal budget constraint of the government given the no-Ponzi game condition (2.7): $\lim_{t \to \infty} b(t) e^{-rt} = 0$. In the general case fiscal and monetary policies in the future may be unknown to the private sector. Thus, equations (5.2)—(5.5) include an operator for rational expectations $E_t\left(\bullet\right)$, which is the operator for the conditional mathematical expectancy of a variable, the future value of which is unknown. Expectations are based on the information set that is available at time t. In all examples that we consider below, the appearance of information and changes in the expectations of economic agents are of principle importance. In order to simplify the analysis, we will assume that the instruments of fiscal and monetary policy, d and μ, are piecewise-constant functions of time. Changes in the levels of d and μ may be unknown at the initial point of time. In this rather simple framework of perfect foresight the use of rational expectation operator may seem redundant, while it would be necessary if we model the dynamics of the growth rate of base money and government deficits as a stochastic processes (for example, Ito processes). But we prefer to keep this general approach for convenience (see, for example, the same notion in the textbook by Turnovsky (2000, ch. 3).

5.3. A permanent increase in the growth rate of base money

It is clear from equations (5.2) and (5.3) that the expected permanent increase in the growth rate of base money results in an increase in inflation and a decrease in real money balances now and in the future. Interestingly, from (5.4) and (5.5) the effect on seigniorage and fiscal sphere is ambiguous. Let us consider the following simple example. Starting with a constant growth rate of base money, $\mu(t) = \mu_0$, at time t_A the central bank announces that in the future, starting from $t_S > t_A$, the growth rate of base money will be increased to $\mu(t) = \mu_1 > \mu_0$. It should be stressed that the existence of the time interval $[t_A, t_S]$ between this announcement and the actual policy switch is crucial to the principal results of our investigation. Using (5.2)—(5.4), we can describe the dynamics of the log of real money balances, inflation, and seigniorage:

$$x(t) = \begin{cases} -\alpha\mu_0, \quad t < t_A, \\ -\left[\int\limits_t^{t_S} \mu_0 e^{-\frac{1}{\alpha}(\tau - t)} d\tau + \int\limits_{t_S}^{\infty} \mu_1 e^{-\frac{1}{\alpha}(\tau - t)} d\tau\right] = \\ \quad = -\alpha\mu_0 - \alpha(\mu_1 - \mu_0) e^{-\frac{1}{\alpha}(t_S - t)}, \quad t_A \le t < t_S, \\ -\alpha\mu_1, \quad t \ge t_S. \end{cases} \tag{5.6}$$

$$\pi(t) = \begin{cases} \mu_0, \quad t < t_A, \\ \mu_0 + (\mu_1 - \mu_0) e^{-\frac{1}{\alpha}(t_S - t)}, \quad t_A \le t < t_S, \\ \mu_1, \quad t \ge t_S. \end{cases} \tag{5.7}$$

$$S(t)=\begin{cases}\mu_0 e^{-\alpha\mu_0}, & t<t_A,\\ \mu_0 e^{-\alpha\mu_0-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_S-t)}}, & t_A\le t<t_S,\\ \mu_1 e^{-\alpha\mu_1}, & t\ge t_S.\end{cases} \tag{5.8}$$

Figure 5.1 shows the time paths of these variables. Prior to the announcement, the money market is in a steady state. The announcement at time $t = t_A$ leads to discrete jumps in the log of real money balances, $\Delta x(t=t_A)=-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_S-t_A)}<0$, and in inflation, $\Delta\pi(t=t_A)=(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_S-t_A)}>0$. No matter what side of the inflation tax Laffer curve the economy is on, the increase in the growth rate of base money initially results in a discrete fall in seigniorage: $\Delta S(t=t_A)=-\mu_0 e^{-\alpha\mu_0}\left[1-e^{-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_S-t_A)}}\right]<0$.

Up to time t_S, when monetary policy switches, the log of real money balances and inflation gradually adjust to their new steady levels. In contrast, at this time seigniorage undergoes another discrete jump, $\Delta S(t=t_S)=(\mu_1-\mu_0)e^{-\alpha\mu_1}>0$. Depending on which side of the inflation tax Laffer curve the economy was on and the magnitude of the change in the growth rate of base money, the new steady state value of seigniorage may be either higher or lower than it was initially.

With regard to the fiscal sphere, what is important is the consequences for the present value (evaluated at time t_A) of future seigniorage revenues. Assume for simplicity that the public debt is initially at the steady state for some constant level of primary budget deficit. If the new steady state level of seigniorage for $t > t_S$ is lower than it was initially (for $t > t_A$), then the present value of seigniorage will fall. This means that the current (predetermined) level of public debt is higher than it should be assuming a sustainable fiscal policy. The bottom diagram in Fig. 5.1 depicts the path of the sustainable level of public debt, b_s, determined by (5.5). Its downward jump (the dotted line) is a result of a decrease in the present value of seigniorage[4]. A primary budget deficit that does not change leads to the explosive growth of the actual level of public debt. To avoid this scenario (i.e., to avert a confidence crisis), the government must adjust the future path of the budget deficit $d(t)$ so that the reduction in its present value compensates the fall in the present value of seigniorage revenues. In the simplest case of a piecewise-constant primary deficit, the government should decrease d at time t_A by an amount equal to the product of the interest rate and the change in steady state level of seigniorage. At the same time, the path of b_S will shift upward for $t > t_A$, bridging the gap with the actual (predetermined) level[5]. Remaining on a stable (sustainable) path, the

[4] Here and below we implicitly assume that the government (central bank) receives the same information about future monetary (fiscal) policy changes and at the same time t_A as the private sector. But this is not, in fact, a crucial assumption.

[5] Figure 5.1 and others do not illustrate this possible change.

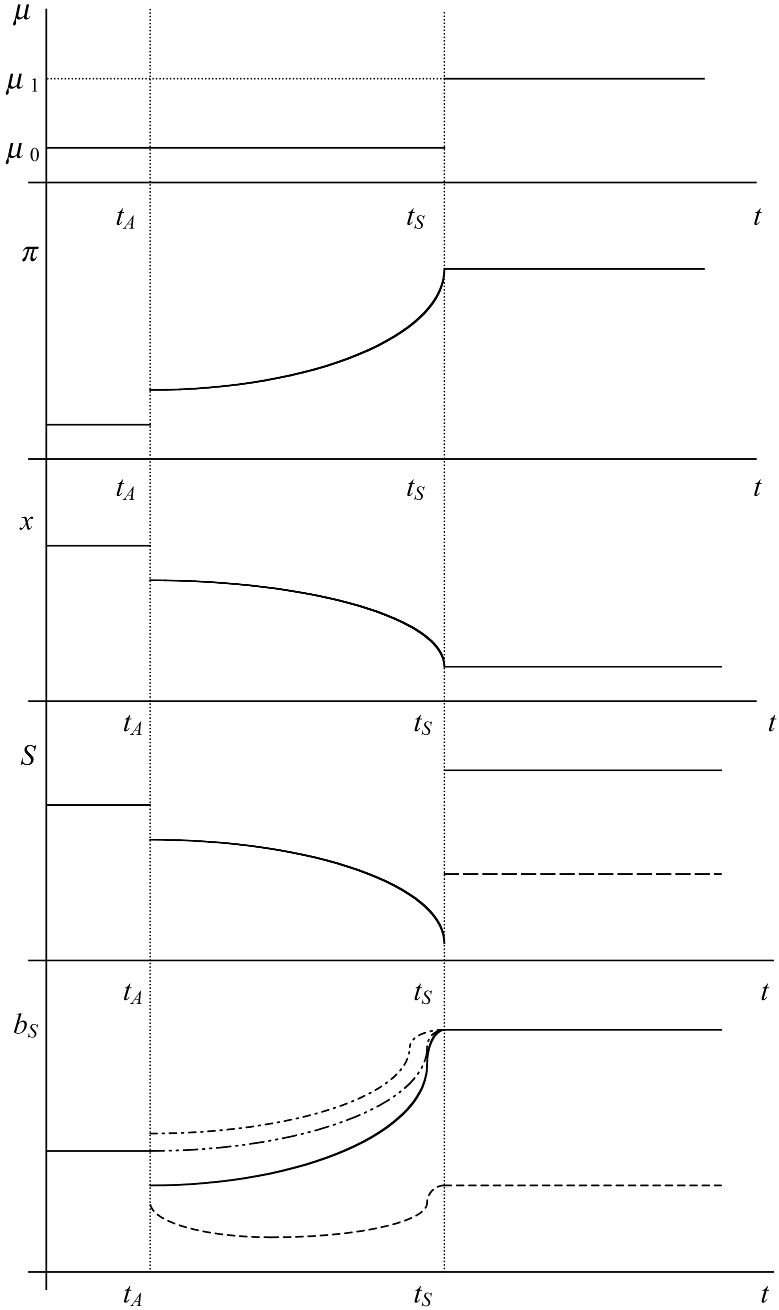

Fig. 5.1. *Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a permanent increase in the growth rate of base money*

public debt will initially decrease and then increase and reach its new steady state level at time t_S, which will in fact be lower than the initial steady state level.

An increase in the steady state level of seigniorage for $t > t_S$ does not automatically lead to an increase in its present value at time t_A. Thus, the effect of this increase is ambiguous and critically depends on the interest rate for public debt. If the time interval $[t_A, t_S]$ is long enough, if the fall in real money balances is large, and (most importantly) if the interest rate is high, then the present value of future seigniorage revenues may decrease. The consequences of this scenario are similar to those described above (see the solid line on the time diagram for b_S). The government will be forced to decrease the primary deficit, eliminating the jump in b_S. Along the sustainable path, public debt will increase up to its new steady state. Table A5.1.1 in the Appendix provides a numerical specification of parameters that shows this scenario to be quite possible.

An increase in the present value of seigniorage is possible, *ceteris paribus*, if the interest rate is relatively low. In this case the accumulated level of debt becomes lower than b_S (see the chain line in Fig. 5.1, and also the numerical example in Table A5.1.1 in the Appendix). If the government does not react, public debt will decrease. However, in this situation the government can increase the primary deficit (its present value in general), which in many circumstances may indeed be desirable for either economic or political reasons. Such action will keep the debt on a stable path. The new steady state level will be higher than it was initially, just as in the case considered above.

The last possible outcome is that of a permanent increase in the growth rate of base money that will not change present value of seigniorage at all[6]. The principle of sustainable fiscal policy is not violated. Public debt rises along the sustainable path up to its new steady-state level (the double dot-chain line in Fig. 5.1[7]).

5.4. A permanent increase in the primary budget deficit

The most important conclusion we learn from the example above is that there is no simple or unambiguous correspondence between changes in the growth rate of base money (and inflation) and the direction in which fiscal policy must be adjusted in order to keep the public debt on a sustainable path. But the reverse is also true. To prove this, let us consider the following simple scenario. Assume that initially the money market and the public debt are in steady states for certain values of the growth rate of base money and of the primary deficit. Then, for some reason, the government needs to increase (permanently) the primary budget deficit (by increasing spending, or by decreasing taxes). To keep the public debt on a sustainable path, it is necessary to increase the present value of seigniorage by an amount equal to

[6] We do not illustrate numerically this extreme case in the Appendix due to the obvious complexity of the necessary calculations. However, this result seems to be quite possible.

[7] All the lines on the time diagram for b_S in Fig. 5.1 should not, in fact, converge to the same steady state level. We show the same steady state levels in order to simplify visual perception. The same applies to the other diagrams below.

the increase in the present value of budget deficits. Assume for concreteness that the economy is on the "right side" of the inflation tax Laffer curve[8]. A possible approach would be to increase the growth rate of base money, as was described above. This must be done at time t_S, while an announcement to that effect should be made at time $t_A < t_S$. This action results in a higher steady state level of seigniorage, after a period of temporary decrease, but at the cost of an increase in the steady state inflation rate and of a decrease in real money balances.

However, this is not the only way to increase the present value of seigniorage. In some circumstances this objective can also be achieved by decreasing the growth rate of base money[9]. The following scenario is illustrated in Fig. 5.2. Indeed, if t_A is the moment at which there is a switch in fiscal policy, and the central bank announces a permanent drop in the growth rate of base money after t_S, then inflation will undergo a discrete fall, while real money balances jump up. Up to the time of actual changes in the growth rate of base money, inflation (real money balances) will gradually decrease (increase) to its new steady state level. This results in a temporary increase in seigniorage. Despite the fact that it eventually falls to a new steady state at time t_S, its present value for time t_A may increase. This scenario is more likely for high interest rates.

In general, just as in the previous example, whether the present value of seigniorage will increase or decrease depends on the interest rate that is used in discounting future values, on the length of the time interval between the announcement of an impending policy switch and its actual implementation, on the magnitude of the change in the growth rate of base money, and on the semi-elasticity of the money demand function. Figure 5.2 depicts possible trajectories for the sustainable level of public debt. For certain parameterizations of the experiment (see the corresponding examples in Table A5.1.2 in the Appendix), and in particular for high interest rates for public debt, a permanent increase in the growth rate of base money leads to a discrete upward jump in b_S. In our example, the size of the jump is equal to the ratio of the change in the primary deficit to the interest rate. We will demonstrate below that, depending on the magnitude of the change in the growth rate of base money and on the length of the time interval ($t_S - t_A$), the central bank's ability to increase the present value of seigniorage is bounded from above, if it exists at all. Without changes in the primary budget deficit, if this kind of monetary policy is able to produce an increase in the present value of seigniorage by time t_A, then, after a discrete increase, b_S will gradually decrease to its new steady state level (the solid line in Fig. 5.2). As long as the new steady state level of seigniorage is lower than it

[8] If the economy is functioning with high inflation (i.e., it is on the "wrong side" of the inflation tax Laffer curve), then a decrease in the growth rate of money will unambiguously lead to an increase in the present value of seigniorage. At the same time, an increase in the growth rate of money will result in a decrease in the present value of seigniorage. For obvious reasons, the direction of the transitory dynamics of seigniorage and the direction of the change in its steady state are the same (upward or downward) along the "wrong side" of inflation tax Laffer curve.

[9] In order to not be misunderstood, we should stress that there is no tradeoff between contractionary and expansionary monetary policy aimed at increasing the present value of seigniorage. We demonstrate below that depending on the parametric specification (most importantly on the interest rate) monetary policy could produce a higher present value of seigniorage only for one direction of change, while the other direction will produce quite the opposite result.

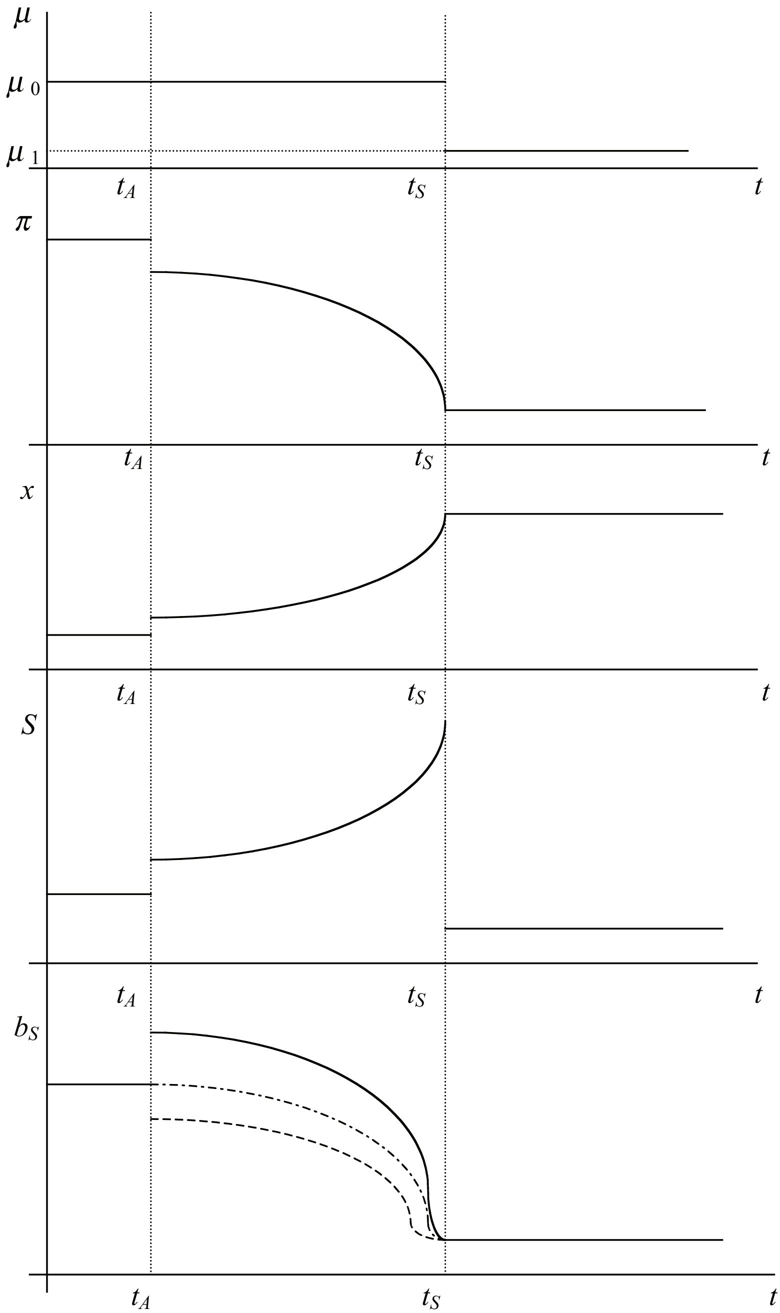

Fig 5.2. D*ynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a permanent decrease in the growth rate of base money*

was initially, the new steady state level of public debt must also be lower. Since the increase in the primary budget deficit should be balanced by the increase in the present value of seigniorage, b_S will not undergo a jump at time t_A; instead it will gradually decrease along the sustainable path to its new steady state level.

Ceteris paribus, in the case of a low interest rate, a decrease in the steady state level of seigniorage in the future plays an important role, and thus the present value of seigniorage may decrease or remain at least the same (see the dotted and chain lines in Fig. 5.2). Qualitatively, the ensuing dynamics of b_S are the same as in the example given above (a decrease to a new constant level). However, along with the increase in primary deficit one could come to a situation in which the predetermined public debt at time t_A is higher than it should be in accordance with (5.5), i.e. it becomes unsustainable.

5.5. Credible stabilization programs: Israel, Chile and Mexico

Discussion in Sections 5.3 and 5.4 stressed one important point: as long as the sustainability of public debt depends not only on future fiscal policy, but on future seigniorage as well, monetary policy may not be able to stabilize inflation without corresponding fiscal adjustments. The necessity of *joint* fiscal and monetary measures to fight high inflation is the essence of the so-called "orthodox stabilization". Here we provide examples of successful high inflation stabilization programs in Israel, Chile and Mexico. In all these cases, the introduction of a tight monetary policy was accompanied by budget cuts that were perceived as a credible attempt to stop high inflation (immediately at the beginning of the program or after a short delay). We do not consider these examples in a chronological order, however, and we start with Israel's 1985—1986 stabilization program since it was the most successful of the three. In all cases we note the presence of additional stabilization policy elements that were mostly part of the alternative package, the so-called "heterodox stabilization" program. Our analysis does not take into account inflation inertia that is considered to be a very important character of chronic high inflation. The elements of the heterodox stabilization policy are designed to break inflation inertia. While in all cases the orthodox program was at the core of the inflation stabilization efforts, the absence of an adequate heterodox program may be viewed as the main reason for the low rate of decrease in inflation in Chile.

Israel, 1985—1986

Israel's experience in the mid 1980's provides a good example of inflation and public debt stabilization under a policy package consisting of monetary anchoring and fiscal adjustment, among other efforts.[10] Moreover, as history shows, a tight monetary policy and cuts in the budget deficit were perceived as a credible long-run policy shift, not just as a short-run attempt to lower inflation.

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[10] The discussion and statistical data presented in this subsection is based mainly on Bruno (1993). See also Bruno and Meridor (1991).

Along with Latin America countries, Israel in 1975—1985 provides a canonical example of an economy with chronic high inflation. During this period inflation moved from the two-digit to the three-digit range so yet never became hyperinflation. The most dramatic episode of inflation intensification was in 1984—1985. By the end of 1984 the inflation rate was close to 500 percent on an annual basis (see Fig. 5.3). Inflation in Israel was characterized by very strong inertia due to indexation institution and other factors, something that has proved to be a common phenomena in high-inflation countries. Indeed, Fig. 5.3 suggests that money growth was simply accommodating an increasing inflation rate. And this may indeed be the case.[11] Nevertheless, it is possible to attribute a significant part of the increase in money to the financing of the budget deficit. As Table 5.1 shows, seigniorage (creation of base money) played a rather significant part in this process. Starting from the mid-1970s, the government ran very high deficits (two-digit percent of GNP). Taken together with monetization, which led to an escalation in inflation, the deficits resulted in a dramatic growth of internal and external public debt. Before the oil-price shock and the Yom Kippur War in 1973, Israel was in its "Golden Age" of growth that was 11.2 percent in 1950—1960 and 9.7 percent in 1961—1972 (annually, on average). Under these conditions, large fiscal deficits (although they were not as large as later on) did not lead to an unsustainable growth of public debt. However, after 1973 economic growth became much slower: 3.4 percent in 1973—1981 and 1.9 percent in 1982—1984. Increasing budget deficits made public debt highly unsustainable. In the mid-1980s the public debt became higher than 200 percent of GNP and reached its historical maximum of 240 percent of GNP.

Stabilization of chronic high inflation is a difficult task. Israel's 1985 stabilization program is a rare example of success. In 1985—1986 inflation was brought down to the two-digit range and was stabilized there at the level between 15 and 20 percent. After that, in the 1990s inflation decreased to the single-digit range. The stabilization process was complex and involved a host of measures on the part of both the government and the central bank. Among them, there are two major elements: the Bank of Israel successfully squeezed money emission while the government cut its budget deficits. Table 5.1 confirms this drastic policy shift. The other elements of greatest importance were: pegging the nominal exchange rate, price control policy and various directions of structural adjustment of the economy. One should also note a very important element — namely, the political and social atmosphere at the time that made the public perceive the stabilization plan of the National Unity Government as credible (at least eventually).

We can illustrate the credibility (or sustainability) of this stabilization program by the logic explained in Section 5.4. As was discussed earlier, an anticipated permanent decrease in the growth rate of base money can produce an increase in the present discounted value of future seigniorage in the case of high interest rates (see Fig. 5.2). However, it can also produce a lower present value of seigniorage when the interest rate is relatively low. Thus, in general, a permanent decrease in the growth rate of base money may not be perceived as a credible

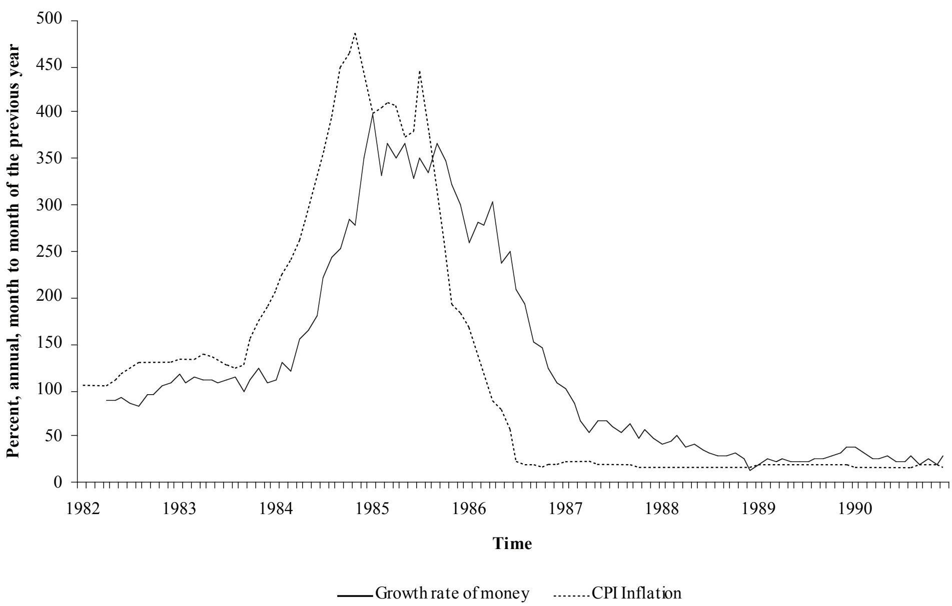
[11] Fischer, Sahay and Vegh (2002) found that this is a prevailing pattern during inflationary episodes.

Table 5.1. Budget deficit finance in Israel, 1978—1990 (percent of GNP)

Period	Budget deficit	Base Money Creation	Domestic debt finance	Foreign debt finance	Unaccounted finance
1978—1980	17,2	2,0	7,3	6,9	
1981—1983	14,1	2,1	7,2	4,9	
1984	12,7	2,9	0,2	5,3	4,4
1985	–0,6	5,8	–6,5	–3,9	4,0
1986—1990	1,3	–0,1	0,3	–0,9	2,0

Source: Bruno, 1993 (extract from Table 3.1, p. 46).

future monetary policy, if only because it may result in unsustainable public debt dynamics. Despite the evidence that interest rates were very high in the 1980s, the mere fact that the public debt to GNP ratio was higher than 200 percent leaves little room to suppose that the Bank of Israel's *unilateral* radical shift to a tight monetary policy would be perceived as credible. However, as long as it was supported by expectations of a future cut in deficits, the monetary squeeze should be viewed as credible. Even if the present value of seigniorage did not increase following a decrease in the growth rate of base money, a decrease in the present value of future budget deficits may produce an increase in the sustainable level of public debt (i.e., in terms of Fig. 5.2, there is an upward jump in b_S at time t_A, and the new steady state



Source: Bank of Israel.

Fig. 5.3. *Inflation and growth rate of money in Israel, 1982—1990*

level of b_S after time t_S may be even higher than the initial steady state, before t_A). Thus, a tight monetary policy that is aimed to fight high inflation is much more likely to be credible if it is supported by fiscal adjustment. After all, this policy mix makes the current level of public debt sustainable.

Chile, 1974—1975

Chilean macroeconomic policy after the military coup in September, 1973 provides another example of a rather successful stabilization program. Along with other Latin American countries, Chile in the 1960s was a typical high inflation country with an average annual inflation rate well above 20 percent. The economic situation became worse in 1972 under the socialist-populist policy of Allende. Its government ran extremely high fiscal deficits (see Fig. 5.4). At the same time inflation moved from the two-digit to the three-digit range (see Fig. 5.5).

In 1974 and 1975 the new military government carried out an orthodox program to stop accelerating inflation. A major tax reform was introduced. Government spending was drastically cut, and some government assets were sold. Budget deficits were reduced and in some time there appeared fiscal surpluses.[12] However, despite the disappearance of the main source of inflation, the rate of inflation decreased relatively slowly, returning to the two-digit range only in 1977 (it continued to further decrease, reaching the one-digit range in 1981). Corbo and Solimano (1991) attribute this failure to the very high degree of immanent inflation inertia, the exchange rate policy of devaluing the peso between 1978 and 1982[13], and effects from backward-looking wage indexation schemes. Indeed, in comparison with aggressive fiscal adjustment, Chilean monetary policy was not very tight, but rather accommodative.

Actually, the problems of a nominal synchronization under inflation inertia that are essential in stabilizing chronic high inflation are not captured in our "flexible-price" model. From a historical perspective this lesson gave rise to the conclusion that orthodox stabilization is a necessarily but not a sufficient condition for successful *high* inflation stabilization. Additional elements of income policy dealing with inflation inertia that are at the core of a heterodox stabilization are also needed.[14] However, orthodox elements of stabilization, i.e. fiscal restraint and monetary tightness, are still *necessary*. Therefore, the model applied to interpret Israel's stabilization works here as well.[15] Heterodox elements determine mainly the costs of the stabilization program.

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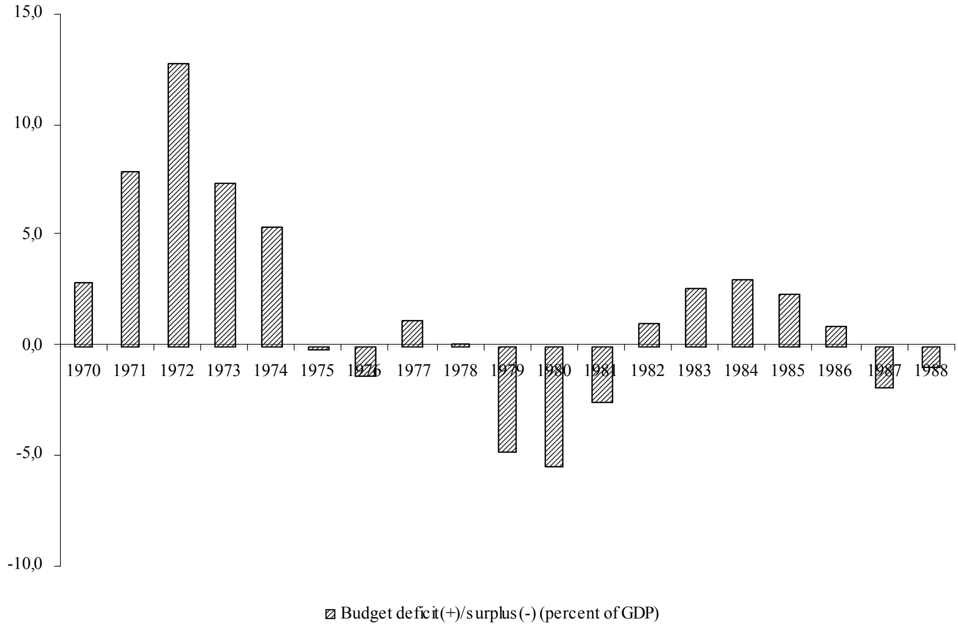
[12] Additional helpful factors were a rollover of 30 percent of debt outstanding and relatively high prices of exportable copper.

[13] It was called *Tablita* — a kind of crawling peg. Bruno (1993) also refers to this policy of a pre-announced decreasing crawl (below the previous month's inflation rate) as a "major macro-policy error" that made the decrease in inflation even slower.

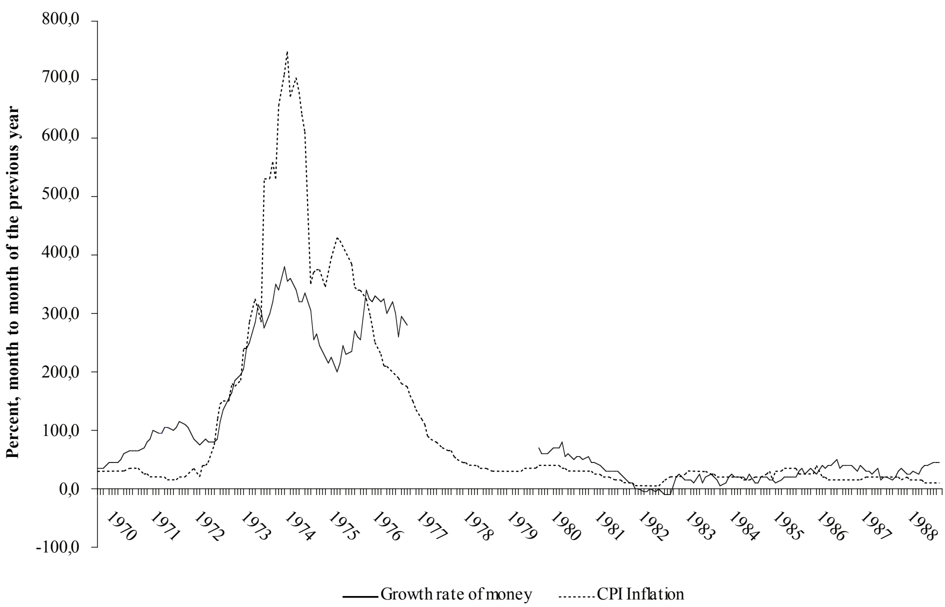
[14] Obviously, this lesson was taken into account in Israel's stabilization discussed above.

[15] In the case of Chile one should also take into account extremely high real interest rates and a serious decline in output following the fiscal contraction, coupled with adverse external shocks (the world-wide oil price shock and the drop of copper prices in 1975). See Corbo and Solimano (1991) for details.



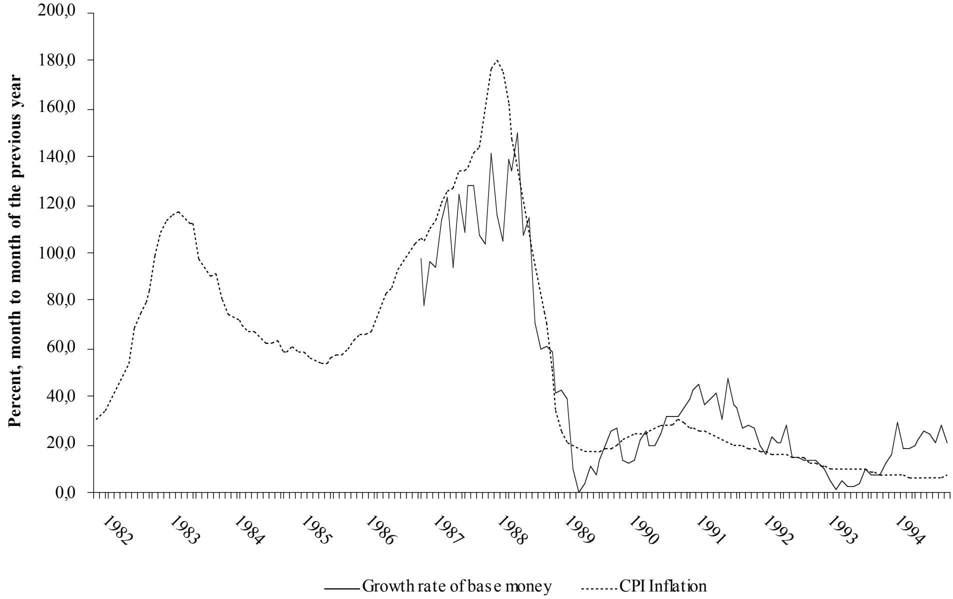
Source: International Financial Statistics, IMF.

Fig. 5.4. *Budget deficit in Chile, 1970—1988*



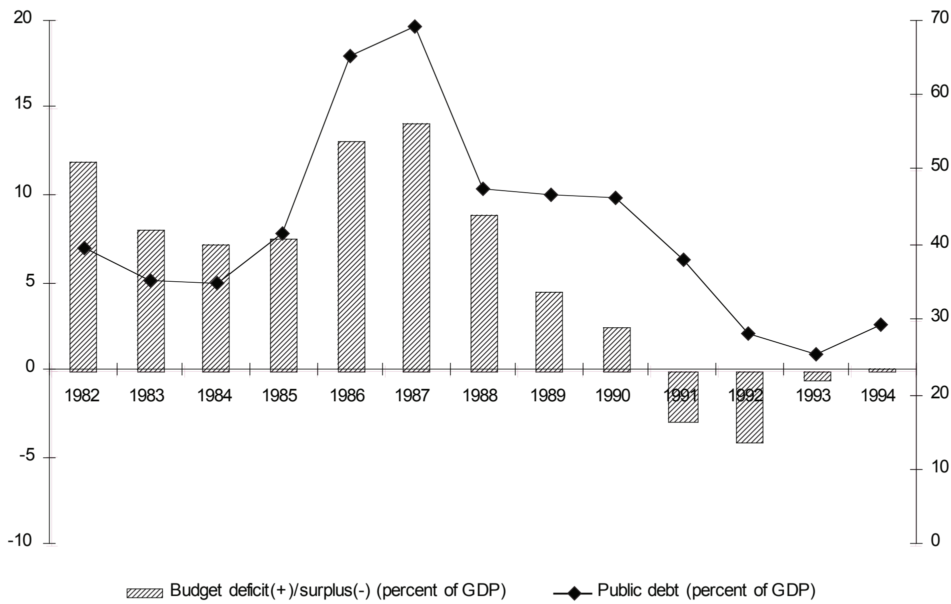
Source: International Financial Statistics, IMF.

Fig. 5.5. *Inflation and growth rate of money in Chile, 1970—1988*



Source: International Financial Statistics, IMF.

Fig. 5.6. *Inflation and growth rate of base money in Mexico, 1982—1994*



Source: International Financial Statistics, IMF.

Fig. 5.7. *Budget deficit and public debt in Mexico, 1982—1994*

Mexico, 1987—1988

The Mexican stabilization program was initiated in 1987. This program was comprised of a Pact *for Economic Solidarity* and a *Pact for Stability and Growth*, and it provides another example of a successful combination of orthodox and heterodox stabilization.[16]

Unlike other Latin American countries, Mexico experienced high inflation over a relatively short period. Until 1982, the inflation rate was well below 30 percent annually[17], while annual GDP growth was well above 6 percent. In 1982 Mexico underwent a serious debt crisis (repudiating its external debt). The exchange rate was devalued by 466 percent, CPI increased by 99 percent. For several years the economy became extremely unstable. Initial attempts to stabilize the economy were undertaken in the right direction: the budget deficit was cut and a rather tight monetary policy was implemented. However, the size of the adjustment was not sufficient. The inflation rate returned to the two-digit range, and yet it still remained very high (see Fig. 5.6). After the earthquake of 1985 in Mexico and the fall of oil prices in early 1986, the balance of payment deteriorated, and the inflation rate again began to accelerate. Finally, in October, 1987 the stock market crashed.

By the end of 1987, the Pact for Economic Solidarity was announced, and it was jointly signed by the government and by representatives from industrial and agricultural workers, and from business. The Pact was written after Israel's successful stabilization in 1985—1986. It included both orthodox and heterodox elements and relied truly on social "solidarity", as in Israel's case. The main agreement was a further increase in the primary budget surplus (a decrease in the huge operational budget deficit stemming from high interest payments). This was done in 1988 and 1989 (see Fig. 5.7). Monetary policy was significantly tightened (in particular, very tight credit ceilings were announced). The Chilean policy error was also taken into account: an agreement between the different sectors of the economy upon key pricing rules lead to a rather rapid decline in inflation (see Fig. 5.6). Public debt was more than halved over the following five years. Thus, we can again refer to the successful logic of stabilizing inflation via a credible tightening of fiscal and monetary policy, supported by measures to break inflation inertia.

5.6. A temporary decrease in the growth rate of base money

Let us consider now a policy switch that is not permanent. Assume, as usual, that initially the money market and the fiscal sphere are in steady states. At time t_A the central bank announces a decrease in the growth rate of base money that will take place at time t_{S_1}, $\mu_1 < \mu_0$. Assume further that it is expected that after time $t_{S_2} > t_{S_1}$ monetary policy will again become

[16] The discussion here relies on Ortiz (1991) and Bruno (1993). See also Diaz and Tercero (1988), and Dornbusch and Fischer (1991).

[17] Before the 1973 oil shock, inflation was even in the single-digit range. Double-digit inflation became chronic only after 1975.

loose, so that $\mu_1 < \mu_0 < \mu_2$, where μ_2 is the growth rate of base money for $t \ge t_{S_2}$. In the simplest case, the temporary nature of a tightening of monetary policy may be announced at time t_A as well. In general, one can infer that the current policy switch cannot be permanent if only because this would violate the sustainability and feasibility constraints. Equations (5.9)—(5.11) describe the dynamics of the economy for this type of policy. The corresponding time paths are illustrated in Fig. 5.8.

$$x(t) = \begin{cases} -\alpha\mu_0, \quad t < t_A, \\ -\left[\int\limits_t^{t_{S_1}} \mu_0 e^{-\frac{1}{\alpha}(\tau - t)} d\tau + \int\limits_{t_{S_1}}^{t_{S_2}} \mu_1 e^{-\frac{1}{\alpha}(\tau - t)} d\tau + \int\limits_{t_{S_2}}^{\infty} \mu_2 e^{-\frac{1}{\alpha}(\tau - t)} d\tau \right] = \\ = -\alpha\mu_0 - \alpha(\mu_1 - \mu_0) e^{-\frac{1}{\alpha}(t_{S_1} - t)} - \alpha(\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}, \quad t_A \le t < t_{S_1}, \\ -\left[\int\limits_t^{t_{S_2}} \mu_1 e^{-\frac{1}{\alpha}(\tau - t)} d\tau + \int\limits_{t_{S_2}}^{\infty} \mu_2 e^{-\frac{1}{\alpha}(\tau - t)} d\tau \right] = \\ = -\alpha\mu_1 - \alpha(\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}, \quad t_{S_1} \le t < t_{S_2}, \\ -\alpha\mu_2, \quad t \ge t_{S_2}. \end{cases} \tag{5.9}$$

$$\pi(t) = \begin{cases} \mu_0, \quad t < t_A, \\ \mu_0 + (\mu_1 - \mu_0) e^{-\frac{1}{\alpha}(t_{S_1} - t)} + (\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}, \quad t_A \le t \le t_{S_1}, \\ \mu_1 + (\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}, \quad t_{S_1} \le t \le t_{S_2}, \\ \mu_2, \quad t > t_{S_2}. \end{cases} \tag{5.10}$$

$$S(t) = \begin{cases} \mu_0 e^{-\alpha\mu_0}, \quad t < t_A, \\ \mu_0 e^{-\alpha\mu_0 - \alpha(\mu_1 - \mu_0) e^{-\frac{1}{\alpha}(t_{S_1} - t)} - \alpha(\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}}, \quad t_A \le t < t_{S_1}, \\ \mu_1 e^{-\alpha\mu_1 - \alpha(\mu_2 - \mu_1) e^{-\frac{1}{\alpha}(t_{S_2} - t)}}, \quad t_{S_1} \le t < t_{S_2}, \\ \mu_2 e^{-\alpha\mu_2}, \quad t \ge t_{S_2}. \end{cases} \tag{5.11}$$

The dynamics of the money market depend on the semi-elasticity of demand, the length of the time interval $(t_{S_2} - t_{S_1})$, and the relative magnitude of change in the growth rate of base money. If the condition

$$(\mu_2 - \mu_1) > (\mu_0 - \mu_1) e^{\frac{1}{\alpha}(t_{S_2} - t_{S_1})} \tag{5.12}$$

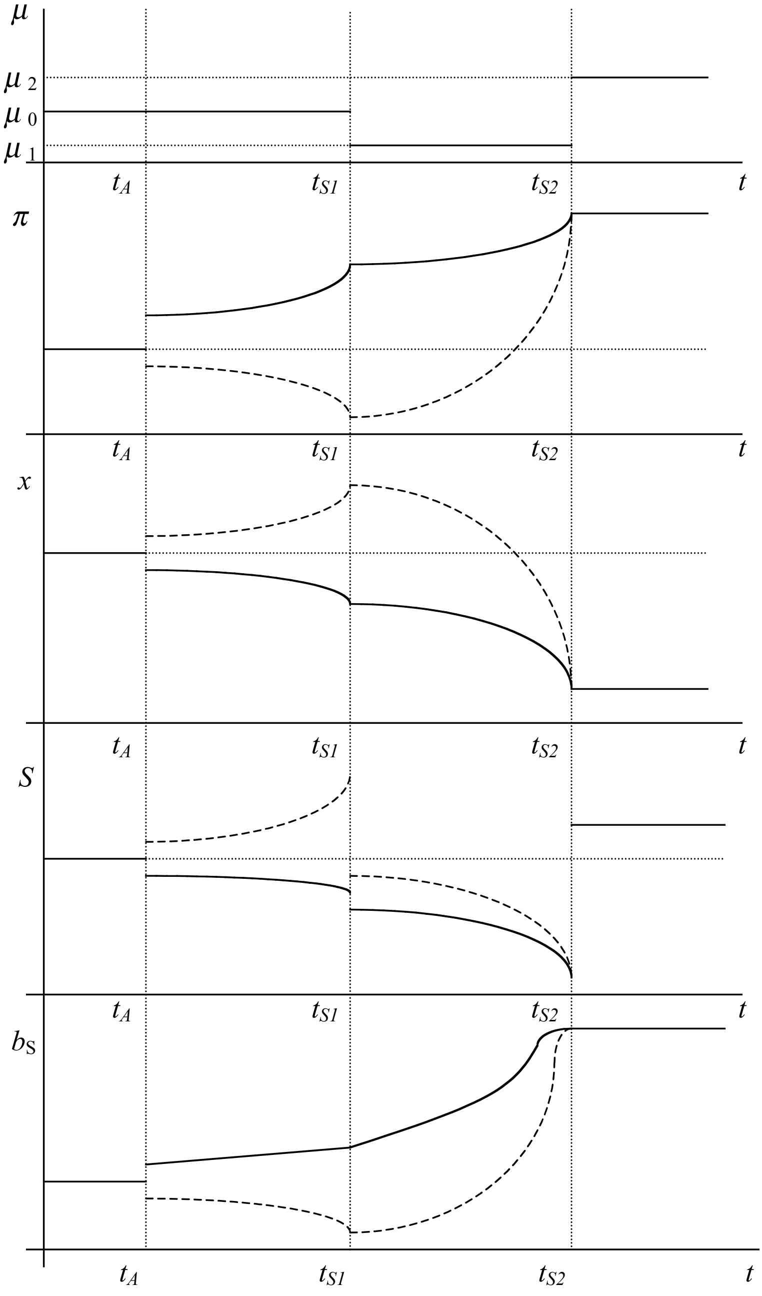


Fig. 5.8. *Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary decrease in the growth rate of base money* ($\mu_1 < \mu_0 < \mu_2$)

holds, then real money balances undergo a discrete downward jump and monotonically decrease to their new steady state level, which is reached at time t_{S_2} (the solid line in Fig. 5.8). At the same time inflation rises, and seigniorage decreases.

However, there is another possible scenario. When condition (5.12) fails to hold, real money balances undergo an upward jump after the announcement. They continue to increase (gradually) up to time t_{S_1}, and only then they start to decrease (see the dotted line in Fig. 5.8). Assume for concreteness that the economy is on the "right side" of the inflation tax Laffer curve. The new steady state seigniorage will then be higher than it was initially. It is also clear that the present value of seigniorage in the second scenario is higher than in the first scenario. However, it depends on parameters of the economy and policy switch in either case whether or not the present value of seigniorage will rise or fall. The consequences for the fiscal sphere and the methods for maintaining the sustainability of the public debt are qualitatively the same as in Section 5.3.

Ceteris paribus, when the interest rate is low, not only the near future is important in the evaluation of the present value, but the distant future as well. Thus, a long-term rise in the steady state of seigniorage implies an increase in b_S at time t_A for the same fiscal policy. Given this situation, the government has the option to increase the primary budget deficit, eliminating the gap between the actual (predetermined) and sustainable levels of debt. The value of b_S gradually increases, starting from time t_A, to its new steady state level (the solid line in Fig. 5.8; if we account for the fiscal correction described above, this line should be shifted down to be continuous).

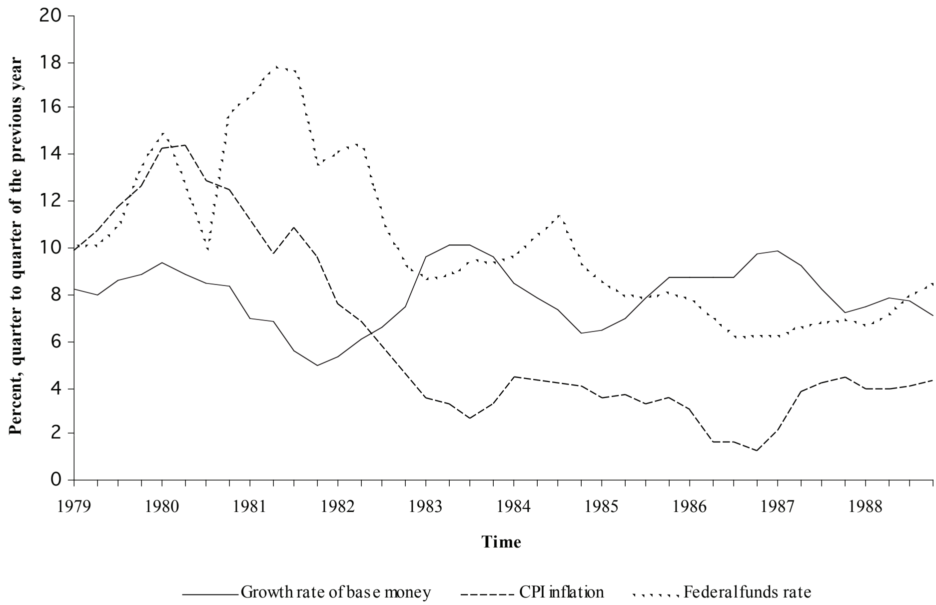
On the other hand, if the interest rate is high enough, this kind of monetary policy will result in a decrease in the present value of seigniorage at time t_A. To maintain sustainability in the fiscal sphere, the government should reduce the primary budget deficit. The public debt will gradually decrease until time t_{S_1}, and then rise to its new steady state level (one should imagine a line parallel to the dotted line for b_S in Fig. 5.8 to account for a fiscal correction to eliminate discontinuity and unsustainability).

And finally, there is a theoretical knife-edge possibility that the described changes in the growth rate of base money will not change the present value of seigniorage at all. Thus there is no need (and no option) for fiscal adjustment[18]. Tables A5.2.1—2 in the Appendix contain the specifications of numerical experiments that support these conclusions.

5.7. Reaganomics II: A forward-looking interpretation

In section 4.7 we proposed an explanation of the decrease in inflation in 1982—1983 in the U.S. that took place despite a substantial ease in monetary policy; that was essentially a backward-looking explanation. Here we suggest an alternative interpretation of the event, one that is based on forward-looking considerations. For convenience, we reproduce the dynamics of the growth rate of base money, federal funds rate and inflation in Fig. 5.9.

[18] We do not depict this case in Fig. 5.8.



Source: International Financial Statistics, IMF.

Fig. 5.9. *Monetary policy and inflation in the U.S., 1979—1988*

Although at first, in 1979, Volcker's attempt to fight inflation was not perceived as a credible policy shift, inflation started to decrease in 1980. And with the exception of a modest increase in the inflation rate in 1983, disinflation was present until 1986. Let us consider the following theoretical experiment that resembles the actual Federal Reserve policy in the time interval from 1982 until 1985. Assume that at some date t_A the public began to expect that monetary policy would be temporally eased in the future time interval $\left[t_{S_1}, t_{S_2}\right]$. It was also expected that after t_{S_2} monetary policy would be even tighter than it was originally: $\mu_2<\mu_0<\mu_2$. This experiment's setting is simply the regular reflection of the case studied in the Section 4.4, in which monetary policy was temporarily tightened and then eased. It follows that the trajectories of other variables can be constructed and interpreted as the regular reflection of trajectories in Fig. 5.8, and so we do not repeat the discussion here. Assume further that condition (5.12) holds. Figure 5.10 illustrates the dynamics of the system.

Despite the temporary ease in monetary policy, the inflation rate declines as long as the public expects that the disinflation policy will be renewed in the future. This can be a probable explanation of actual beliefs. Indeed, as was discussed in Section 4.7, the Federal Reserve was forced to reduce the federal funds rate in the face of a threat that the Mexican financial crisis may have a negative impact on the American economy due to very high interest rates at the time. Thus, it could have been expected that the policy shift was temporary, and after the passing of some time the Federal Reserve would continue to fight inflation.

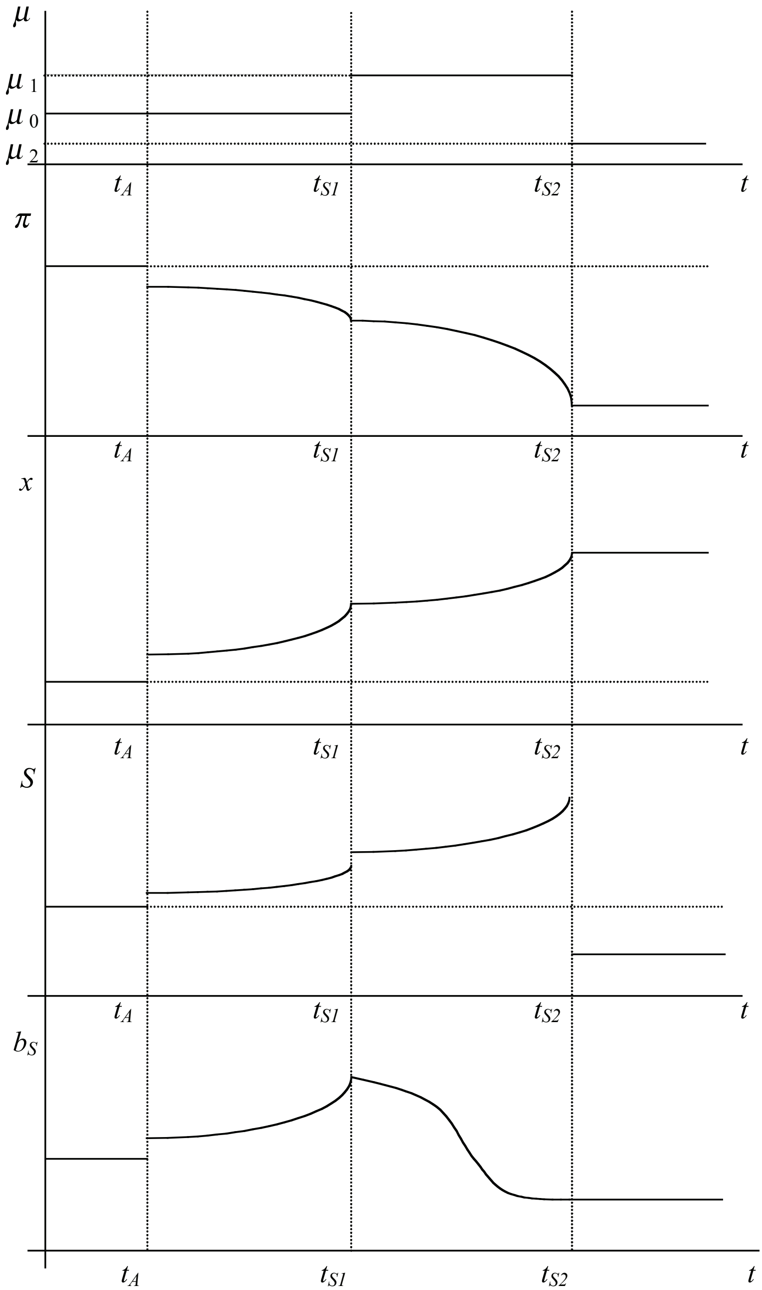


Fig. 5.10. *Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary increase in the growth rate of base money* ($\mu_2 < \mu_0 < \mu_1$)

We can also see that while the steady state level of seigniorage becomes lower for $t > t_{S_2}$, it will temporarily become higher during the interval $\left[t_A, t_{S_2}\right]$. It then follows that its present discounted value may increase at time t_A, which is most likely if the interest rate on public debt is sufficiently high. Indeed, as we noted, the interest rates in U.S. economy were relatively high during that period.

If the present value of seigniorage indeed increases at time t_A, then, assuming no change in expected future budget deficits, the sustainable level of public debt also increases at time t_A.[19] After that it increases gradually for some time and then decreases. Eventually it reaches a constant level that is lower than the initial level. This follows from the fact that the new steady state level of seigniorage becomes lower than it was initially. This observation has important implication for future policy: a lower sustainable level of public debt imposes stronger restrictions on the government's ability to support budget deficits. Thus, disinflation that was a result of the policy experiment considered in this section (and in actual history) does not solve the problem stressed by Sargent (1985, 1986): tight monetary policy and fiscal imbalances are not credible in the long run. At least one agent will "chicken out" sooner or later. If we take monetary policy as exogenous (dominant), then the public should expect that the government will be able to provide fiscal surpluses in a sufficient amount (and over a sufficiently long period).

5.8. Temporary changes in policy and "unpleasant monetarist arithmetic"

As shown above, when an economy is functioning on the "right side" of the inflation tax Laffer curve, a permanent reduction in the growth rate of base money can lead to a fall in the present value of seigniorage, and thus make the public debt unsustainable. In principle, the government should adjust its fiscal policy and reduce the primary budget deficit. It is, however, possible that the government either does not want to do this because of certain political or economic considerations, or because of the existence of a lower bound on $d(t)$.[20] In this case, a switch in monetary policy of this sort cannot be permanent. It is also natural to assume that private agents will realize this fact and take it into consideration.

Assume that both the type and the timing of policy changes are known in advance, as if they were an announced commitment. In reality, of course, economic agents face uncertainties about the type and timing of policy switches. We will return to this point in the next section. Introduction of these simplifying assumptions brings our analysis closer to the logic of the celebrated "unpleasant monetarist arithmetic". At time t_{S_1} monetary policy becomes loose, as was known in advance at time t_A. However, if this policy destroys the sustainability of public debt, it cannot be permanent. At a certain time t_{S_2} the central bank has to bring the economy back to a steady state.

[19] Note that this is the sustainable, not actual, level of public debt, and therefore we can apply this result to interpret the actual public debt dynamics during the period being considered.

[20] We discuss this problem later in Section 5.14.

Must it always be true that the economy will eventually suffer from a higher steady state rate of inflation (a higher growth rate of base money)? In other words, should private agents form expectations that $\mu_0<\mu_2$ is the only possible outcome? The scenario that we considered earlier (Fig. 5.8) can be viewed as a corroboration of the Sargent-Wallace result: monetary policy cannot be tightened permanently; lower inflation now, if it is possible at all, eventually results in higher inflation in the future.

Surprisingly, for certain values of the parameters it is quite possible to keep the present value of seigniorage constant (or even increase it) when $\mu_1<\mu_2<\mu_0$, i.e. when the final monetary policy need not be more expansionary than it was initially. In other words, we will show that in a certain sense monetary policy can be tightened in the long run without violating fiscal sustainability and, more importantly, without long-run inflationary consequences. Figure 5.11 illustrates the logic. From equations (5.9)—(5.11) and the criterion (5.12) one can unambiguously conclude that for $\mu_1<\mu_2<\mu_0$ the log of real money balances and hence seigniorage increase on the interval $\left[t_A, t_{S_1}\right]$, including a discrete increase at t_A, while inflation decreases. Then, for the time interval $\left[t_{S_1}, t_{S_2}\right]$, the log of real money balances starts to decrease to its new steady state, and reaches it at time t_{S_2} (inflation, consequently, increases). The new steady state level of real money balances (inflation) is higher (lower), than it was initially. One can view this as something like “pleasant monetarist arithmetic”. At the same time, seigniorage jumps up at t_A; it then gradually increases until t_{S_1}, jumps down and decreases on the interval $\left[t_{S_1}, t_{S_2}\right]$; eventually, after a final discrete increase at time t_{S_2}, it will stay at a new steady state level that is lower than it was initially (we are using our usual assumption about the economy being on the “right side” of the Laffer curve). Even so, the present value of seigniorage at time t_A may remain constant or even increase, for the simple reason that on the time interval $\left[t_A, t_{S_1}\right]$ seigniorage will be higher then it was initially. This is likely to be possible for high interest rates, which make the fall in seigniorage in the distant future less important (for the evaluation of present value) than its increase in the short run. Consequently, fiscal sustainability is not violated, and there is even an option for the government to expand[21].

Figure 5.11 illustrates this “pleasant monetarist scenario”. The primary budget deficit remains constant. At time t_A the value of b_S may discretely fall (*ceteris paribus* for low interest rates), rise (for high interest rates), or simply remain unchanged (shown by the solid, dotted, and chain lines, respectively, in Fig. 5.11).

If the actual parameters of the economy are such that it is possible to find the needed parameterization for this kind of monetary policy, the public debt may be kept on a sustainable path. After a gradual decrease during the interval $\left[t_A, t_{S_1}\right]$, it increases to its new steady

[21] Of course, this is true under the assumption that private agents do know precisely which kind of policy will be chosen by policymakers.

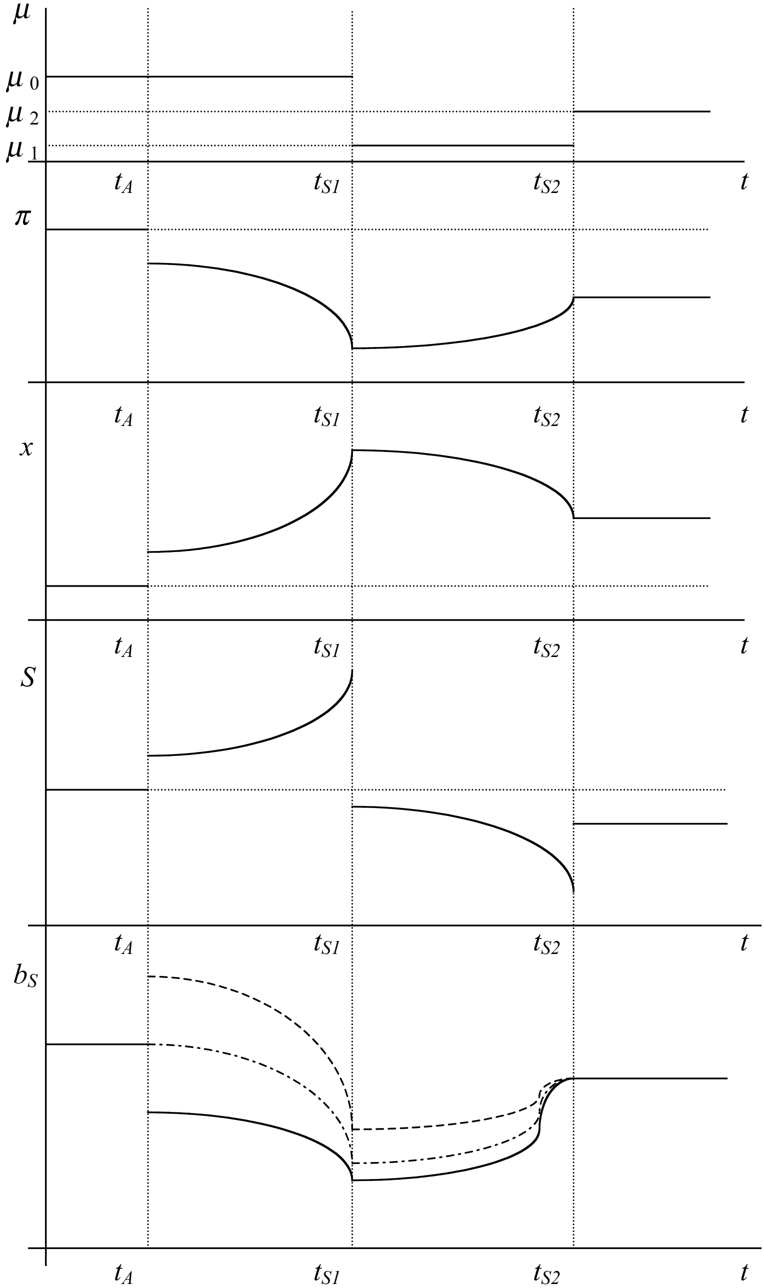
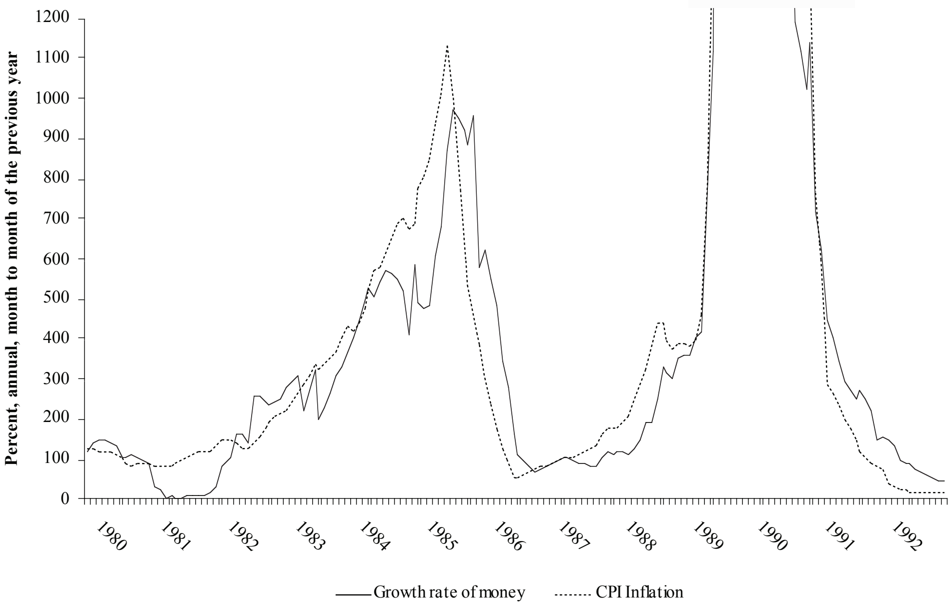
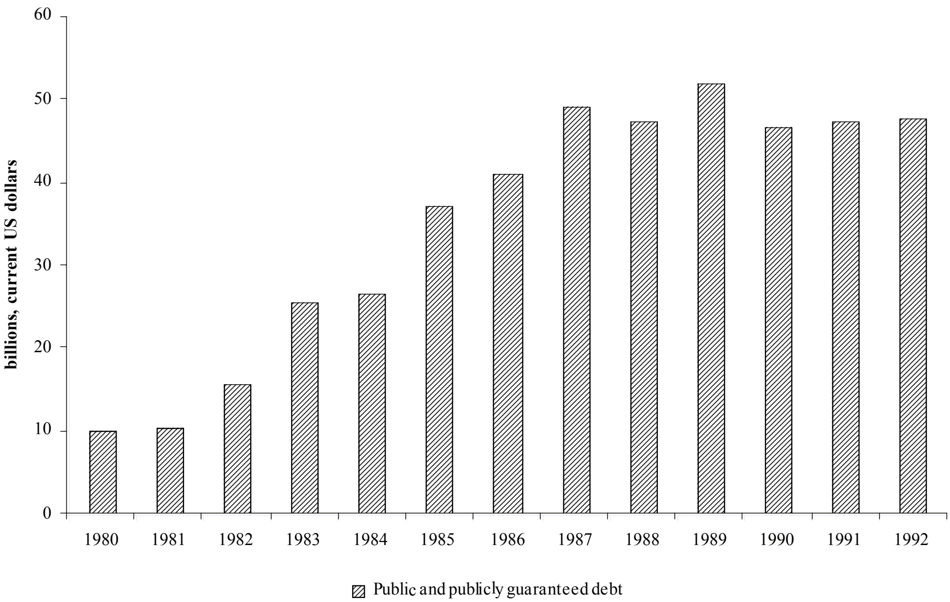


Fig. 5.11. *Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary decrease in the growth rate of base money* ($\mu_1 < \mu_2 < \mu_0$)



Source: International Financial Statistics, IMF.

Fig. 5.12. *Inflation and growth rate of money in Argentina, 1980—1992*



Source: World Development Indicators, The World Bank Group.

Fig. 5.13. *Debt burden in Argentina, 1980—1992*

state level, which is lower than the initial one. Table A5.3 in the Appendix presents concrete specifications of the parameters in the model and a numerical experiment that demonstrates the fall and rise of $b_S(t_A)$. Again, due to computational complexity we do not illustrate numerically the knife-edge case of an unchanged $b_S(t_A)$ that seems, nevertheless, possible.

5.9. Unpleasant monetarist arithmetic at work: The failure of the Austral Plan in Argentina

In Section 5.5 we discussed examples of a more or less successful stabilization of high inflation and public debt in two Latin American countries, namely Chile and Mexico, and in Israel. The stabilization program in Argentina, the so-called Austral Plan, started roughly at the same time as Israel's stabilization program. However, Argentina's stabilization effort (along with the Crusado Plan in Brazil in 1986) provides an example of an incomplete and unsuccessful stabilization program. What is most interesting for us is that this failure resembles the logic of unpleasant monetarist arithmetic.[22]

The economic situation in Argentina in the late 1970s and 1980s was extremely bad. Average annual growth rate of GDP was about 0.5 percent between 1975 and 1985 (it was positive in the 1970's and it became negative in the 1980s). During this period, inflation was almost always in the three-digit range (see Fig. 5.12). It was brought down to the two-digit range in 1980. Soon after, however, it again entered the three-digit range and accelerated further. In May 1985, the annual inflation rate became higher than 1000 percent. The fiscal position was characterized by chronic deficit. Public and publicly guaranteed debt more than tripled between 1980 and 1985 (see Fig. 5.13).

The Austral Plan was announced in June 1985. Like Israel's stabilization program, it combined orthodox measures (a cut in the budget deficit aimed at stopping inflationary finance) and a price, wage and exchange rate freeze (aimed at breaking inflation inertia) along with an introduction of a new currency, the *austral* (pegged at USD0.8).

Table 5.2. Budget deficit and seigniorage in Argentina, 1984—1988 (percent of GDP)

	Primary deficit	Interest payments	Operational Deficit	Seigniorage
1984				
I	5,8	5,2	11,0	10,2
II	3,4	5,9	9,3	7,2
III	2,1	4,8	6,9	5,2
IV	3,7	5,6	9,3	5,8

[22] Discussion in this section is based on Heymann (1991) and Bruno (1993). See also Canavese and Di Tella (1988), Machinea and Fanelli (1988), and Kiguel and Liviatan (1991).

Continuation of Table 5.2

	Primary deficit	Interest payments	Operational Deficit	Seigniorage
1985				
I	3,6	6,5	10,1	6,0
II	0,1	6,4	6,5	6,8
III	-3,5	6,5	3,0	8,9
IV	-4,8	6,8	2	4,1
1986				
I	–1,1	5,8	4,7	4,1
II	–3,5	5,7	2,2	3,3
III	–1,3	2,8	1,5	2,4
IV	3,0	5,7	8,7	3,1
1987				
I	1,0	4,1	5,1	4,5
II	0,4	6,3	5,7	2,7
III	1,4	6,7	8,1	1,7
IV	1,6	4,3	5,9	5,0
1988				
I	0,3	9,0	9,3	3,3
II	–0,7	5,8	5,1	4,2
III	2,6	0,9	3,5	5,3
IV	2,1	4,0	6,1	5,0

Source: Heymann (1991).

The Plan was initially successful. The government was indeed able to substantially cut the deficit (see Table 5.2). The annual inflation rate decreased from 1129 percent in July 1985 to 50 percent in July 1986. However, success was very short lived. The main problem was that the government was not able to succeed in cutting the budget. The initial increase in tax revenues was mainly associated with the Olivera-Tanzi opposite effect of the price freeze. By the end of 1986 the budget deficit was again very high. Inflation started to accelerate once more. Things went out of control under open hyperinflation that was stabilized only in 1991.[23]

For the purposes of our analysis, we are not interested in the particular reasons why the government was not able to sustain a sufficient budget cut over a long period of time.[24] Tak-

[23] Brazil, which was in roughly the same economic situation in the 1980s, introduced the Crusado Plan in 1986. Initially, Brazil was able to reduce inflation mainly via a price freeze, but as in Argentina's case this eventually led to even higher inflation. Researches come to the conclusion that the Austral Plan in Argentina was at least well designed initially, while there was no attempt to adjust the fiscal position or conduct tight monetary policy during Brazil's stabilization. See, for example, Cardoso (1991), Dornbusch and Fischer (1991), and Kiguel and Leviatan (1991). It is for this reason that we pay little attention to the Brazilian experience of the 1980's.

[24] See a discussion on this subject and a comparison with Israel's stabilization in Bruno (1993).

ing this fact as it is, we can interpret the Austral Plan as an example of unpleasant monetarist arithmetic at work. Indeed, what was done (although it was not planned so badly) was an effort to fight inflation by tight monetary policy without implementing the corresponding fiscal correction. As we discussed in Section 5.6, a permanent decrease in the growth rate of money, if not supported by fiscal adjustment, may not be credible in general. This was true in the case of the Austral Plan. In a situation of extremely high public debt, when the government became unable to continue its initially tight fiscal policy in the future, monetary policy was pushed to finance the increasing budget deficit. After a period of successful decrease, the inflation rate started to increase again. This scenario roughly resembles the time path of inflation depicted by the dotted line in Fig. 5.8. Moreover, seigniorage revenue, which first rose at the beginning of the stabilization program, then decreased, and finally became higher again (see Table 5.2), also corresponds to the time path in Fig. 5.8.

5.10. The Asian crisis of 1997: Tight monetary policy and prospective deficits

Usually, economists treat the Asian crisis of 1997 as a currency crisis.[25] However, there are certain fiscal and monetary features of this crisis that make it a good historical example for our analysis. Burnside, Eichenbaum and Rebelo (2001) suggest a theoretical model and empirical evidence in support of the view that a currency crisis may take place even when monetary policy is reasonably tight and the fiscal sphere is *currently* balanced, so that there is no concern about insufficient reserves for maintaining a fixed exchange rate regime or about poor current fiscal fundamentals. The key idea is that a large publicly guaranteed debt accumulated by the private sector creates expectations of large *prospective* fiscal deficits. This in turn creates fears of the monetization of future deficits, and thus higher inflation now and in the future. We can strengthen this point by means of the theoretical examples considered above.

Burnside, Eichenbaum and Rebelo (2001) consider the situation in the period before the Asian crisis in five countries: Indonesia, South Korea, Malaysia, the Philippines, and Thailand. In all these countries, the fiscal balance was positive in 1995—1996 (as shown in Fig. 5.14). However, as we have stressed throughout the chapter, the current fiscal stance is not essential in determining the sustainability of the fiscal sphere. Indeed, what is important is the future backing of government liabilities, that is, the government's ability to provide sufficient budget surpluses and/or seigniorage in the future to meet its current obligations. And this was one of the main problems in all of the five chosen countries. Difficulties arose in the private banking sector. Burnside, Eichenbaum and Rebelo (2001) provide evidence that the public was expecting a failure in the banking sector, and, due to implicit bailout guaranties, the consequent rise of large government deficits.

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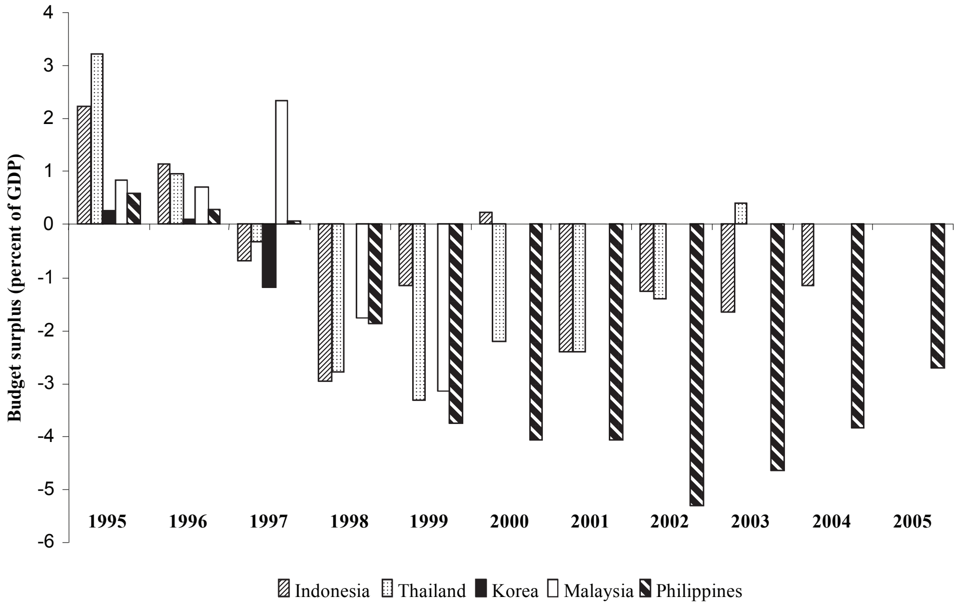
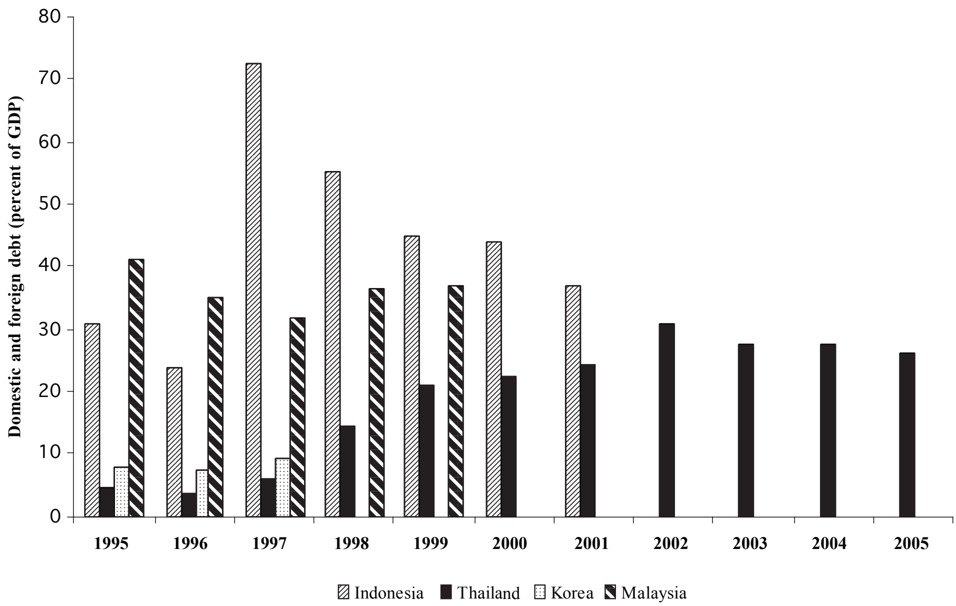
[25] See a general discussion on the Asian 1997 crisis in Furman and Stiglitz (1998), Kaminski and Schmukler (1999), Radelet and Sachs (1998), and Corsetti, Pesenti and Roubini (1998a, b), among others.



Source: International Financial Statistics, IMF.

Fig. 5.14. *Budget surplus (deficit) in selected countries, 1995—2005*



Source: International Financial Statistics, IMF.

Fig. 5.15. *Domestic and foreign debt in selected countries, 1995—2005*

In fact, for the purposes of our study it is not of much importance what the real source of expectations was that the government would be stricken by huge fiscal deficits in the future. We take expected future deficits as an assumption, but we can indeed see a tremendous turnover in the fiscal stance after the crisis in Fig. 5.14 and 5.15.

The question is: Do prospective deficits necessarily provoke inflation and was it true for the Asian countries? The simple arithmetic provided in Section 5.3 shows that an expected increase in future deficits *can* lead to higher inflation. Indeed, at the time when public change expectations about the future fiscal balance (expected future surpluses are replaced by expected future deficits), the current level of public debt may become unsustainable or unbacked by the government itself. Treating this shift in fiscal policy as exogenous, since the government has to meet its guaranties on bad private loans, one should expect an endogenous increase in the present discounted value of future seigniorage as an additional source of finance.[26] This in turn can be achieved by means of loose monetary policy. Figure 5.1 provides the simplest example of an increase in the present discounted value of seigniorage supported by a permanent increase in (the constant) growth rate of base money. But as we stressed in Section 5.3 this is the policy option that holds only in the case of a relatively low interest rate. When the interest rate on public debt is relatively high, a permanent increase in the growth rate of base money can produce a decrease in the present discounted value of seigniorage. This makes the current public debt even more unsustainable, and thus this is not a policy option here. Section 5.4 and Fig. 5.2 provide the logic of how a permanent decrease in the growth rate of base money can produce an increase in the present discounted value of seigniorage in the case of a relatively high interest rate. Sections 5.6 and 5.8 develop the similar argumentation in the case of temporary changes in macroeconomic policy.

Addressing this logic for the case of the Asian crisis of 1997 is not an easy task. There are two separate problems. The first is determining what "relatively low" and "relatively high" interest rates actually are. In our model, different policy options appear not only because of different magnitudes of the real interest rate, but also because of different semi-elasticities of money demand and the time intervals (or their combinations, to be precise). Moreover, in the case of a temporary change in the growth rate of base money, we derived a specific condition, (5.12), that determines the possible outcomes. After all, in the real world, interest rates are not constant through time and states of nature, as in our simple model, and public debt consists of different financial instruments with different yields. On one hand, our logic hardly answers the question of whether prospective deficits provoked inflation in Asia in 1997. However, we can at least stress that there could be different policy options (stated above) for different economies.[27] On the other hand, having observed monetary expansion and an increase in inflation after the crisis (see Fig. 5.16 and 5.17), we can use the first scenario (in which an increase in the present value of seigniorage may be provided by a permanent increase in the

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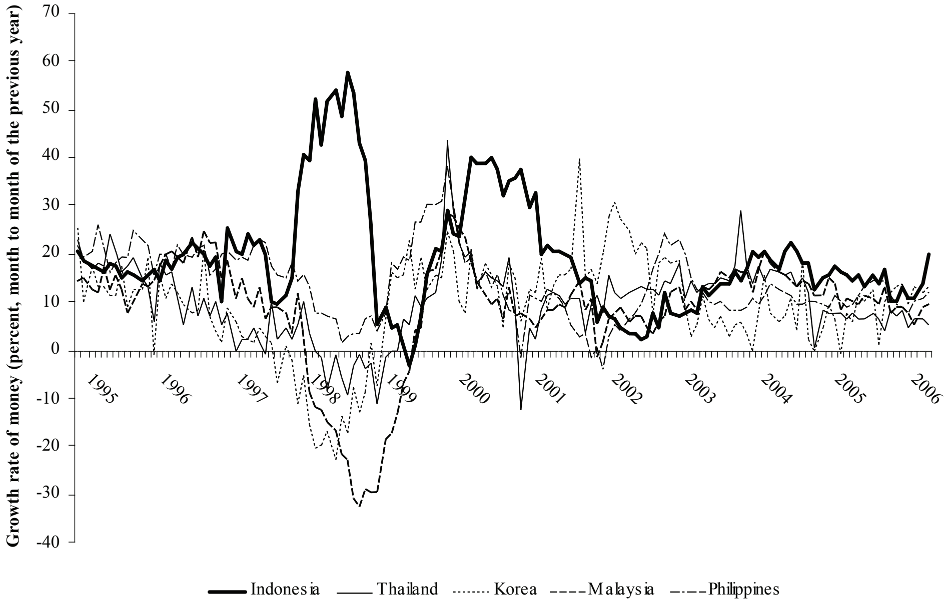
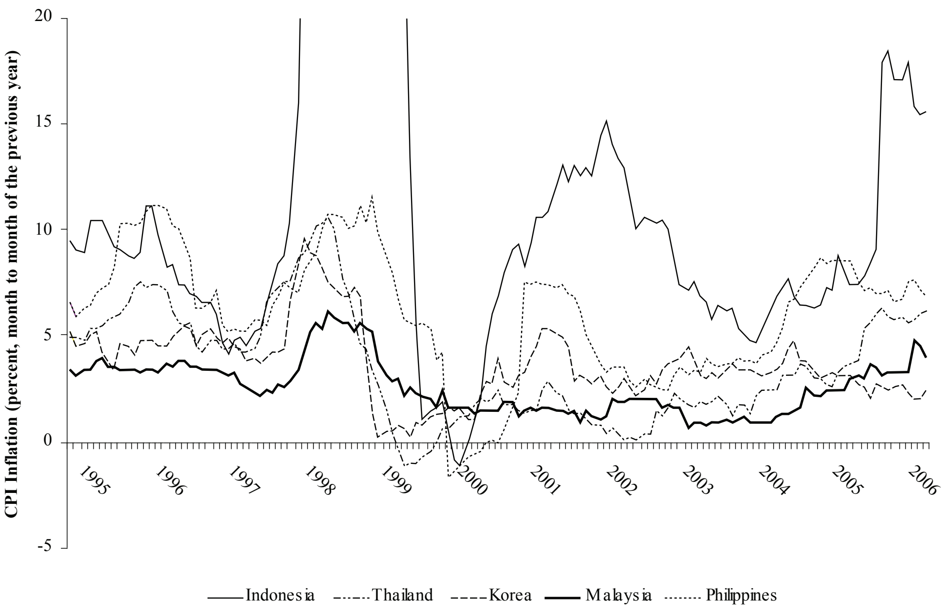
[26] Burnside, Eichenbaum and Rebelo (2001) argue that it was hardly expected that government will be able to adjust its balance.

[27] This contradicts the unambiguous statement of Burnside, Eichenbaum and Rebelo (2001).



Source: International Financial Statistics, IMF.

Fig. 5.16. *Growth rate of money in selected countries, 1995—2005*



Source: International Financial Statistics, IMF.

Fig. 5.17. *CPI growth rate in selected countries, 1995—2005*

growth rate of base money) to understand the logic of the crisis in terms of a problem of fiscal sustainability.[28]

The second problem is that the whole discussion on the importance of fiscal sustainability relies on the specific assumptions that we stressed in Chapter 2: the interest rate should be higher than the GDP growth rate (the dynamics of the public debt to GDP ratio should be stable on a backward-looking basis).[29] Addressing this question for the selected five countries before and after the crisis is again a difficult task, since GDP growth varies substantially from year to year just like interest rates do.[30] Moreover, the crisis led to a dramatic slump for at least one year in all five countries. Table 5.3 shows the annual GDP growth rates and the real rates of interest. The latter is taken as the lending rate minus the inflation rate. Although this is not a precise measure for the discount rate in the calculation of the present value of future budget surpluses and seigniorage, it is sufficient for the purposes of illustration. Positions marked by bold italic type depict periods in which the interest rate was higher than the GDP growth rate. We can see that these periods prevail in all countries except for Malaysia. In the first approximation, this fact can be interpreted as that, indeed, fiscal sustainability matters for this case study. However, it goes without saying that more rigorous research is needed here.

The last point in this discussion is that, again, the narrow framework of our research limits us. Although fiscal and monetary policy interaction issues may be important for explaining the crisis, its true nature is much more complicated. Specifically, further analysis should take into account not only monetary policy, but also the exchange rate policy of the central bank before and after the crisis.

Table 5.3. GDP growth and real interest rates in selected countries, 1995—2005

		1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Indonesia	GDP growth[1]	8,4	*7,6*	*4,7*	–13,1	*0,8*	4,9	3,8	*4,4*	*4,7*	*5,1*	5,6
	Real interest rate[2]	8,3	*9,5*	*8,2*	–24,6	*11,8*	–1,7	1,6	*12,2*	*12,0*	*7,4*	0,3
Thailand	GDP growth[1]	9,5	*5,9*	*–1,4*	*–10,5*	*4,4*	*4,8*	*2,2*	*5,3*	7,0	6,2	4,5
	Real interest rate[2]	7,3	*9,0*	*9,2*	*4,7*	*13,6*	*6,4*	*5,1*	*6,0*	4,2	2,1	1,2
Korea	GDP growth[1]	9,2	7,0	*4,7*	*–6,9*	*9,5*	8,5	*3,8*	7,0	*3,1*	4,7	*4,0*
	Real interest rate[2]	1,5	3,5	*6,9*	*8,9*	*9,5*	7,8	*4,0*	3,8	*3,4*	3,3	*5,9*

[28] This means that we “believe” that interest rates were “relatively low”.

[29] Burnside, Eichenbaum and Rebelo (2001) do not discuss this problem.

[30] This resembles the polemic between Darby (1984) and Miller and Sargent (1984) that was discussed in Chapter 2.

Continuation of Table 5.3

		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	GDP growth[1]	9,8	10,0	7,3	*-7,4*	*6,1*	8,9	*0,3*	4,4	5,4	7,1	5,3
	Real interest rate[2]	4,9	6,0	6,9	*3,4*	*8,5*	2,7	*10,3*	2,7	2,7	-0,2	1,4
Philippines	GDP growth[1]	*4,7*	*5,8*	*5,2*	-0,6	*3,4*	6,0	*1,8*	4,4	*4,5*	6,0	5,1
	Real interest rate[2]	*6,6*	*6,7*	*9,5*	5,7	*3,5*	4,3	*5,7*	4,4	*5,6*	3,8	3,9

Source: World Development Indicators, The World Bank Group.

[1] Annual, percent.

[2] Annual, percent. Defined as lending interest rate adjusted for inflation.

5.11. Uncertainty about the magnitude and the direction of change in the growth rate of base money

Up to now we have accepted the assumption of perfect foresight: there was no uncertainty about what kind of change in macroeconomic policy would occur and when. Here and in the following section we consider two simple examples. In the first one there is uncertainty about the magnitude as well as about the direction of the change in the growth rate of base money. In the second example we consider the situation in which private agents do not know for certain the type of impending policy switch. Specifically, they do not know whether there will be changes in fiscal or in monetary policy. However, in both examples we continue to assume that the timing of the changes in the policies is perfectly known.

Suppose that at time t_A private agents are informed that the central bank intends to change the growth rate of base money at time t_S. However, up to time t_S there is no information about whether it will be reduced or increased with respect to the initial value of μ_0. For this situation, equations (5.6)—(5.8) can be written as

$$x(t) = \begin{cases} -\alpha\mu_0, \quad t < t_A, \\ -\alpha\mu_0 - \alpha(E_{t_A}\left[\mu_1\right] - \mu_0)e^{-\frac{1}{\alpha}(t_S - t)}, \quad t_A \le t < t_S, \\ -\alpha\mu_1, \quad t \ge t_S. \end{cases} \tag{5.13}$$

$$\pi(t) = \begin{cases} \mu_0, \quad t < t_A, \\ \mu_0 + (E_{t_A}\left[\mu_1\right] - \mu_0)e^{-\frac{1}{\alpha}(t_S - t)}, \quad t_A \le t < t_S, \\ \mu_1, \quad t \ge t_S. \end{cases} \tag{5.14}$$

$$S(t) = \begin{cases} \mu_0 e^{-\alpha\mu_0}, & t < t_A, \\ \mu_0 e^{-\alpha\mu_0 - \alpha(E_{t_A}[\mu_1] - \mu_0) e^{-\frac{1}{\alpha}(t_S - t)}}, & t_A \le t < t_S, \\ \mu_1 e^{-\alpha\mu_1}, & t \ge t_S. \end{cases} \quad (5.15)$$

where $E_{t_A}[\mu_1]$ is the expected new growth rate of base money at time t_A.

Figure 5.18 depicts the dynamics of the economy for various cases. Let us assume for concreteness that the central bank actually increases the growth rate of base money. The opposite situation can be easily considered as well. The first possibility is that the expected growth rate of base money will be higher than that which was actually chosen. The path of the log of real money balances (the chain line in Fig. 5.18) is located lower than it would be under certainty (the solid line in Fig. 5.18). No matter what the new steady state is, the economy suffers from excess inflation during transition. The actual present value of seigniorage is lower than under certainty. Quite naturally, a situation in which private agents overestimate the future growth rate of base money is a disadvantage both for the central bank and for the government.

In the second case, $\mu_0 < E_{t_A}[\mu_1] < \mu_1$, and the log of real money balances (inflation) is decreasing (increasing). However, its path (the long-chain line in Fig. 5.18) is above (below) the solid line that characterizes the certainty case. This scenario is favorable both for the central bank and for the government, as long as the present value of seigniorage is higher and inflation lower than they could be, at least during transition. The government acquires the option to increase spending or to cut taxes.

In the third and final case, $\mu_0 < E_{t_A}[\mu_1] < \mu_1$, the log of real money balances and seigniorage increase and inflation falls during the transition period $[t_A, t_S]$ (see the double-dashed line in Fig. 5.18).

All of the cases considered above demonstrate the interest of both the central bank and the government in having private agents underestimate the future growth rate of base money, and especially for them to expect its decrease rather than its increase[31]. As an extreme case, the best way to increase the present value of seigniorage, given that the economy is on the "right side" of the inflation tax Laffer curve, is to form expectations among private agents for a decrease in the growth rate of base money, and then to actually increase it[32].

The bottom diagram in Fig. 5.18 shows sustainable public debt dynamics. We see from the previous analysis that, under conditions of certainty, a permanent increase in the growth rate of base money results in a discrete fall in b_S at time t_A (the solid line in Fig. 5.18), if

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[31] However, in this specification one must be careful about extra jumps in inflation. Most economists believe that such shocks have a negative effect on the economy for many reasons. See, e.g., Beckerman (1992), Heymann, Leijonhufvud (1995).

[32] In general this can lead to the dynamic inconsistency problem (Kydland, Prescott, 1977), but here we are not concerned about this for the simple reason that we do not introduce any kind of policy trade-off that could give rise to this problem.

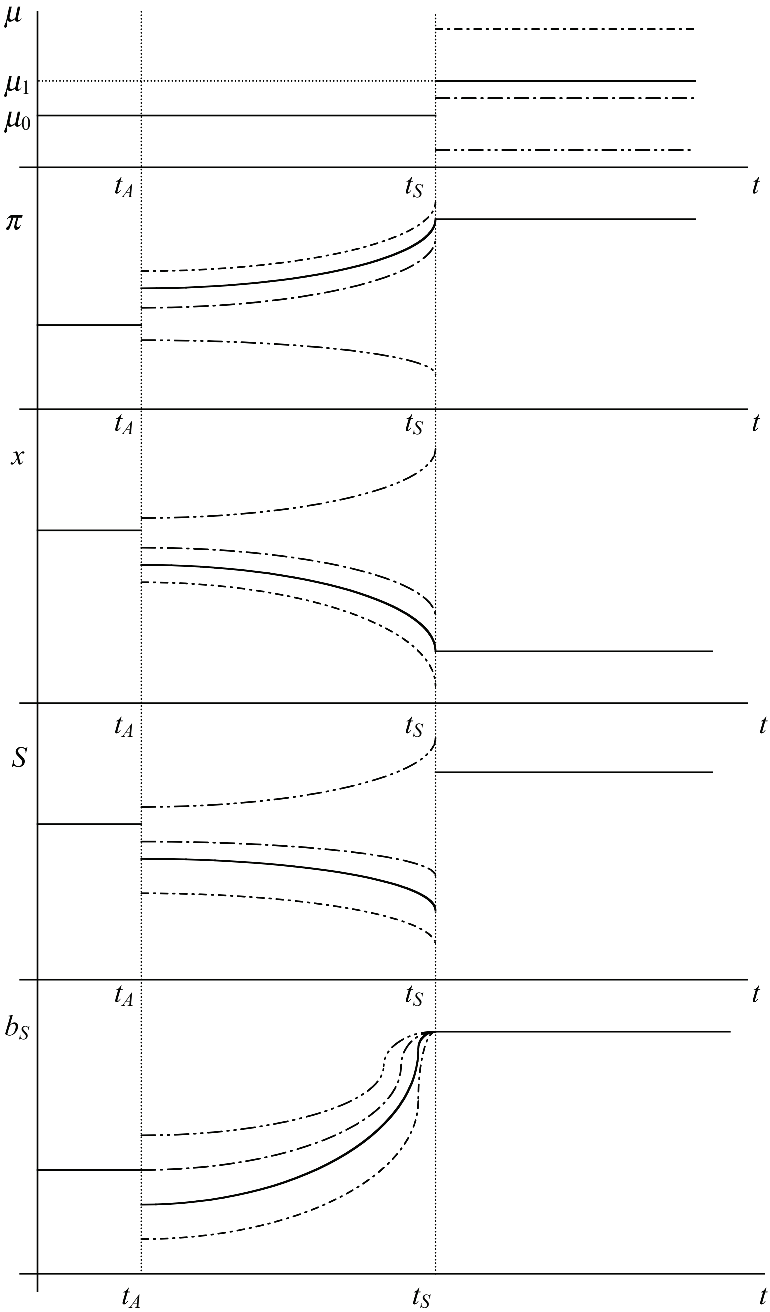

Fig. 5.18. *Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for the case of a permanent increase in growth rate of base money of uncertain magnitude*

only the interest rate is high enough. The government must cut the primary budget deficit in order to keep the debt on a sustainable path. If, under conditions of uncertainty, private agents overestimate the rise in the growth rate of base money, then the announcement of a downward jump in b_S should be even larger (the chain line in Fig. 5.18). The government must implement a greater cut in the primary deficit. In the case when $\mu_0 < E_{t_A}\left[\mu_1\right] < \mu_1$, b_S will undergo a smaller downward jump, or it can remain the same, or even jump up (the long-chain line in Fig. 5.18). Finally, if the central bank is able to form expectations of a decrease in the growth rate of base money, the present value of seigniorage should rise. b_S jumps upward at time t_A (the double-dashed line in Fig. 5.18), allowing the government to increase the primary budget deficit while keeping the accumulated debt sustainable[33].

5.12. Uncertainty about the type of change in macroeconomic policy

Due to the fact that the second equation of system (5.1) does not include any parameter or variable pertaining to the fiscal sphere, any certain or uncertain changes in fiscal policy can affect the money market only via the unavoidable interaction with monetary policy. Thus, for the dynamics of inflation, the only relevant uncertainty is that which pertains to monetary policy. To illustrate this, assume that initially the economy was in a steady state, and at some point the government increases the primary budget deficit. This action, of course, moves the public debt off its sustainable path. To prevent this, either the government must cut the budget deficit at some point in the future, or the central bank must somehow increase the present value of seigniorage. Actually, in fact, a policy mix is also possible.[34]

Assume further that private agents do not precisely know the type of policy that must be implemented at time t_S (as usual, assume that (quantitative) information concerning deregulation in the fiscal sphere was revealed earlier, at time t_A). Assume the economy is functioning on the "right side" of the inflation tax Laffer curve. We know from the analysis in Sections 5.3—5.4 that, acting alone, the central bank can increase the present value of seigniorage either by permanently increasing the growth rate of base money in the case of low interest rate, or by permanently decreasing it if the interest rate is sufficiently high. In general, the central bank can do this either by increasing the growth rate of base money from μ_0 up to μ_{H_1} or μ_{H_2} ($\mu_0 < \mu_{H_1} \le \mu_{H_2}$), or by decreasing it down to μ_{L_1} or μ_{L_2} ($\mu_{L_2} \le \mu_{L_1} < \mu_0$).

Figures 5.19 and 5.20 depict the discrete change in the sustainable level of debt, $\Delta b_S(t_A)$, as a function of the future growth rate of base money μ_1.

For all realistic parametric specifications, the function $\Delta b_S(t_A)$ has a single maximum with a positive value. Besides the initial growth rate of base money, $\Delta b_S(t_A)$ equals zero at only one other point (μ_{max} in Fig. 5.19 and μ_{min} in Fig. 5.20, respectively). If the interest rate is rela-

[33] Here we have considered only the case when the economy is on the "right side" of the inflation tax Laffer curve. One can easily consider the other case as well.

[34] Kawai and Maccini (1990, 1995) study the effects of anticipated switches in the method of budget deficit's finance. Their model demonstrates no straightforward connection between inflation and budget deficits. This result conforms our general finding in Chapters 4 and 5.

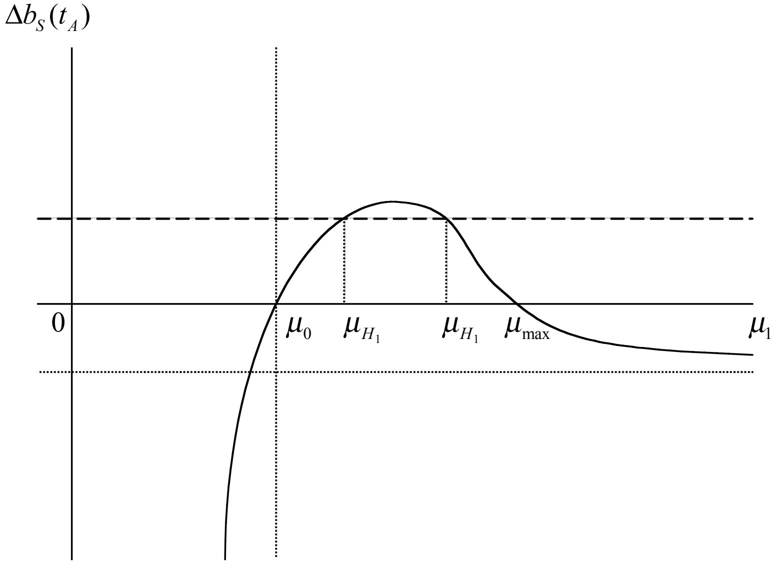

Fig. 5.19. *Discrete change in the sustainable level of public debt as a function of the future growth rate of base money given a low interest rate*

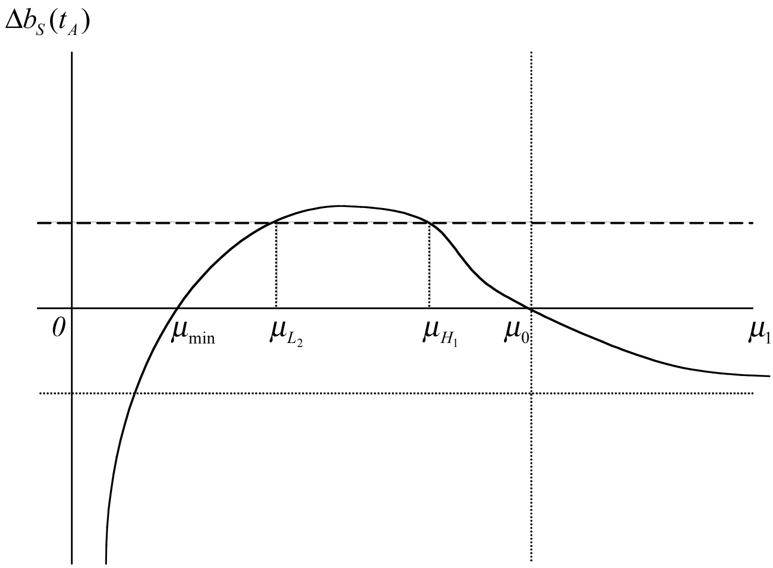

Fig. 5.20. *Discrete change in the sustainable level of public debt as a function of the future growth rate of base money given a high interest rate*

tively low, the maximum of $\Delta b_S(t_A)$ is located to the right of μ_0 (see Fig. 5.19). Thus, the only way the central bank can increase the present value of seigniorage is by increasing the growth rate of base money. Furthermore, if the desired increase in the present value of seigniorage does not exceed the maximum of $\Delta b_S(t_A)$, there are two values of the new growth rate of base money, μ_{H_1} and μ_{H_2}, which the central bank can implement.

On the other hand, if the interest rate is sufficiently high, the only way the central bank can increase the present value of seigniorage is by reducing the growth rate of base money. This is because the maximum of $\mu b_S(t_A)$ lies to the left of μ_0 (see Fig. 5.20). Again, in general there are two values of μ_1, denoted μ_{L_1} and μ_{L_2}, that achieve the desired result[35].

If, in fact, only monetary policy will be changed to keep the public debt sustainable, if this is known to economic agents, and if the central bank does not intend to increase the present value of seigniorage any more than needed, then expectations concerning the future growth rate of base money can only be either $E_{t_A}\left[\mu_1\right] = \mu_{L_i}$, or $E_{t_A}\left[\mu_1\right] = \mu_{H_i}$, $i = 1{,}2$, depending on the possibilities of the central bank (i.e., depending on interest rate). On one hand, private agents should not expect that the central bank would choose μ_1, which does not correspond to the required change in the present value of seigniorage. On the other hand, after private agents have formed their expectations (i.e. have chosen one of the two possible values of μ_1), monetary policy will simply be forced to follow them. If expectations are different, the actual change in the present value of seigniorage will be lower or higher than required.

As long as we do not have any formal equilibrium selection device, the equilibrium is indeterminate. As an informal device, we can assume that central bank will always prefer lower inflation if possible, i.e. it will always choose a lower growth rate of base money[36]. However, in the current setup monetary policy must follow formed expectations, while private agents may or may not take the central bank's preferences into consideration. Thus, in fact, there may be a kind of "sunspot equilibrium"[37].

In the case of a policy mix aimed to keep the public debt sustainable, i.e. when both the central bank and the government intend to adjust their policies, private agents quite possibly do not know for certain what changes in the present value of seigniorage or primary budget deficit to expect. Thus they do not know the two possible values of the growth rate of base money. If we assume that changes in monetary policy should not be at least less than the present value of seigniorage, then we can determine the possible range of inflationary expectations — it is simply the interval $[\mu_{\min}, \mu_0]$ or $[\mu_0, \mu_{\max}]$, depending on the interest rate, where the function $\Delta b_S(t_A)$ is positive.

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[35] The shape of the curves depicted in Fig. 5.19—5.20 was derived by numerical calculations using MathCad® 2000 Pro. The parameterization of the calculations is the same as in the examples considered in Sections 5.3—5.4.

[36] Since the choice of the growth rate of base money also determines the new steady state level of public debt, which is important in the general context of the coordination of macroeconomic policy, one may suggest an alternative (and just as informal) criterion for the choice of equilibrium: the central bank may have the intention to position the fiscal sphere in a particular way.

[37] See excellent reviews of this problem in Azariadis (1993) and Farmer (1999), among others.

5.13. Uncertainty about the timing of change in macroeconomic policy

In this section we consider the hypothetical situation in which there is no uncertainty about the type of policy switch, but there is uncertainty about its timing. As before, we consider the generic case, when there is uncertainty regarding future monetary policy.

Assume that initially the money market is in equilibrium for some growth rate of base money μ_0, and economy is on the "right side" of the inflation tax Laffer curve. At time t_A private agents receive information that at some unknown moment in the future the growth rate of base money will be increased to μ_1. As an illustrative example we propose the simplest scenario: the switch in monetary policy must be done either at time t_{S_1}, or at a later date t_{S_2}, but then for certain. Let $p \in [0,1]$ be the subjective probability that monetary policy will be changed at the earlier date t_{S_1}. At this moment the agents learn when switches in monetary policy will be implemented. If the earlier date is chosen, then this change will endure. If not, then it will switch at the later time t_{S_2} with unit probability[38]. Equations (5.16)—(5.18) describe the dynamics of the money market.

$$x(t) = \begin{cases} -\alpha\mu_0, \quad t < t_A, \\ = -\alpha\mu_0 - \left(\alpha\left[p\mu_1 + (1-p)\mu_0\right] - \mu_0\right)e^{-\frac{1}{\alpha}(t_{S_1}-t)} - \\ \quad - \alpha\left(\mu_1 - \left[p\mu_1 + (1-p)\mu_0\right]\right)e^{-\frac{1}{\alpha}(t_{S_2}-t)} = \\ = -\alpha\mu_0 - \alpha(\mu_1 - \mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)} + (1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right], \quad t_A \le t < t_{S_1}, \\ \left\{\begin{matrix} -\alpha\mu_0 - \alpha(\mu_1 - \mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}, \quad \mu(t) = \mu_0 \\ -\alpha\mu_1, \quad \mu(t) = \mu_1 \end{matrix}\right\}, \quad t_{S_1} \le t < t_{S_2}, \\ -\alpha\mu_1, \quad t \ge t_{S_1}. \end{cases} \tag{5.16}$$

$$\pi(t) = \begin{cases} \mu_0, \quad t < t_A, \\ \mu_0 + (\mu_1 - \mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)} + (1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right], \quad t_A \le t < t_{S_1}, \\ \left\{\begin{matrix} \mu_0 + (\mu_1 - \mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}, \quad \mu(t) = \mu_0 \\ \mu_1, \quad \mu(t) = \mu_1 \end{matrix}\right\}, \quad t_{S_1} \le t < t_{S_2}, \\ \mu_1, \quad t \ge t_{S_1}. \end{cases} \tag{5.17}$$

[38] This illustrative example is rather standard. See, e.g., Bertola and Drazen (1993), Miller and Zhang (1997).

$$S(t)=\begin{cases}\mu_0 e^{-\alpha\mu_0}, & t<t_A,\\ \mu_0 e^{-\alpha\mu_0-\alpha(\mu_1-\mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)}+(1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right]}, & t_A\le t<t_{S_1},\\ \left\{\begin{matrix}\mu_0 e^{-\alpha\mu_0-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}}, & \mu(t)=\mu_0\\ \mu_1 e^{-\alpha\mu_1}, & \mu(t)=\mu_1\end{matrix}\right\}, & t_{S_1}\le t<t_{S_2},\\ \mu_1 e^{-\alpha\mu_1}, & t\ge t_{S_1}.\end{cases} \tag{5.18}$$

Figure 5.21 illustrates the dynamics. As long as there is no uncertainty after time t_{S_1}, the dynamics of inflation, the log of real money balances, and seigniorage during the time interval $\left[t_{S_1},t_{S_2}\right]$ are determined only by the actual value of the growth rate of base money. If the growth rate of base money increases at time t_{S_1}, then the money market jumps to a steady state and all variables will become constant (the long-dotted lines in Fig. 5.21). If monetary policy switches only at the later date t_{S_2}, then again, no matter what the preceding dynamics were, inflation and the log of real money balances should be on paths that lead to new steady states (the solid lines in Fig. 5.21). Seigniorage will also follow some path, yet after a gradual decrease on the interval $\left[t_{S_1},t_{S_2}\right]$ it will undergo an upward jumps at time t_{S_2}.

During the interval $\left[t_A,t_{S_1}\right]$, the dynamics of variables are driven by expectations. If there is no subjective confidence that monetary policy will switch at the later date t_{S_2}, i.e. when $p=0$, inflation (the log of real money balances and seigniorage) jumps upward (downward) slightly and then gradually increases (decrease). The corresponding trajectories are depicted by solid lines in Fig. 5.21. If, in fact, changes in policy take place only at time t_{S_2}, then during the interval $\left(t_A,t_{S_2}\right)$ the dynamics of all variables will be smoothened. However, if the growth rate of base money increases at the earlier time t_{S_1}, then inflation and seigniorage jump up, while the log of real money balances jumps down to its steady state.

In the other extreme, when private agents are certain that monetary policy will switch soon at time t_{S_1}, i.e. $p=1$, inflation (the log of real money balances) has a significant discrete increase (fall), and then a gradual increase (decrease); see the double-chain lines in Fig. 5.21. However, if expectations were wrong and the growth rate of base money increases at the later date t_{S_2}, all the variables will undergo one more jump in the opposite direction, and then gradually adjust.

The intermediate case, $0<p<1$, is depicted in Fig. 5.21 by dotted trajectories. We do not illustrate the possible dynamics of sustainable public debt $b_S(t)$. As in the examples given above we may conclude that, *ceteris paribus*, there is a possibility of an increase in the present value of seigniorage at t_A if the interest rate is low enough. At the same time the timing of the policy switch is important. If we do not take into consideration the formation of expectations, then an increase in the growth rate of base money at the earlier moment t_{S_1} obviously allows the central bank to gain the maximal possible increase (or at least the minimal possible

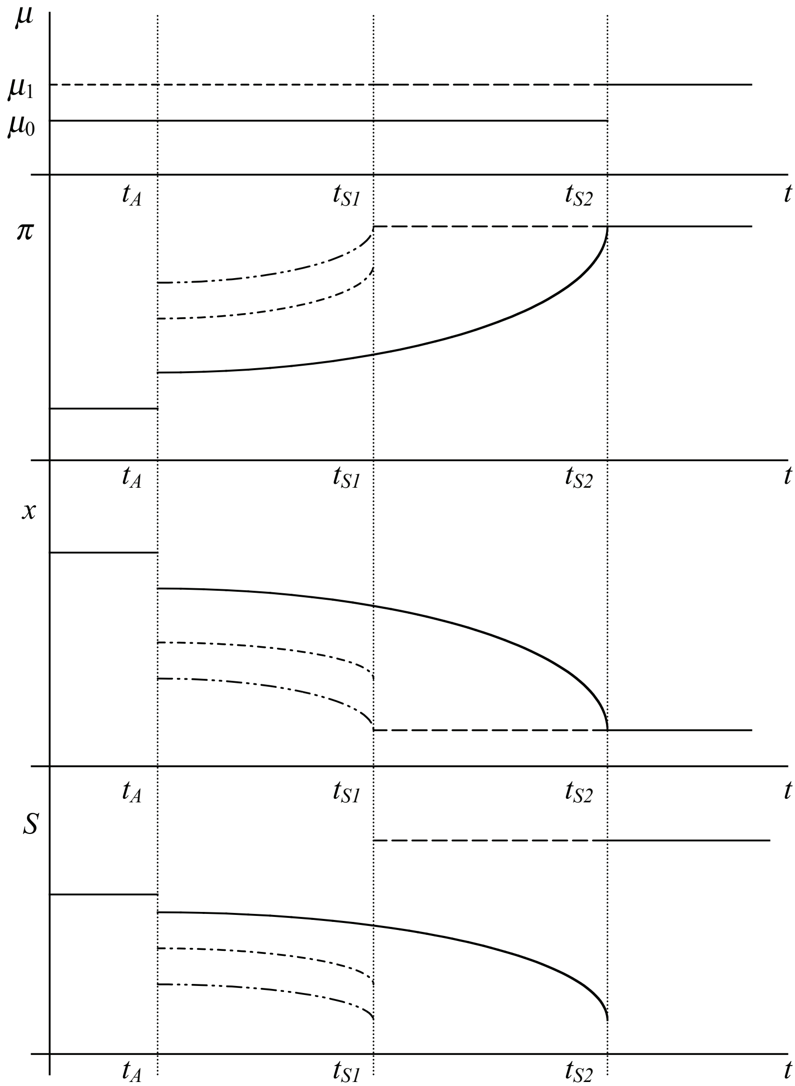

Fig. 5.21. *Dynamics of inflation, the log of real money balances, and seigniorage for a permanent increase in the growth rate of base money at an uncertain time*

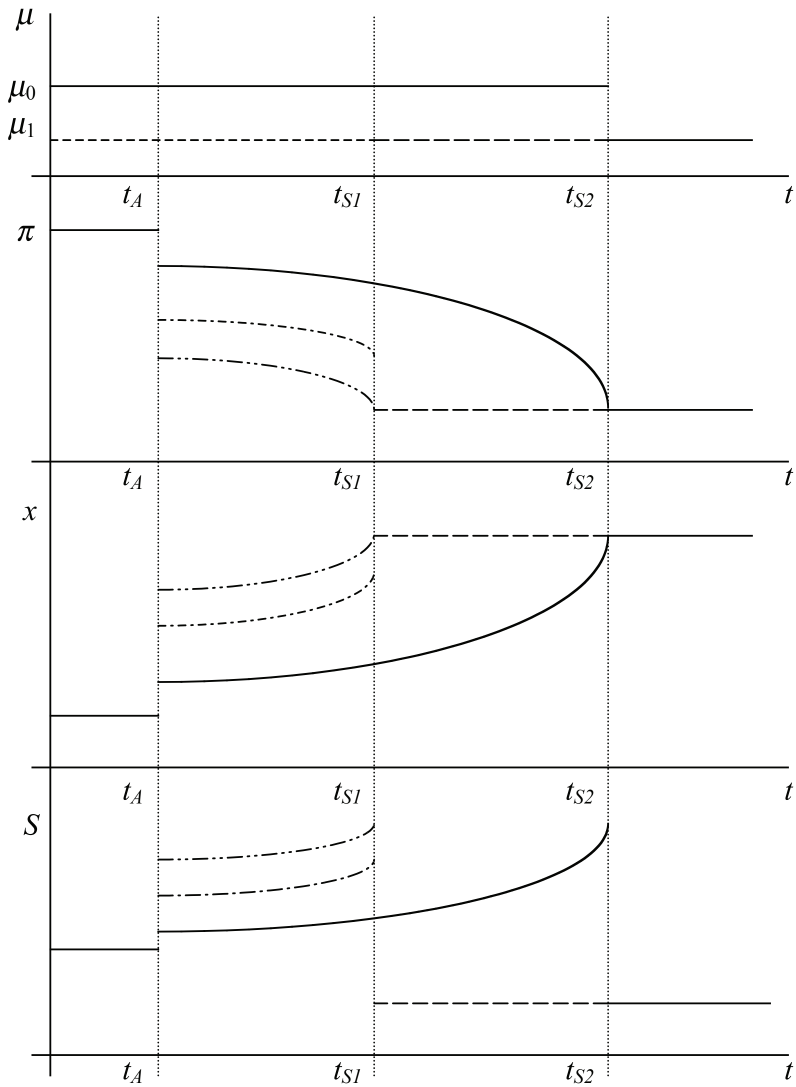

Fig. 5.22. *Dynamics of inflation, the log of real money balances, and seigniorage for a permanent decrease in the growth rate of base money at an uncertain time*

fall) in the present value of seigniorage. This conclusion is important with regard to the sustainability of the fiscal sphere. We should, however, account for the process by which expectations are formed. Private agents can also exploit the same conclusion — they will estimate the probability p quite close to unity. In turn, this will result in a decrease in the seigniorage during the interval $\left[t_{S_1}, t_{S_2}\right]$, and thus in a decrease in its present value.

Figure 5.22 depicts analogous situations for the case in which the growth rate of base money is expected to fall at some unknown date. The qualitative description of the transitory dynamics and the notation are the same as in the example above. Here the central bank has greater chances to increases the present value of seigniorage if the interest rate is relatively high. *Ceteris paribus*, the increase in the present value of seigniorage will be maximal (or at least its fall will be minimal), if the central bank does not change its policy until time t_{S_2}. Again, economic agents should take this fact into consideration. As a consequence, p will tend to zero. During the interval $\left[t_{S_1}, t_{S_2}\right]$ the temporary increase in seigniorage will not be as large as possible, and this will have a negative effect upon its present value.

5.14. Sustainability and feasibility of macroeconomic policy

Keeping the public debt on a sustainable path given any changes in the parameters of fiscal and monetary policy was an important requirement in the above analysis of various ways that fiscal and monetary policies may interact. In fact, as was shown in the previous chapter, having the public debt on an unstable path on a temporary basis does not necessarily lead to a confidence crisis. However, it is quite possible that actions by the government, either unilateral or supported by the central bank, will not be able to return the public debt to a sustainable path; this is in essence the same as saying that the government will not be able to ever completely meet its obligations, while debt is increasing exponentially in the first approximation. Having the public debt on a path of unsustainable growth should not worry rational investors, if only the government is able to adjust its expenditures and income so that their present values correspond to the current volume of debt.[39] If, however, the government loses this ability, then investors should understand that the only way for the government to stop what is in essence a Ponzi scheme is a complete or partial refusal to pay its debts. In an economy with rational agents, this criteria determines when the government will face a confidence crisis.[40]

In the previous chapter, in considering analogous problems in the context of the backward-looking dynamics of the system, it was shown that there exists a certain critical value

[39] Here the principle of sustainability of fiscal policy (5.5) does not at all demand that the government must sooner or later pay off its debts. In reality, this should not be its goal in any case.

[40] It would be a mistake, nonetheless, to forget that being on a sustainable path does not guarantee that the volume of public debt will not increase indefinitely. The no-Ponzi-game condition (2.7) simply excludes the possibility of a growth rate that is "too high". Formally, this may bring about a different problem, when the ability of the economy to absorb the public debt is exhausted. However, this critical volume of debt, except for simply pathological situations, can hardly be less than the limiting volume determined by the principle of sustainability of fiscal policy.

of the public debt, after which the government and central bank will not be able to avoid a confidence crisis. The same logic may be applied for forward-looking dynamics as well. The primary deficit (surplus) is bounded from below (from above), and, as it was shown above, the possibility of increasing the present value of future volumes of seigniorage is bounded from above as well. In the steady state, the maximum volume of seigniorage coincides with the maximum on the inflation tax curve. However, as shown above, given any initial state with certain (favorable) values of the parameters, even on the peak of the inflation tax curve, the real value of seigniorage may be increased by increasing or decreasing (depending on the parameters of the model) the growth rate of base money. What is of principle importance here are the expectations of economic agents and the transition dynamics of the system, given that there will be a certain interval of time between the announcement and the implementation of changes in monetary policy. We have shown for the simplest cases that a permanent or temporary change in μ may the present value of future volumes of seigniorage only by a limited amount.[41] In the general case, an increase in the value of seigniorage above that determined by the maximum of the inflation tax curve, is possible only at the expense of a temporary positive value of pure seigniorage, $\dot{m} > 0$, in other words at the expense of a decrease in inflation expectations. However, the increase in real money balances cannot be infinitely large.

5.15. Conclusion: the role of expectations and of economic regimes in the interaction of fiscal and monetary policies

Now we will attempt to give a general description of the various scenarios considered above, and to give what we consider to be the most important explanations for the theoretical results we have arrived at.

The principle of conducting sustainable financial policies, which is central to the research given in this chapter, requires that the volume of public debt at each moment in time corresponds to the present value of the pure income of the government (the present value of seigniorage flow minus the present value of the primary budget deficit flow). In this respect, one of the most important goals of monetary policy is managing the volume of seigniorage (of its present value) so that the public debt does not depart from a sustainable path. In the context of the rational behavior of economic agents and forward-looking dynamics of the variables of the money market, three factors are of principle importance: information concerning impending changes in monetary policy, the level of inflation in the economy, and the interest rate for on the public debt.

Seigniorage is comprised of two components: the inflation tax and the increase in real money balances (pure seigniorage). Throughout our analysis, we have used the following interesting property of an economic system: if the economy is on the "right side" of the infla-

[41] Formally, we may describe and attempt to solve the problem of maximizing the value of seigniorage, where the control variables will be not only the growth rate of base money, but also the time interval between the announcement and the implementation of a new policy. However, closed form solution may only be found for some simple specifications of monetary policy.

tion tax curve and there exists a time interval between the announcement and the implementation of changes in macroeconomic policy, then the direction of the transition dynamics of seigniorage is different from what it would be in the steady state. This fact may be widely used by the central bank in controlling the present value of seigniorage, and the possibilities of monetary policies in this respect are greatly enhanced if the central bank is able to form expectations among economic agents by informing them ahead of time about impending changes in its policies or, on the other hand, by hiding information about its future actions. We wish to underline here that we are not considering such momentous problems such as the credibility or the dynamic inconsistency of policies that are now being considered in the context of the new political economy[42]. Their integration into the analysis that is given above seems to be a promising avenue for further investigation. The role of expectations in our analysis is determined primarily by the importance of the transitional dynamics that precede actual changes in macroeconomic policies. In this respect, the range of problems considered here is qualitatively like those discussed in papers by Bental and Eckstein (1990), Drazen and Helpman (1988, 1990), Bertola and Drazen (1993), Miller and Zhang (1997).

If the economy is on the "wrong side" of the inflation tax Laffer curve, then the direction of change of seigniorage during transition will be the same as if it were in a steady state. However, in this case the character of monetary policy will be different: monetary expansion will bring about a decrease in the steady volume of seigniorage and of its present value, and a tightening of policy will bring about its increase. These results underline once again an important fact: the principles of formulating monetary policy (and its coordination with fiscal policies) under high inflation are cardinally different from those for an economy with low inflation.

The role of expectations and of transition dynamics of the money market in the context of controlling the present value of seigniorage determines the importance of the interest rate. On one hand, this is not a new result, as the interest rate on public debt determines how fast the latter will increase. On the other hand, the real interest rate is a discount rate used in evaluation of the present value of seigniorage and thus determines the relative weight of various current values of the seigniorage in both the short and the long run. We have shown that, *ceteris paribus* and taking into account the difference in the direction of the transition dynamics of seigniorage and the changes in the steady state on the "right side" of the inflation tax Laffer curve, the central bank may be able to achieve an increase in the present value of seigniorage by an increase in the growth rate of base money, if the interest rate is sufficiently low. This will allow the government to increase the primary budget deficit. On the other hand, if the interest rate is high enough, the short-term dynamics of seigniorage are of most importance and a monetary policy that is meant to increase the present value of seigniorage must resort to a decrease in the growth rate of base money. Given this, the principle of Sargent and Wallace's "unpleasant monetarist arithmetic", which states that for an exogenous fiscal

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[42] See, for example, an overview of these problems in the latest works by Drazen (2000) and Persson and Tabellini (2000).

policy, monetary policy cannot be tight in the long run, is not universal. If the interest rate is a relatively high, then a temporary increase in the volume of seigniorage that is caused by a temporary decrease in the growth rate of base money may be of principle importance in keeping the fiscal sphere on a sustainable path and does not require a final increase in the growth rate of base money (in order to increase the steady volume of seigniorage) to a level that is higher than the initial one. In other words, for an exogenous (dominating) fiscal policy, a tight policy on the part of the central bank may be long-term.

Just as one can discuss high or low inflation in an economy, by analogy we may discuss different fiscal regimes in an economy with high or low interest rates on the public debt. This can be done since this interest rate is of principle importance both for fiscal and monetary policies. Furthermore, just as it is done for different levels of inflation, the principles of formulating the policies of the central bank or the principles of interaction between fiscal and monetary policies are determined to a great extent by the fiscal regime.

Appendix. Numerical examples

Here we give numerical examples for the parameterization of our model that confirm the main results[43]. The choice of values for the parameters was made mostly for demonstrative purposes, but they are not by any means unrealistic. Absolute values, such as real money balances, deficit, public debt, and seigniorage are not important as along as we do not present models in which the main variables are given as fractions of GDP. In all examples given below the GDP determines only the scale for other absolute values. Assuming that the semi-elasticity of money demand is $\alpha = 10$, we have put the maximum of inflation tax at an inflation rate equal to 10%. In other words, for low-inflation conditions (the "right side" of the inflation tax Laffer curve) the inflation rate must be below 10%, while for high-inflation conditions (the "wrong side" of the inflation tax Laffer curve) the inflation rate must be greater than 10%[44]. In fact, this value of the semi-elasticity of demand with respect to inflationary expectations (or the nominal interest rate in general) may seem too high for developed low-inflation economies. Again, the results are robust to changes in this parameter, if we also shift the scale for other relative values, such as the growth rate of money and inflation. In order to characterize fiscal regimes with low and high interest rates, we choose correspondingly 1% and 10%. The length of all time intervals is 10 years.

The tables below contain values of all variables at the initial time ($t = 0$), at the moment when changes in macroeconomic policies are announced ($t = t_A$), and at the times when actual policy switches are implemented ($t = t_S$ or $t = t_{S_1}, t = t_{S_2}$). Since seigniorage typically undergoes an additional jump at the time of policy switch, we also consider its values just before that time ($t = t_{S-}$ or $t = t_{S_1-}, t = t_{S_2-}$).

[43] All calculations were implemented in MathCad® 2000 Pro.

[44] It is hard to say whether this is a realistic definition of low and high inflation regimes. In fact, the important distinctions between the two regimes are mostly qualitative, rather than quantitative. For a discussion see Dornbusch, Sturzenegger and Wolf (1990).

Table A5.1.1*

Permanent increase in the growth rate of base money

$\alpha = 10,\ d = 0.01,\ t_A = 1,\ t_S = 11,\ \mu_0 = 0.05,\ \mu_1 = 0.07$

	π	x	S	b_S	
				$r = 0.01$	$r = 0.1$
$t = 0$	0.05	–0.5	0.03	2.033	0.203
$t = t_A$	0.057	–0.574	0.028	2.4	0.199
$t = t_{S_1 -}$			0.025		
$t = t_S$	0.07	–0.7	0.035	2.476	0.248

*See Section 5.3.

Table A5.1.2*

Permanent decrease in the growth rate of base money

$\alpha = 10,\ d = 0.01,\ t_A = 1,\ t_S = 11,\ \mu_0 = 0.07,\ \mu_1 = 0.05$

	π	x	S	b_S	
				$r = 0.01$	$r = 0.1$
$t = 0$	0.07	–0.7	0.035	2.476	0.248
$t = t_A$	0.063	–0.625	0.037	2.119	0.259
$t = t_{S_1 -}$			0.042		
$t = t_S$	0.05	–0.5	0.03	2.033	0.203

* See subsection 5.4.

Table A5.2.1*

Temporary decrease in the growth rate of base money

$\alpha = 10,\ d = 0.01,\ t_A = 1,\ t_S = 11,\ t_{S_1} = 11,\ t_{S_2} = 21,$

$\mu_0 = 0.05,\ \mu_1 = 0.04,\ \mu_2 = 0.09$

	π	x	S	b_S	
				$r = 0.01$	$r = 0.1$
$t = 0$	0.05	–0.5	0.03	2.033	0.203
$t = t_A$	0.053	–0.531	0.029	2.439	0.179
$t = t_{S_1 -}$			0.028		
$t = t_{S_1}$	0.058	–0.584	0.022	2.498	0.162
$t = t_{S_2 -}$			0.016		
$t = t_{S_2}$	0.09	–0.9	0.037	2.659	0.266

* See Section 5.6.

Table A5.2.2*

Temporary decrease in the growth rate of base money

$$\alpha = 10,\ d = 0.01,\ t_A = 1,\ t_S = 11,\ t_{S_1} = 11,\ t_{S_2} = 21,$$
$$\mu_0 = 0.05,\ \mu_1 = 0.03,\ \mu_2 = 0.07$$

	π	x	S	b_S	
				$r = 0.01$	$r = 0.1$
$t = 0$	0.05	–0.5	0.03	2.033	0.203
$t = t_A$	0.048	–0.481	0.031	2.294	0.186
$t = t_{S_1 -}$			0.032		
$t = t_{S_1}$	0.045	–0.447	0.019	2.31	0.139
$t = t_{S_2 -}$			0.015		
$t = t_{S_2}$	0.07	–0.7	0.035	2.476	0.248

* See Section 5.6.

Table A5.3*

Temporary decrease in the growth rate of base money

$$\alpha = 10,\ d = 0.01,\ t_A = 1,\ t_S = 11,\ t_{S_1} = 11,\ t_{S_2} = 21,$$
$$\mu_0 = 0.09,\ \mu_1 = 0.07,\ \mu_2 = 0.08$$

	π	x	S	b_S	
				$r = 0.01$	$r = 0.1$
$t = 0$	0.09	–0.09	0.037	2.659	0.266
$t = t_A$	0.084	–0.84	0.039	2.61	0.279
$t = t_{S_1 -}$			0.043		
$t = t_{S_1}$	0.074	–0.737	0.034	2.563	0.24
$t = t_{S_2 -}$			0.031		
$t = t_{S_2}$	0.08	–0.8	0.036	2.595	0.259

* See Section 5.8.

Chapter 6
Conclusion

Beginning with the classic work by Sargent and Wallace in 1981, one of the fundamental problems in the analysis of macroeconomic policy is that of the interaction between the government and the central bank in conducting fiscal and monetary policies. In our research, we have continued this line of inquiry. Like the founders of the fiscal theory of inflation, we did not wish to describe a concrete economic situation. On the contrary, we attempted to elucidate the most general problems which may in principle arise in describing the logic of the interaction between fiscal and monetary policies. Various results that we arrive at may be used to analyze various economic situations. Some of our results pertain more to the problems of macroeconomic policy in developed countries. Other results can be applied to economies with undeveloped financial markets.

We have shown above the important consequences that are inherent in the effect of inflation on the budget deficit from the point of view of the fiscal and monetary policy interaction. In studying the dynamics of inflation and the public debt, we were able to identify important constraints that fiscal and monetary policy face. On one hand, the government and the central bank are interconnected by a consolidated budget constraint for the public sector: the central bank creates seigniorage by conducting operations on the open market and thus creates one of the sources of financing the budget deficit. On the other hand, the rate of inflation and the volume of accumulated public debt for obvious reasons must also be of concern both for the government and for the central bank, though perhaps to different extents. Thus, our investigation is able to determine which constraints for the government are created by various monetary policies and, vice versa, which constraints for the central bank are created by various fiscal policies.

Returning to the questions posed in Chapter 1, we are now ready to provide answers to them. These questions do not cover all the results of our investigation. However, to a certain extent, they are representative.

- *Is inflation a completely monetary phenomenon?* No, far from it. In many cases (in particular, in countries with undeveloped financial markets) seigniorage may be an important source for the financing of the budget deficit. In this case inflation will have fiscal causes.
- *Is there a simple cause-and-effect relationship between inflation and the budget deficit?* No, and because of many possible reasons. First of all, this interconnection operates both ways. On one hand, if the budget deficit is partially financed by seigniorage, then the level of the deficit dictates the growth rate of base money and thus influence the rate of inflation. On the other hand, inflation has an impact on the real income and the real expenditures of the budget. There are many possible mechanisms by which inflation may influence the real budget deficit, so that the resulting effect of inflation

depends on the economic institution. Second of all, depending on the elasticity of demand for real money balances with respect to inflation expectations, equilibriums with both low and high inflation may be stable for a given level of the budget deficit. Thirdly, the reaction of the money market to changes in monetary policy brought about by changes in fiscal policy depends on the character of the inflationary process. In particular, this reaction depends on whether the dynamics of inflation are inertial, or rather the level of inflation and the demand for real money balances are determined by the rational forward-looking behavior of economic agents. Fourthly, a situation is possible in which the government will be forced to change the level of the budget deficit in response to changes in monetary policy rather than vice versa. Depending on many factors (such as the expectations of economic agents or the interest rate for the servicing of the public debt), the government may be forced to sometimes decrease and sometimes increase the budget deficit in response to a tightening of monetary policy.

- *Can chronic inflation be overcome only by a tight monetary policy that is formally independent of fiscal requirements?* There is no straight answer to this question. Both theory and practice show that tight monetary policy by itself is not enough to stabilize inflation. One policy implication of our research is that tight monetary policy must be supported by certain fiscal policy that will allow the government to decrease its need for seigniorage both now and in the future.
- *What importance do expectations of future stabilization policy have?* Rational forward-looking expectations of economic agents concerning possible changes in macroeconomic policy play a central role; this has been confirmed both in theory and in practice. What is important is that the reaction of the money market to new information about impending changes in monetary policy may come before these changes are actually implemented. We specifically underline why this fact could and must be taken into account when formulating macroeconomic policies. Given that the volume of seigniorage depends on the actual growth rate of base money as well as on inflation expectations (which determine the demand for real money balances), changes in inflation expectations play an important role, as not only actual switches in monetary policy, but information about forthcoming changes also influence seigniorage; this, in its turn, influences the state of the fiscal sphere and the dynamics of the public debt. A typical situation here is one in which the direction of change of seigniorage in transition is different from the direction of change of its steady state. This, in its turn, implies that the change in the real value of seigniorage is not always the same, and depends on factors such as the interest rate and the time interval between the announcement of a change in policy and its actual implementation. This is important, as in accordance with the sustainability principle of fiscal policy it is the seigniorage (along with the real value of future budget surpluses) that acts as a backing for the accumulated public debt.

- *Can monetary policy be permanently or only temporarily tightened given exogenous fiscal policy?* The classic investigation by T. Sargent and N. Wallace, "unpleasant monetarist arithmetic", gives the following answer to this question: monetary policy can not be tightened permanently given an exogenous fiscal policy of the government. A decrease in the growth rate of base money will inevitably bring about a higher rate of inflation not only in the future, but possibly at the current time as well. One of the important results of our research lies in the fact that we have found a possible scenario for "pleasant monetarist arithmetic": by influencing expectations concerning the real value of seigniorage, under certain conditions the central bank may achieve a decrease in the growth rate of base money and in inflation in the long run, and without violating the principle of sustainability of the public debt.
- *Should an increase in the government budget deficit be accompanied by an increase or a decrease in the growth rate of base money?* What short-term and long-term consequences will this have for inflation? We show that there is no unique answer to these questions. As we noted above, many factors play a central role here, such as the elasticity of demand for real money balances with respect to inflation expectations, the character of the dynamics of inflation and of inflation expectations, and the interest rate on public debt, among others.
- *What situations are there in which neither fiscal nor monetary policies are able to avoid a financial crisis, and how can they be avoided?* In formulating macroeconomic policy, it is important to take into account the feasibility constraints. In a critical situation, when the economy is close to a debt crisis, the government may not be able to supply the needed surplus in the state budget, simply because the volume of tax revenues is bounded from above and the volume of state expenditures is bounded from below. Here, as discussed above, monetary policy by itself may be unable to cure the economic situation. Taking this important aspect into account, fiscal and monetary policies must be coordinated so that the economy does not approach this dangerous frontier, after which an aversion of a financial crisis becomes impossible.

Samenvatting
(Summary in Dutch)

De overheid en de Centrale Bank zijn allebei gebonden aan de beperkingen die de begroting van de geconsolideerde staatssector oplegt: het operationele tekort wordt door nieuwe kredieten en seignorage gefinancierd. Aan de ene kant, heeft de Centrale Bank die controle over de geldemissie heeft, een laag en stabiel inflatieniveau tot doel. Aan de andere kant moet de Centrale Bank ook voor de stabiliteit van het financiële systeem zorgen, en onder anderen moet zij oog hebben voor het onderhoud van de staatsschulden. Dat betekent dat hoewel de Centrale Bank formeel afhankelijk is van de regering, de Bank problemen op het gebied van financiën in acht moet nemen en een merkbaar deel van het budgettentekort door seignorage moet dekken. Met andere woorden, de politieke lijn van de regering en die van de Centrale Bank beïnvloeden elkaar.

De basis van ons onderzoek is de fiscaal-economische theorie van inflatie die aan het begin van de jaren 1980 als deel van de nieuwe klassieke economie tot stand is gekomen. Dankzij deze fiscale theorie is het mogelijk geweest monetaire politiek breder en dieper te begrijpen dan de oorspronkelijke monetaire benadering, en te begrijpen dat het fiscale beleid een belangrijke rol speelt in het vaststellen van het inflatiecijfer.

Wij verzorgen de argumentatie ter analyse van de fiscale en monetaire politiek en bieden hoofdlijnen van de fiscale en monetair- krediettheorieën in Hoofdstuk 2 aan. De budgetbeperking waarmee de regering rekening moet houden, stelt de ontwikkeling van de staatsschulden vast. Het principe van rationele fiscale politiek vraagt dat op ieder moment het totale volume van de staatsschulden ondersteund is door de reële waarde van toekomstige begrotingsoverschotten en seignorage. Op zichzelf kunnen de ontwikkeling van inflatie en seignorage worden beschreven in het kader van de algemeen geaccepteerde monetaire benadering. Met behulp van deze begrippen geven we een overzicht van de moderne benaderingen die gebruikt worden bij de analyse van de samenwerking tussen fiscaal en monetair beleid, namelijk de fiscale theorie van inflatie en de monetaire benadering van prijsbepaling.

Daarna is Hoofdstuk 3 gewijd aan de analyse van de invloed van inflatie op het primaire begrotingstekort. We stellen voor de verandering van het basismodel voor de dynamiek van inflatie en staatsschulden om het reële effecten van inflatie te bepalen. Dit nieuwe dynamische systeem heeft interessante niet-lineaire eigenschappen die voor de auteur bekend tot nu toe in de economische literatuur niet in acht werden genomen. Met inachtneming van het financieren van het begrotingstekort door seignorage, geven we een vergelijkende analyse van situaties waarin inflatie geen invloed uitoefent op het primaire begrotingstekort en waarin het effect positief of negatief is. We nemen bifurcaties in het systeem onder de loep die de ontwikkeling van staatsschulden en het ware monetaire evenwicht beschrijven. We bieden aan een beschrijving van zulke vormen van fiscaal en monetair beleid die tot een financiële ineenstorting kunnen leiden in de vorm van hyperinflatie en ernstige problemen bij het dekken van staatsschulden. Een nieuwe economische interpretatie van de hysterese-bifurcatie in de niet-lineaire ontwikkeling van inflatie en staatsschulden kan als een verklaring dienen van de financiële crisis van 1998 in Rusland.

In Hoofdstuk 4 schenken we aandacht aan verschillende scenario's voor de samenwerking tussen fiscaal en monetair beleid, waarbij de meest eenvoudige vorm van de stabilisering van inflatie op een vast niveau voorgenomen is. Het onderzoek is uitgevoerd met het gebruik van het hetzelfde systeem van de inflatieontwikkeling en staatsschulden. We analyseren uitvoerbare vormen van fiscaal en monetair beleid. Er zijn situaties gedefinieerd waarbij ongeco r-dineerd beleid onmogelijk zou zijn. We nemen in acht de grenzen van de realiseerbaarheid van fiscaal beleid en bepalen situaties waarbij zowel fiscaal als monetair en kredietbeleid niet in staat zouden zijn om hyperinflatie en crisis bij afbetaling van staatsschulden af te wenden. In de loop van dit onderzoek is een aantal nieuwe resultaten ontvangen die de fiscale theorie van inflatie uitbreidt. Met name een goed bekende principe van "unpleasant monetarist arithmetic" werd uitgebreid door het vaststellen van de consequenties van "unpleasant monetarist arithmetic" voor fiscaal beleid. Bovendien laten de resultaten ons een systematisering van de mogelijke oplossingen uitvoeren voor de samenwerking tussen de regering en de Centrale Bank. Er waren ook doelstellingen van fiscaal en monetair beleid vastgesteld die zonder coördinatie onrealiseerbaar zouden zijn geweest. Dankzij de analyse van de beperkingen van houdbaarheid en haalbaarheid van macro-economische politiek in het kader van het model voor de ontwikkeling van inflatie en staatsschulden hebben we mogelijkheden gevonden een gebied op het fase-diagram te bepalen waarop zelfs de gecoördineerde macro-economische politiek niet in staat zou zijn om de crisis bij afbetaling van staatsschulden en hyperinflatie af te wenden.

In Hoofdstuk 5 bieden we aan een breed overzicht van de wisselwerking tussen de regering en de Centrale Bank. Hun gezamenlijk beleid moet niet in conflict zijn met het principe van stabiliteit wat het onderhoud van de staatsschulden betreft. Deze benadering verklaart niet alleen de huidige situatie op het gebied van financiën en op de monetaire markt, maar ook de richtlijnen van het toekomstige beleid als zodanig. Beschouwend de rationele verwachtingen van de privésector als toelaatbaar, laten we de uitbreiding van mogelijkheden van fiscale en monetaire politiek zien als hun ontwerpers in staat zouden zijn een actieve invloed uit te oefenen op de verwachtingen van de maatschappij. Bij de toelating van een mogelijkheid veranderingen in de macro-economische politiek eerder te melden dan de uitvoering daarvan plaats zou vinden hebben we nieuwe belangrijke resultaten geboekt op het gebied van de fiscale theorie van inflatie. Ten eerste, zijn we in staat om een oplossing te vinden van het probleem van "unpleasant monetarist arithmetic". Met name demonstreren we dat het onder bepaalde omstandigheden monetair beleid en kredietbeleid permanent verscherpt kunnen worden bij (exogeen) fiscaal beleid. Ten tweede laat ons onderzoek zien dat voor de samenwerking tussen fiscaal, monetair en kredietbeleid het huidige volume van seignorage minder van belang is dan de bekwaamheid van de Centrale Bank invloed uit te oefenen op de nu te verwachten grootheid van toekomstige seignorage. Ten derde zijn we in staat om drie factoren te definiëren die van belang zijn geweest bij de uitvoering van fiscale, monetaire en kredietpolitiek. Deze factoren zijn: (i) de verwachtingen van economische agenten ten opzichte van de aanstaande veranderingen in monetair beleid, (ii) het inflatieniveau in de economie (regime van inflatie), en (iii) de rentevoet die bepaald is voor het onderhoud van staatsschulden. Deze laatste factor is bepalend niet alleen voor de dynamiek in de fiscale sfeer, maar ook bij de vorming van monetair beleid en kredietbeleid.

In de thesen is een aantal historische episoden behandeld die ontleend waren uit de macro-economische politiek van heel verschillende landen zoals Argentinië, Chili, Indonesië, Israel, Korea, Maleisië, Mexico, de Filippijnen, Rusland, Thailand en de Verenigde Staten. Daarbij stelden we ons tot doel op basis van deze voorbeelden verschillende manieren van samenwerking tussen fiscale, monetaire en kredietpolitiek te presenteren en de mogelijke problemen te illustreren die tijdens deze samenwerking zouden kunnen ontstaan.

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