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 macroeconomic policy, namely the principle of a sustainable fiscal policy. This principle states that at every point in time the public debt must be backed by the present discounted value of the net government revenue, 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. The ability of the central bank to control the flow of seigniorage (given the primary budget deficit or surplus) 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 unpleasant monetarist arithmetic (considered in Section 2.4) in certain aspects. First, 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 inflation regime (position the inflation tax Laffer curve).[1] The logic and results of the Sargent and Wallace model are true only for the increasing branch of the inflation tax Laffer curve, that is, for low inflation (when the demand 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 is the product of the *actual* growth rate of base money and the quantity 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 seigniorage and the present discounted value of future seigniorage flow may change even before switches in macroeconomic

[1] This fact was first noted in connection with the principle of "unpleasant monetarist arithmetic" by Liviatan (1984) and Drazen (1985). See also Liviatan (1986, 1988). The analysis in the Chapters 3 and 4 also used this very important consideration.

policy are implemented. This factor, beyond any doubt, plays a very important role and, as we will show later, may violate the principle of "unpleasant monetarist arithmetic" even in a low-inflation economy.[2]

Third. The interest rate on the public debt play an important role in the fiscal and monetary policy interaction; 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 future values of budget surpluses and seigniorage that is considered by the principle of sustainable macroeconomic 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 given exogenous 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

[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 interest rate on the public debt as it determines the burden 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 policy. It should also be noted that we consider the interaction of fiscal and monetary policy 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 base money, 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 burden of public debt service. 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.

sustainability and feasibility constraints for macroeconomic policy. In the final section, 5.15, we summarize 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 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 standard pair of equations that describe the dynamics of the public debt and of real money balances:

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

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

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

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

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

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

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 policy. 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 $E_t(\bullet)$. 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 we arrive at. Using (5.2)-(5.4), we can describe the dynamics of the log of real money balances, inflation, and seigniorage:

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

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

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

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, $\Delta\pi(t=t_A)=(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_S-t_A)}>0$. Fig. 5.1 shows the time paths of these variables. 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 (to

[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. However, this is not, in fact, a crucial assumption.

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 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 on 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 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] Fig. 5.1 and others do not illustrate this possible change.

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

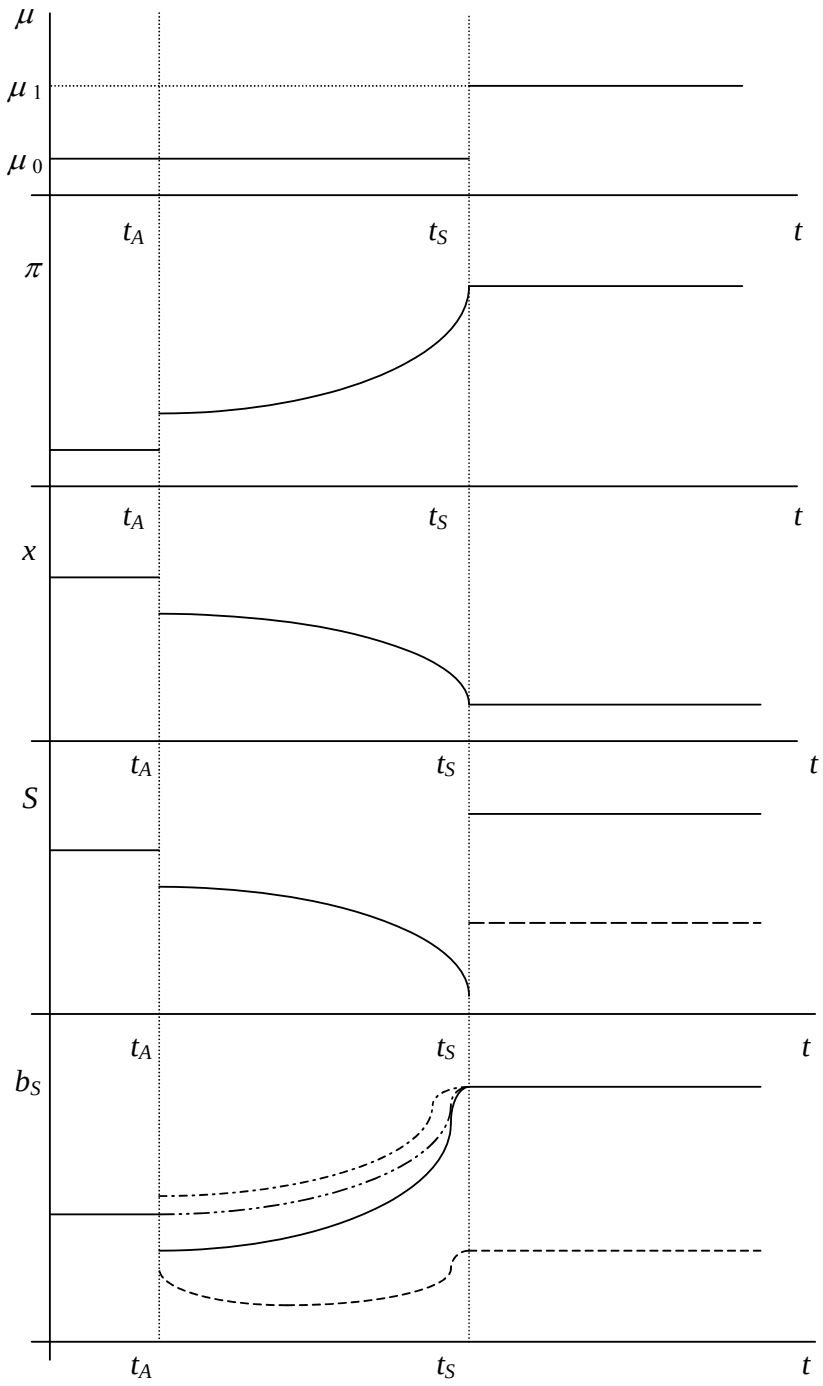


Fig. 5.1. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a permanent increase in the growth rate of base money

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. 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 the increase in the present value of future budget deficits. Assume for concreteness that the economy is on the increasing branch 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 could 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 rate of inflation 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. Fig. 5.2 depicts possible trajectories for the sustainable level of public debt.

[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 base 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.

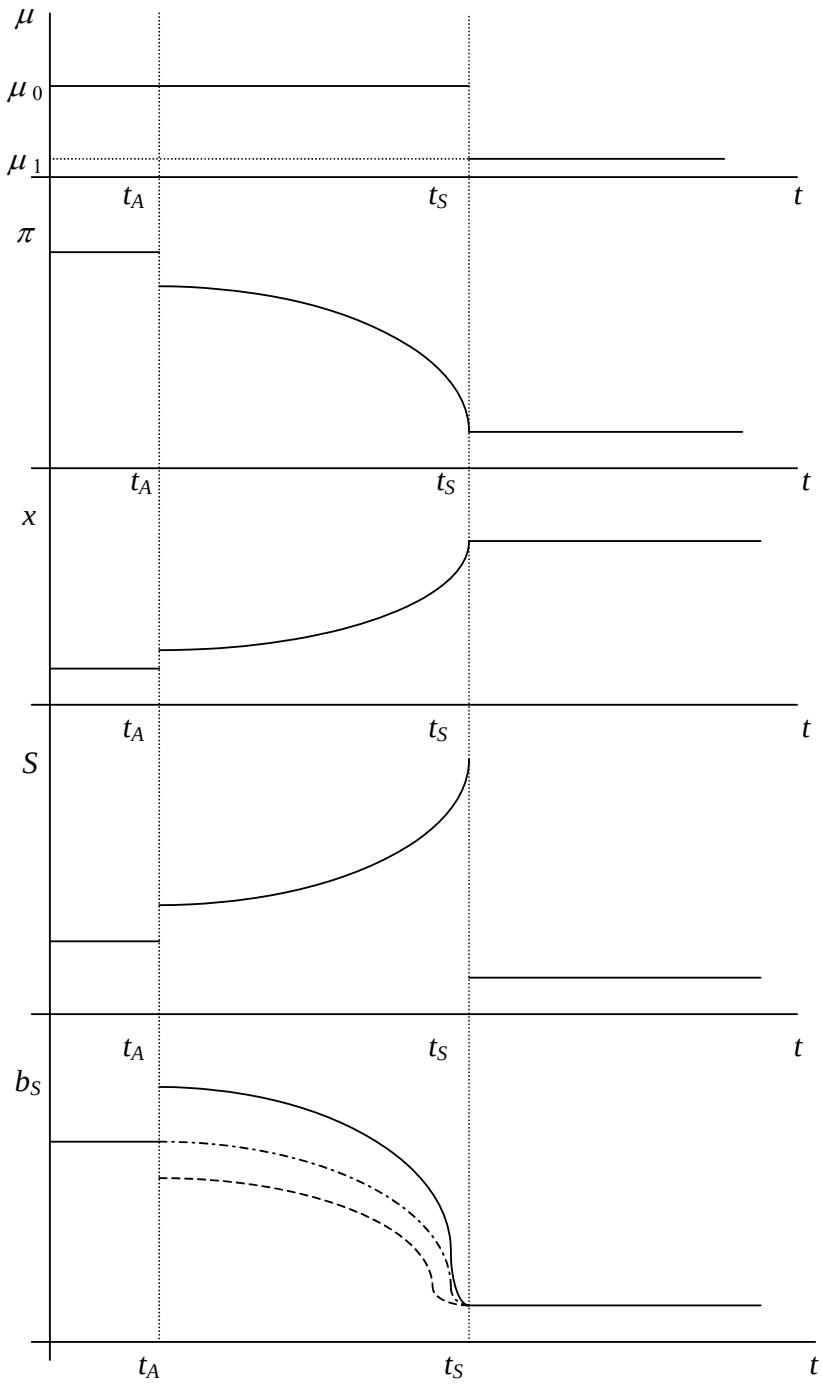


Fig 5.2. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a permanent decrease in the growth rate of base money

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 in Section 5.12 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 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 it is possible 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 fight inflation.

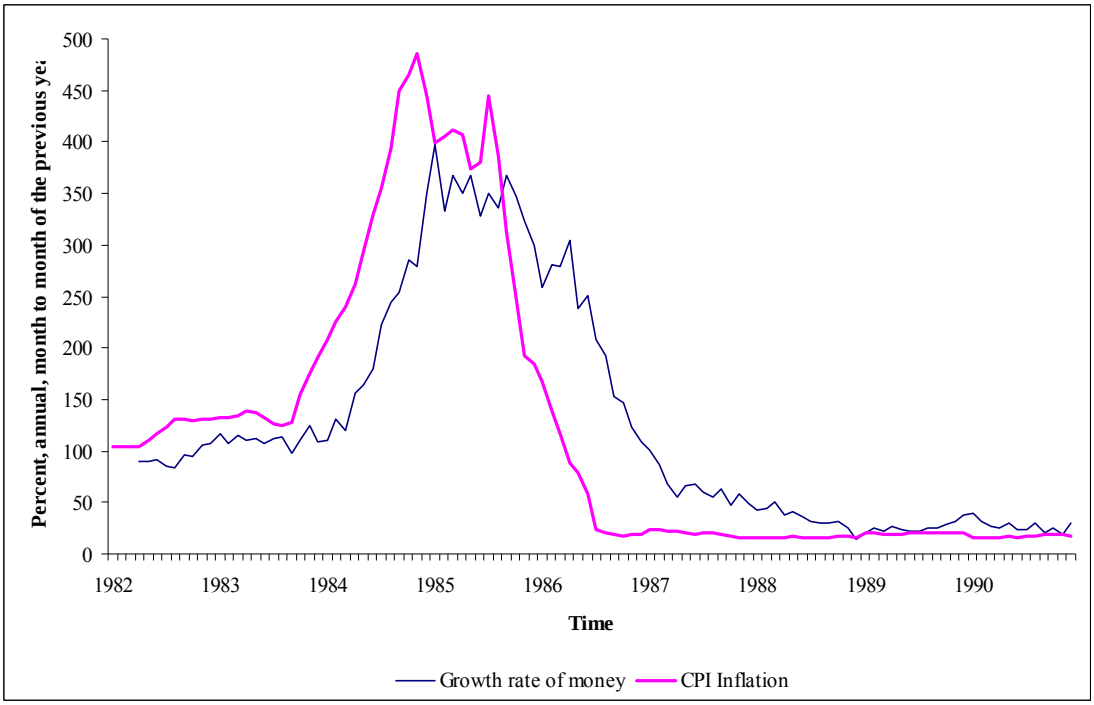
Along with Latin America countries, Israel in 1975-1985 provides a canonical example of an economy with chronic high inflation. During this period, inflation moved from the two-digit to the three-digit range so yet never became hyperinflation. The most dramatic episode of inflation intensification was 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 phenomenon 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 struc-

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

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

tural 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).



Source: Bank of Israel.

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

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).

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 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 (that is, in terms of Fig. 5.2, there is an upward jump in b_S at time t_A, and the new steady state 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.

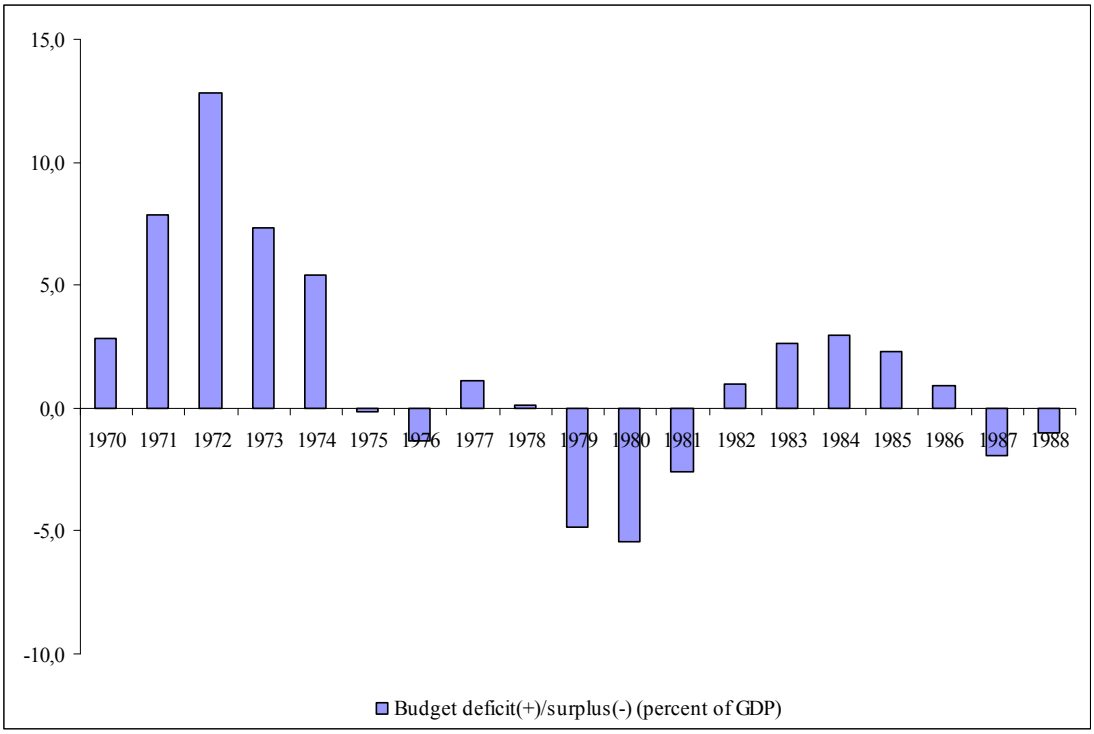
Chile, 1974-1975

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.

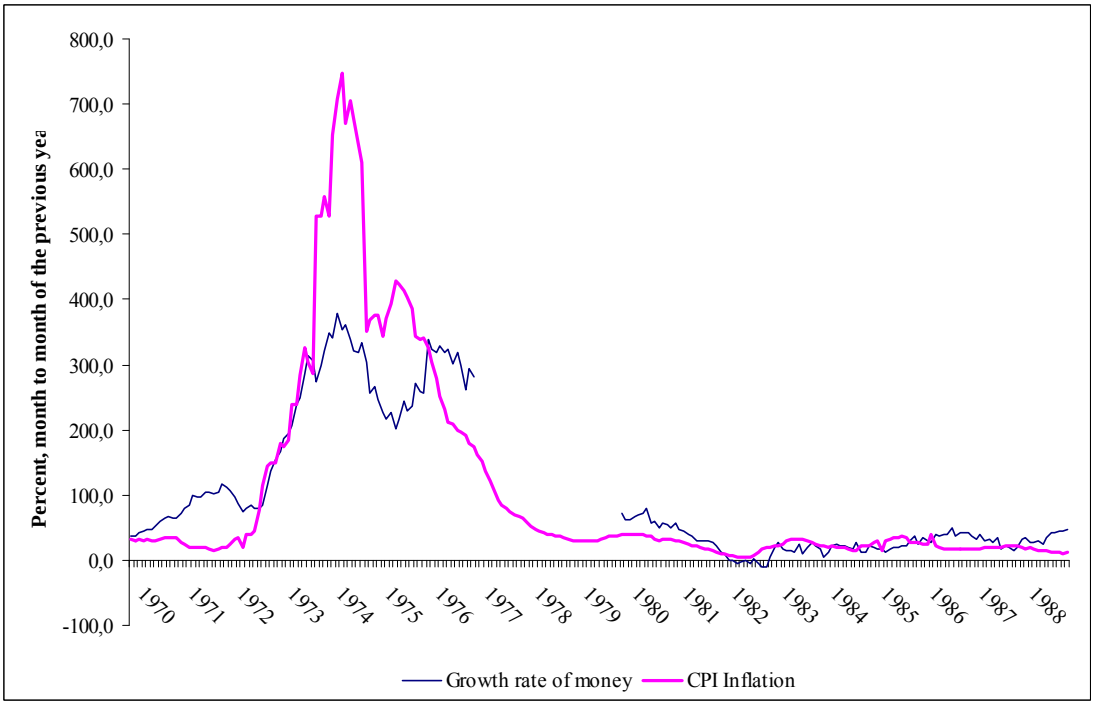
[12] Additional helpful factors were a rollover of 30 percent of debt outstanding and relatively high prices of exportable copper.

[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.



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

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.

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]

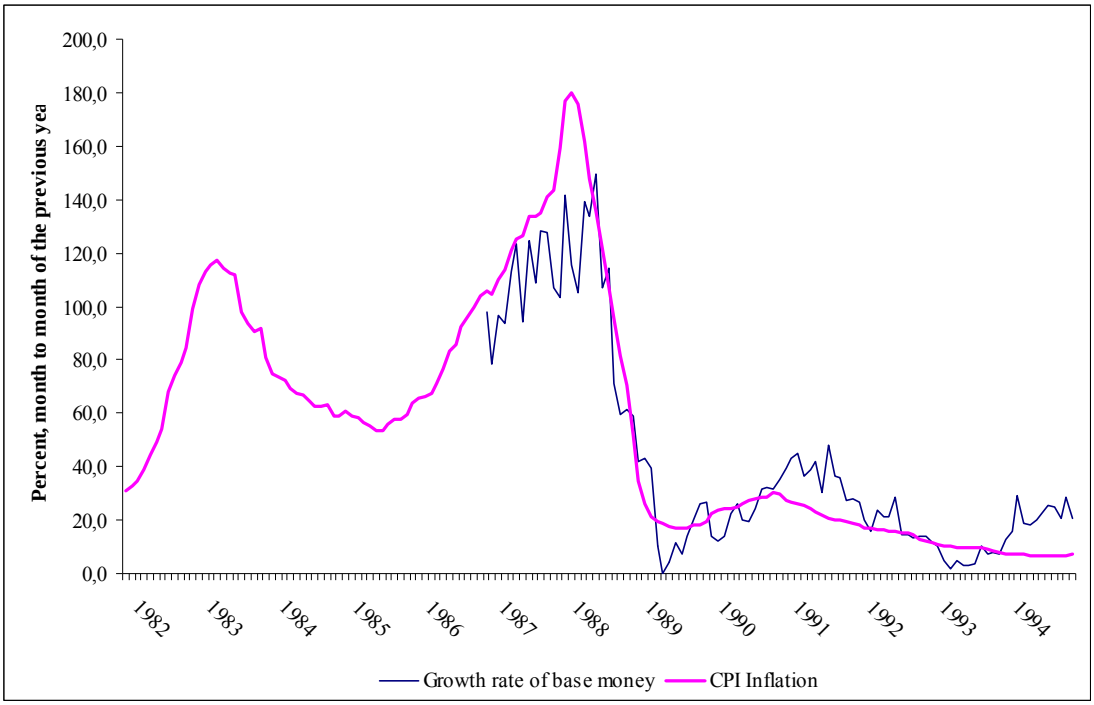
Unlike other Latin American countries, Mexico experienced high inflation over a relatively short period. Until 1982, the inflation rate was well below 30 percent annually,[17] while annual GDP growth was well above 6 percent. In 1982 Mexico underwent a serious debt crisis (repudiating its external debt). 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.

[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.

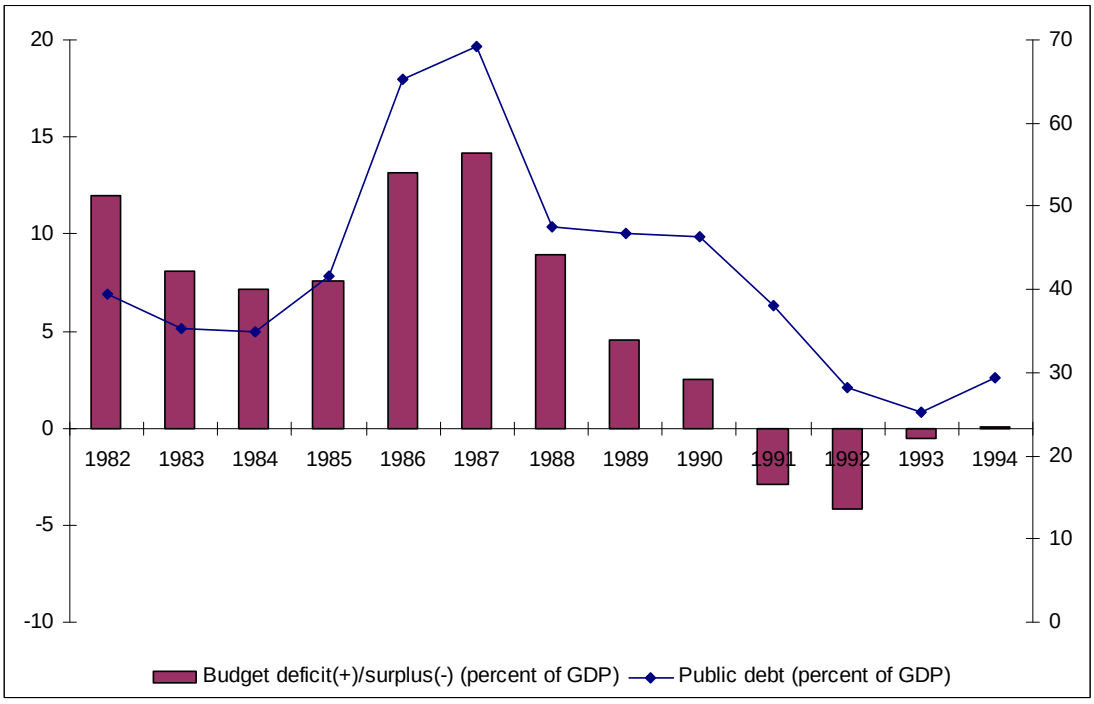
[16] The discussion here relies on Ortiz (1991) and Bruno (1993). See also Diaz and Tercero (1988), and Dornbusch and Fischer (1991).
[17] Before the 1973 oil shock, inflation was even in the single-digit range. Double-digit inflation became chronic only after 1975.

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.



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

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 loose, so that $\mu_1 < \mu_0 < \mu_2$, where μ_2 is the growth rate of base money for $t \geq t_{S_2}$. 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.

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

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

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

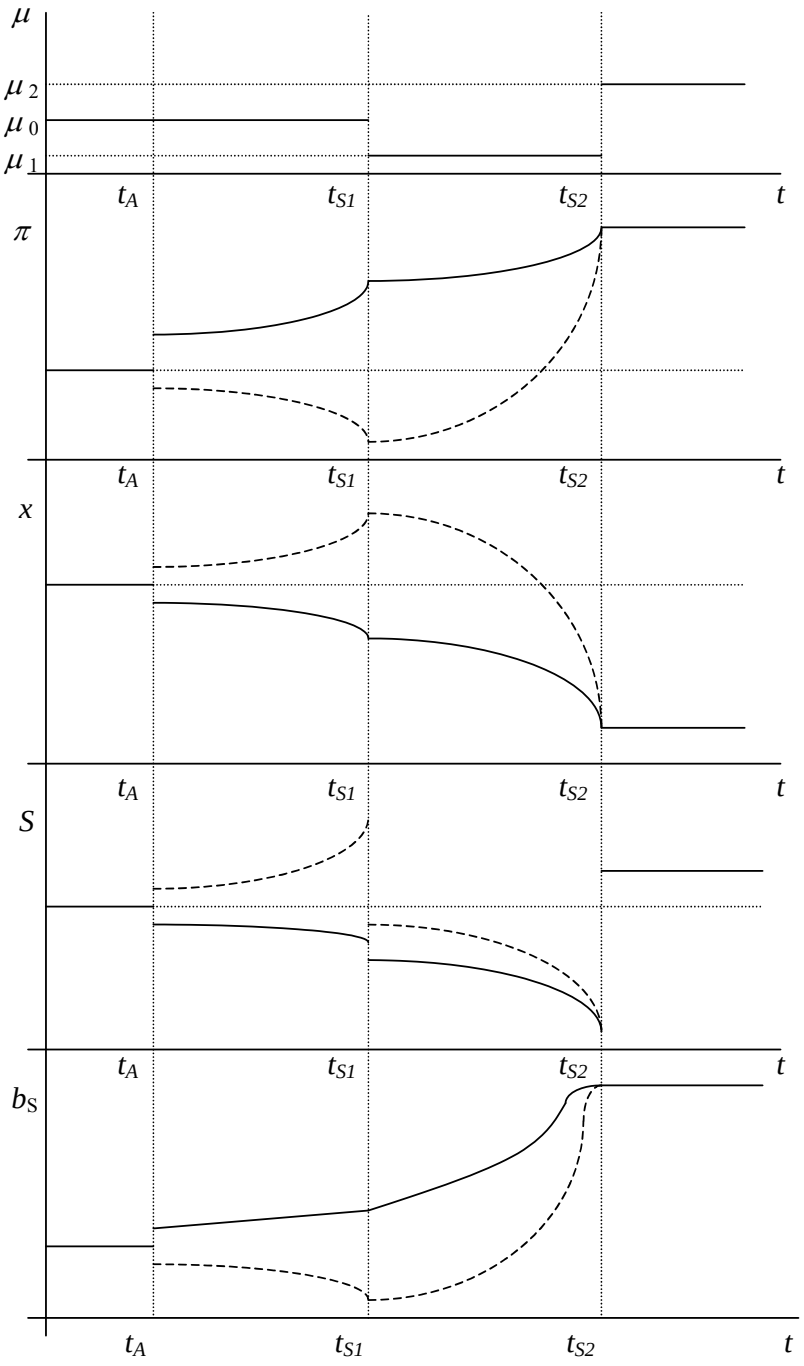


Fig. 5.8. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary decrease in the growth rate of base money ($\mu_1 < \mu_0 < \mu_2$)

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

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

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 level of 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).

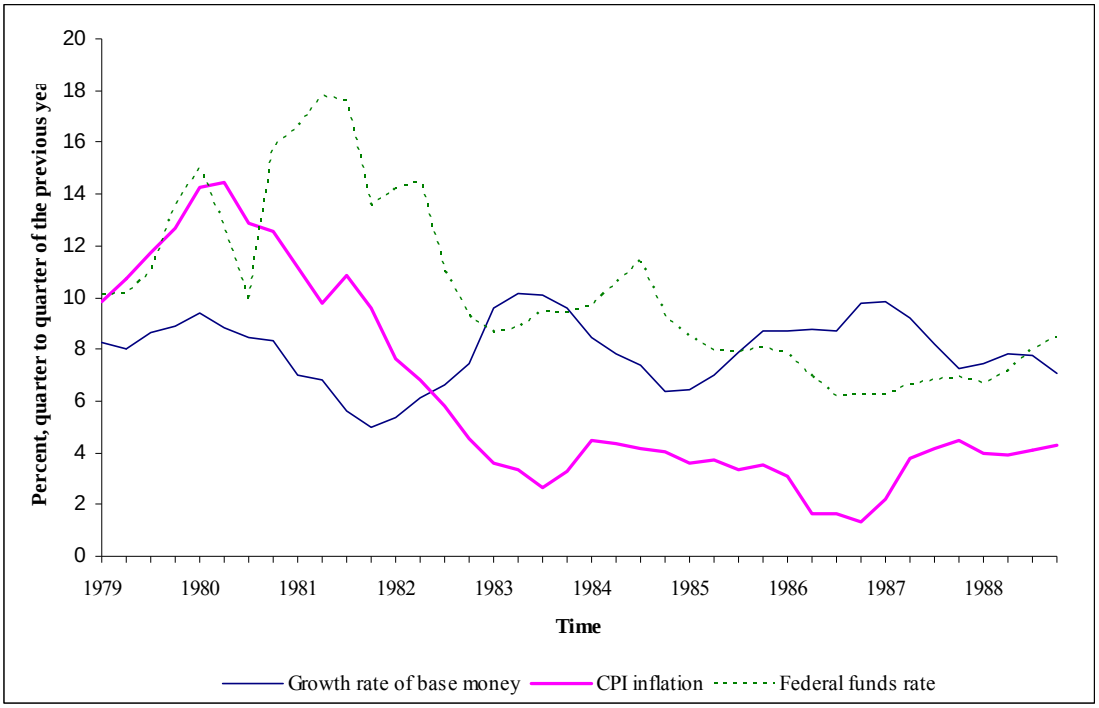
On the other hand, if the interest rate is high enough, this kind of monetary policy will result in a decrease in the present value of future seigniorage revenues at time t_A. To maintain sustainability in the fiscal sphere, the government should reduce the primary budget deficit. The public debt will 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).

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 and A5.2.2 in the Appendix contain the specifications of numerical experiments that support these conclusions.

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

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.



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: $\mu_2 < \mu_0 < \mu_1$. 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. Fig. 5.10 illustrates the dynamics of the system.

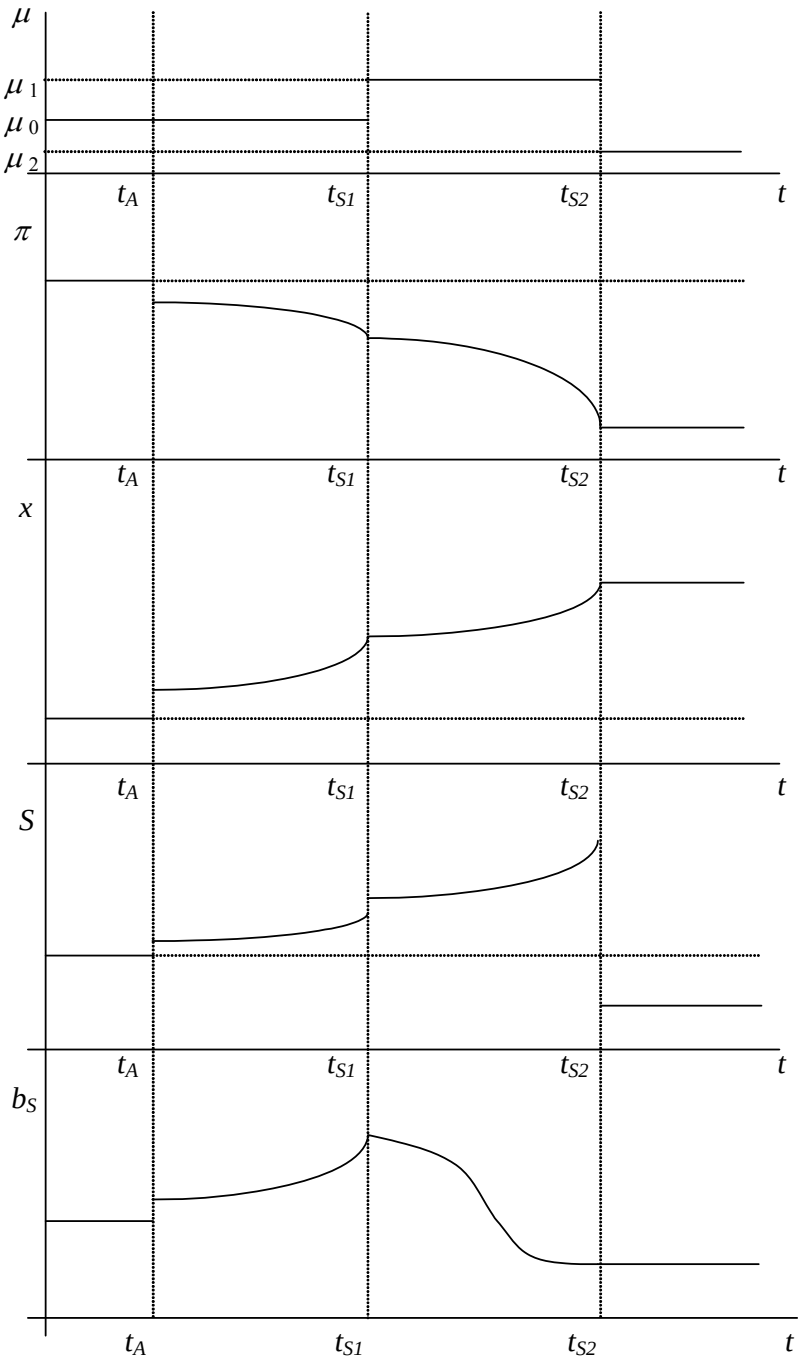


Fig. 5.10. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary increase in the growth rate of base money ($\mu_2 < \mu_0 < \mu_1$)

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.

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 $\lfloor t_A, t_{S_2} \rfloor$. 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 run 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 future seigniorage revenues, 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 Sections 5.11-5.13. Introduction of these simplifying assumptions brings our analysis closer to the logic of the celebrated "unplea-

[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.

sant 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.

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 $\mu_1 < \mu_2 < \mu_0$, that is when the ultimate 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. Fig. 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 $\lfloor t_A, t_{S_1} \rfloor$, including a discrete increase at t_A, while inflation decreases. Then, for the time interval $\lfloor t_{S_1}, t_{S_2} \rfloor$, 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".

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.

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 $\lfloor t_A, t_{S_2} \rfloor$. 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.

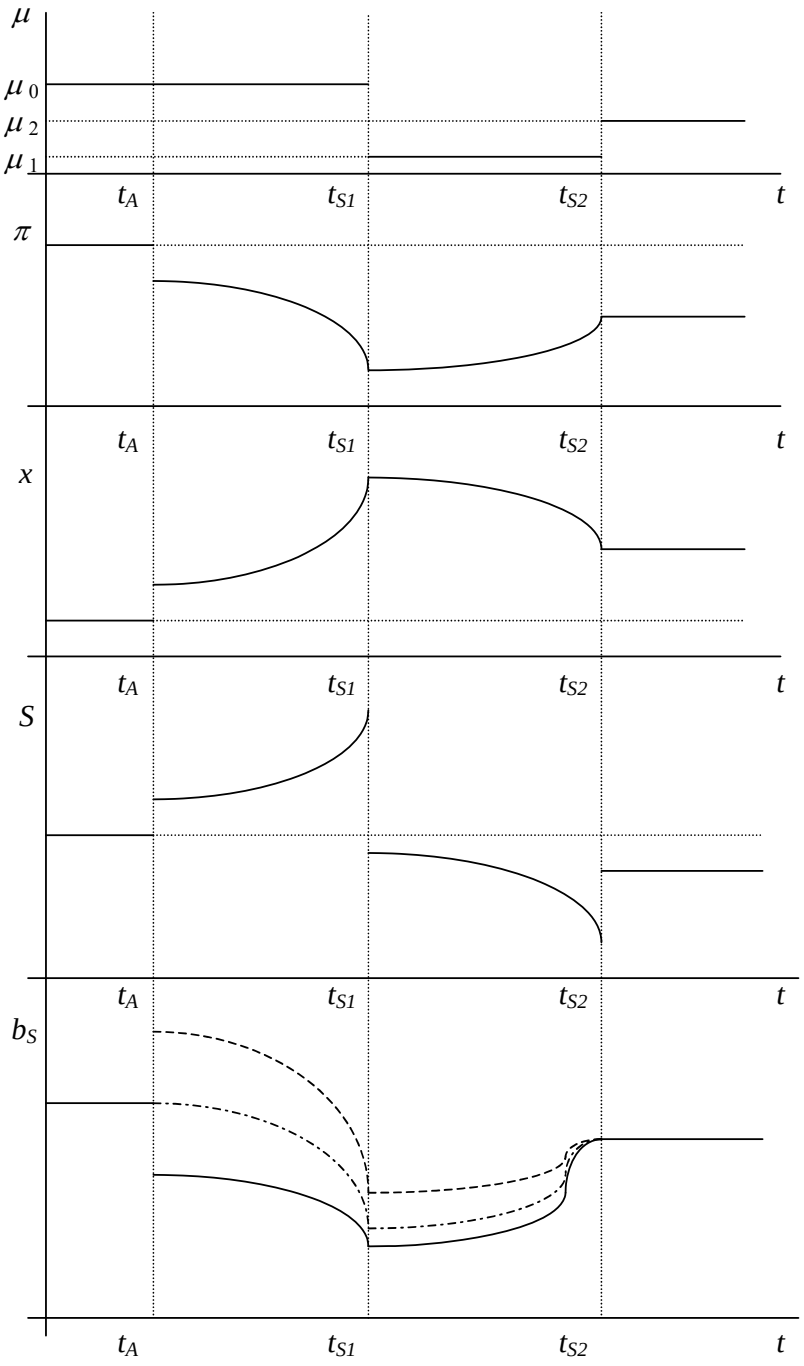


Fig. 5.11. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for a temporary decrease in the growth rate of base money ($\mu_1 < \mu_2 < \mu_0$)

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.[21] 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

[21] 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.

policy: a lower sustainable level of public debt imposes stronger restrictions on the government's ability to run 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).

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 $\lfloor t_{S_1}, t_{S_2} \rfloor$; 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 (assuming the economy is on the increasing branch 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 $\lfloor t_A, t_{S_1} \rfloor$ 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.[22]

Fig. 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).

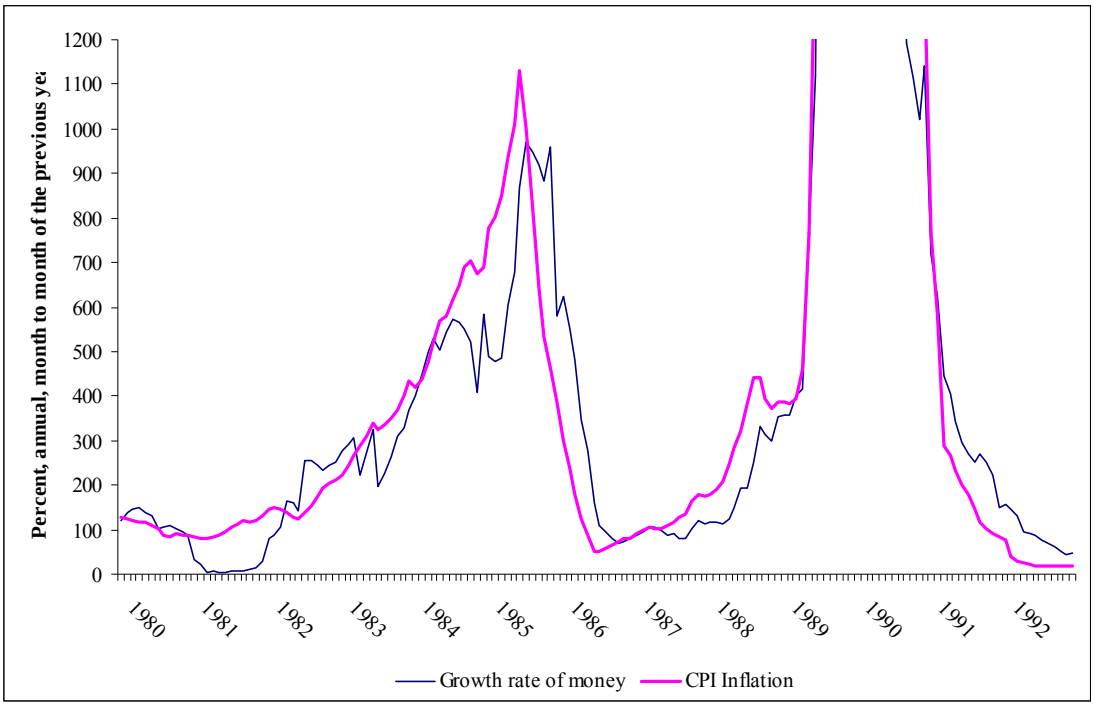
If the parameters of the economy are such that it is possible to find the needed parameterization for this kind of monetary policy, the public debt may be kept on a sustainable path. After a gradual decrease during the interval $\lfloor t_A, t_{S_1} \rfloor$, it increases to its new steady state level,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

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

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 program. What is most interesting for us is that this failure resembles the logic of unpleasant monetarist arithmetic.[23]

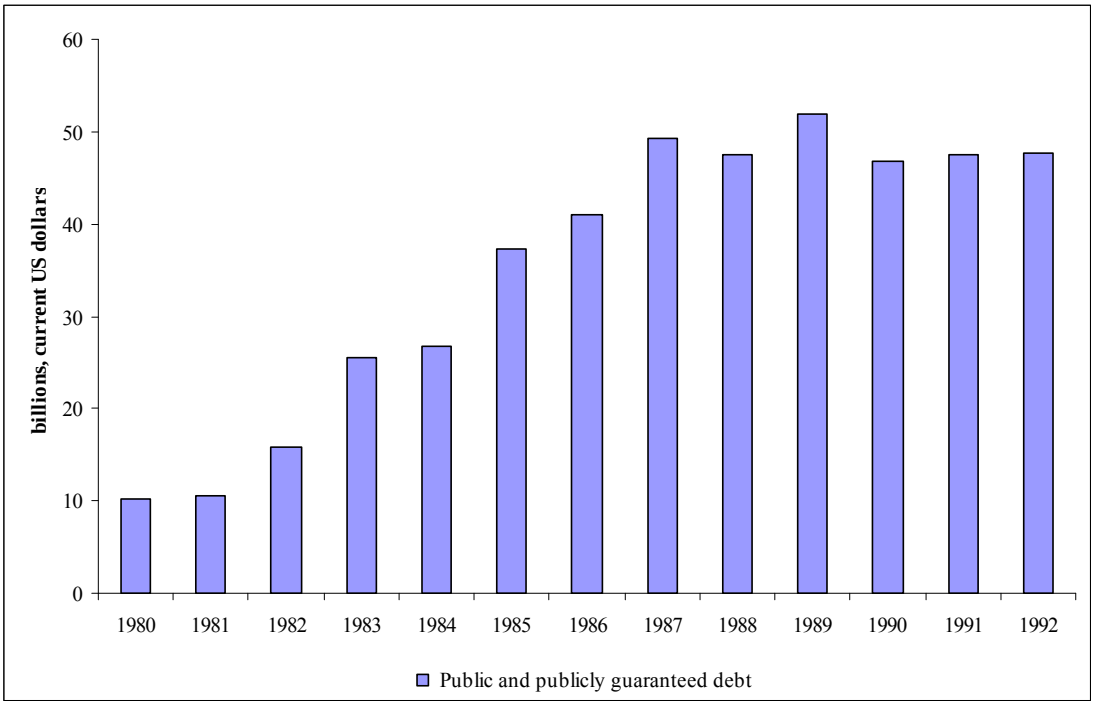
The economic situation in Argentina in the late 1970s and 1980s was extremely bad. Average annual growth rate of GDP was about 0.5 percent between 1975 and 1985 (it was positive in the 1970's and it became negative in the 1980s). During this period, inflation was almost always in the three-digit range (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 stance was characterized by chronic deficit. Public and publicly guaranteed debt more than tripled between 1980 and 1985 (see Fig. 5.13).



Source: International Financial Statistics, IMF.

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

[23] 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).



Source: World Development Indicators, The World Bank Group.

Fig. 5.13. Debt burden in Argentina, 1980-1992

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 USD 0.8).

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.[24]

[24] 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. Researchers conclude 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). For this reason we pay little attention to the Brazilian experience of the 1980's.

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
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).

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.[25] Taking 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 ex-

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

tremely 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.

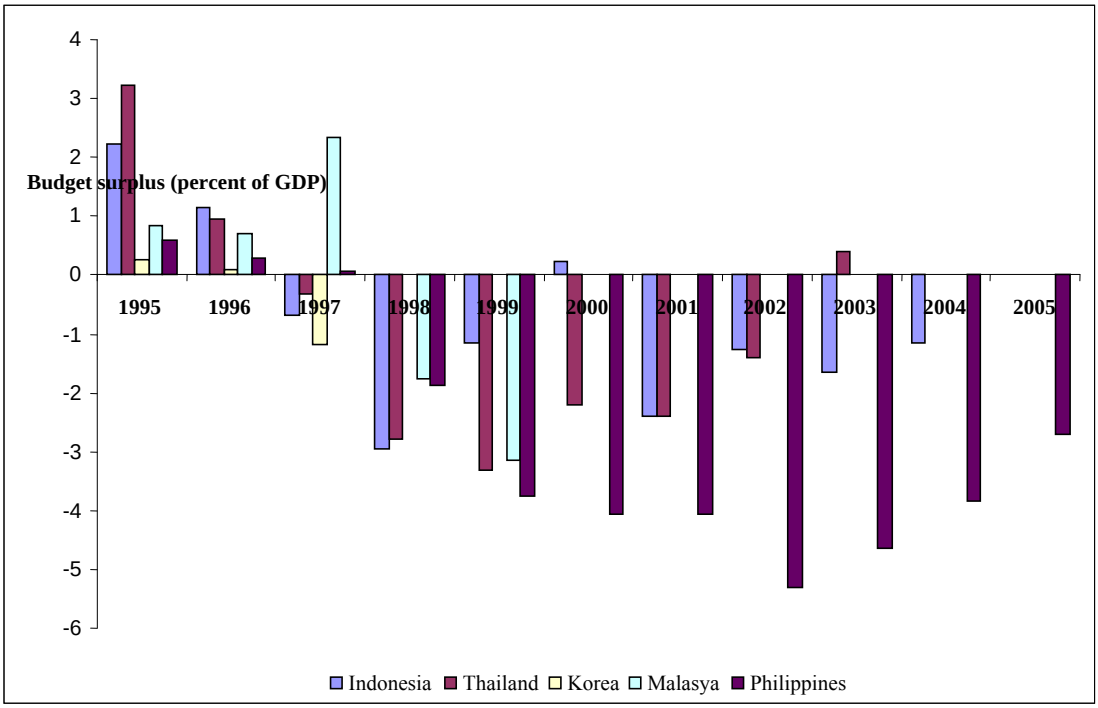
5.10 The Asian crisis of 1997: Tight monetary policy and prospective deficits

Usually, economists treat the Asian crisis of 1997 as a currency crisis.[26] 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 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.

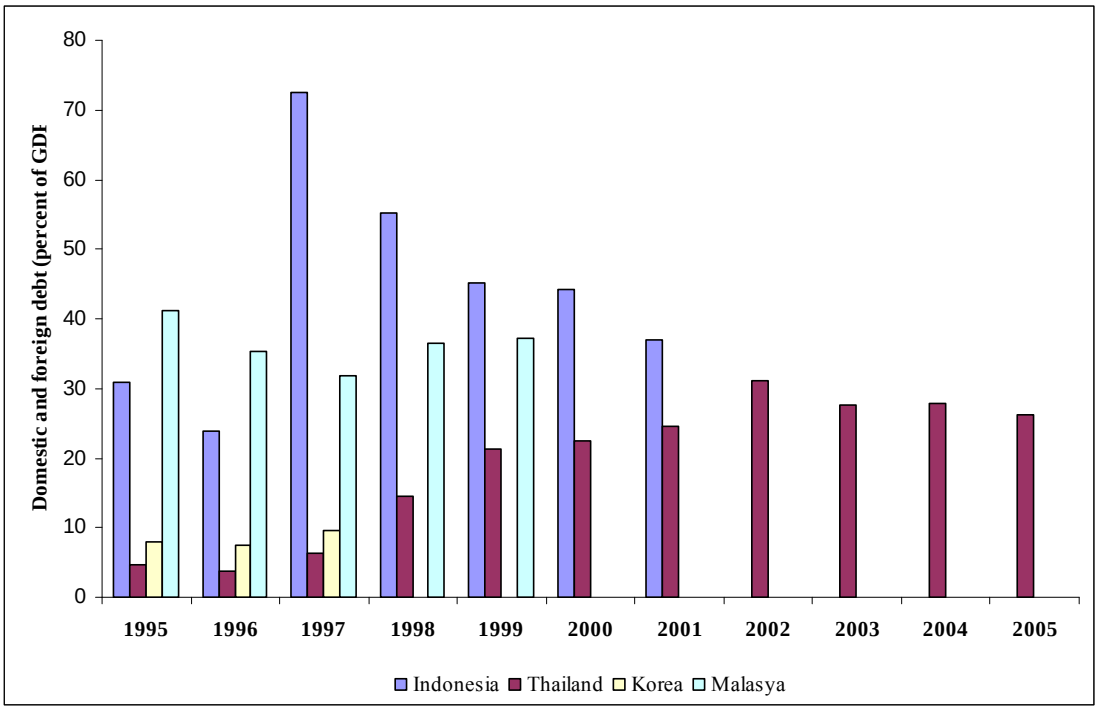
In fact, for the purposes of our study it is not of much importance what the real source of expectations was that the government would be stricken by huge fiscal deficits in the future. We take expected future deficits as an assumption, but we can indeed see a tremendous turnover in the fiscal stance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

[26] 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.

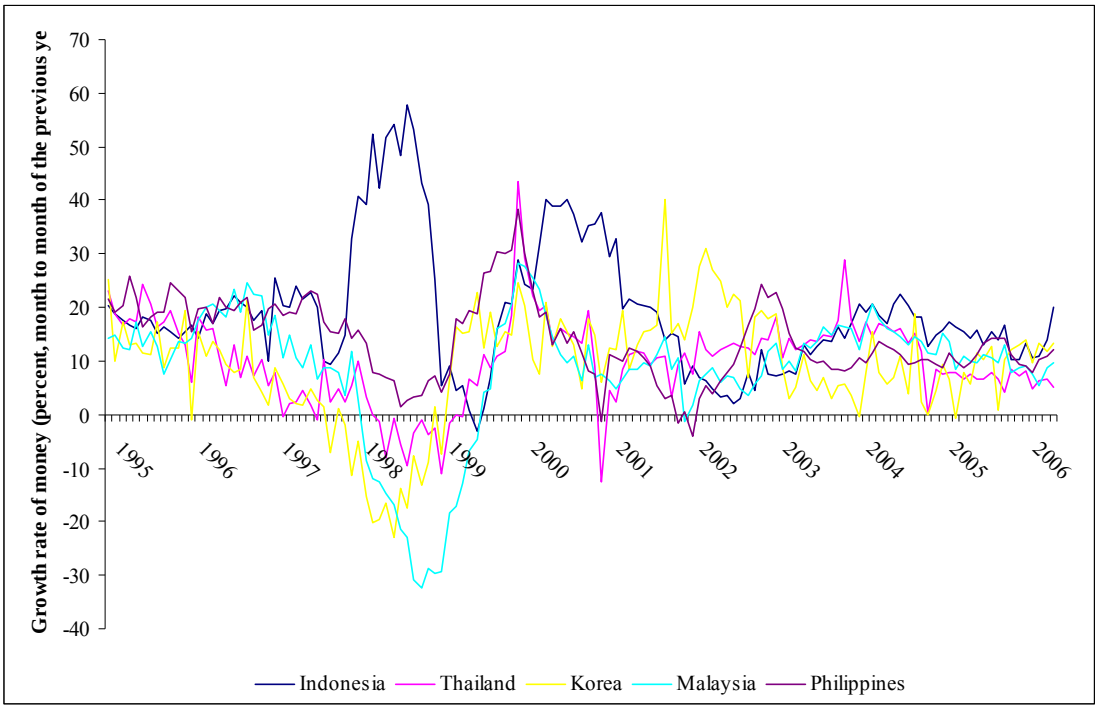
Fig. 5.15. Domestic and foreign debt in selected countries, 1995-2005

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.[27] This in turn can be achieved by means of loose monetary policy. Fig. 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. However, 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 future seigniorage revenues. 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 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.

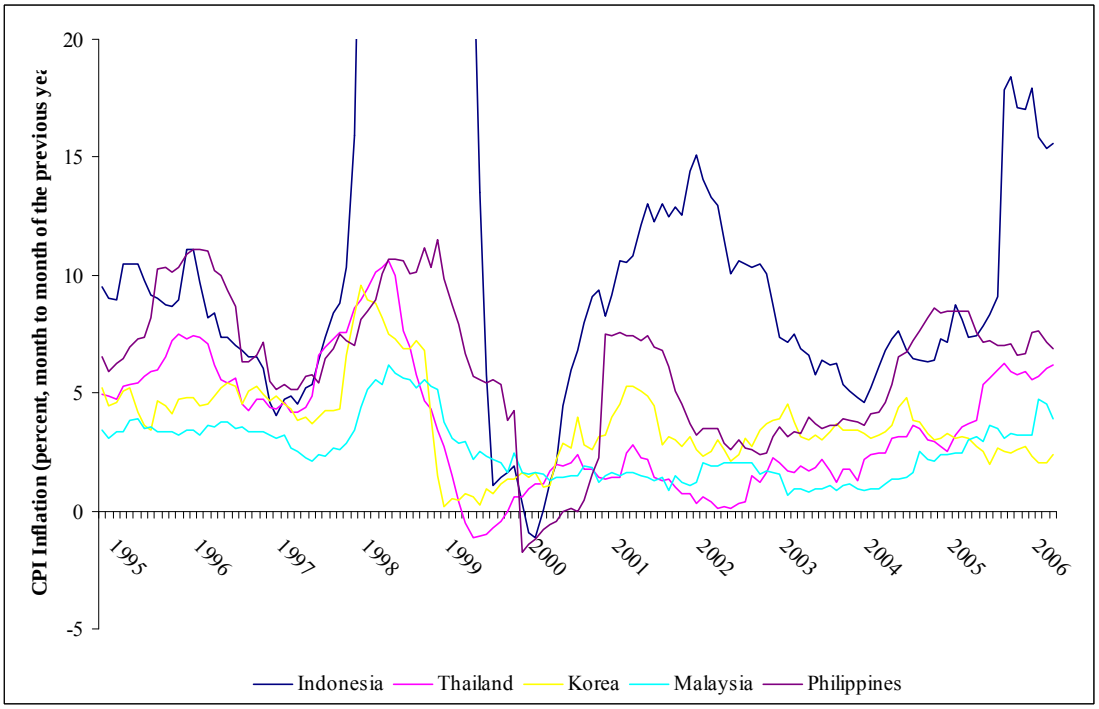
Addressing this logic for the case of the Asian crisis of 1997 is not an easy task. There are two separate problems. The first is determining what "relatively low" and "relatively high" interest rates actually are. In our model, different policy options appear not only because of different magnitudes 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.[28] On the other hand, having observed monetary expansion and an increase in inflation after the crisis (see Fig. 5.16 and Fig. 5.17), we can use the first scenario (in which an increase in the present value of future seigniorage revenues may be provided by a permanent increase in the growth rate of base money) to understand the logic of the crisis in terms of a problem of fiscal sustainability.[29]

[27] Burnside, Eichenbaum and Rebelo (2001) argue that it was hardly expected that government will be able to adjust its balance.
[28] This contradicts the unambiguous statement of Burnside, Eichenbaum and Rebelo (2001).
[29] This means that we "believe" that interest rates were "relatively low".



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

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).[30] 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.[31] 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, 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 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*	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*	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	***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	***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	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	1,5	3,5	***6,9***	***8,9***	***9,5***	7,8	***4,0***	3,8	***3,4***	3,3	***5,9***
Malaysia	GDP growth	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	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	***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	***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.
* Annual, percent.

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

[30] Burnside, Eichenbaum and Rebelo (2001) do not discuss this problem.
[31] This resembles the polemic between Darby (1984) and Miller and Sargent (1984), see Chapter 2.

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 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

$$x(t) = \begin{cases} -\alpha\mu_0, & t < t_A, \\ -\alpha\mu_0 - \alpha(E_{t_A}[\mu_1] - \mu_0)e^{-\frac{1}{\alpha}(t_S - t)}, & t_A \le t < t_S, \\ -\alpha\mu_1, & t \ge t_S. \end{cases} \tag{5.13}$$

$$\pi(t) = \begin{cases} \mu_0, & t < t_A, \\ \mu_0 + (E_{t_A}[\mu_1] - \mu_0)e^{-\frac{1}{\alpha}(t_S - t)}, & t_A \le t < t_S, \\ \mu_1, & t \ge t_S. \end{cases} \tag{5.14}$$

$$S(t) = \begin{cases} \mu_0 e^{-\alpha\mu_0}, & t < t_A, \\ \mu_0 e^{-\alpha\mu_0 - \alpha(E_{t_A}[\mu_1] - \mu_0)e^{-\frac{1}{\alpha}(t_S - t)}}, & t_A \le t < t_S, \\ \mu_1 e^{-\alpha\mu_1}, & t \ge t_S. \end{cases} \tag{5.15}$$

where $E_{t_A}[\mu_1]$ is the expected new growth rate of base money at time t_A.

Fig. 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 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 present value of future seigniorage revenues 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.

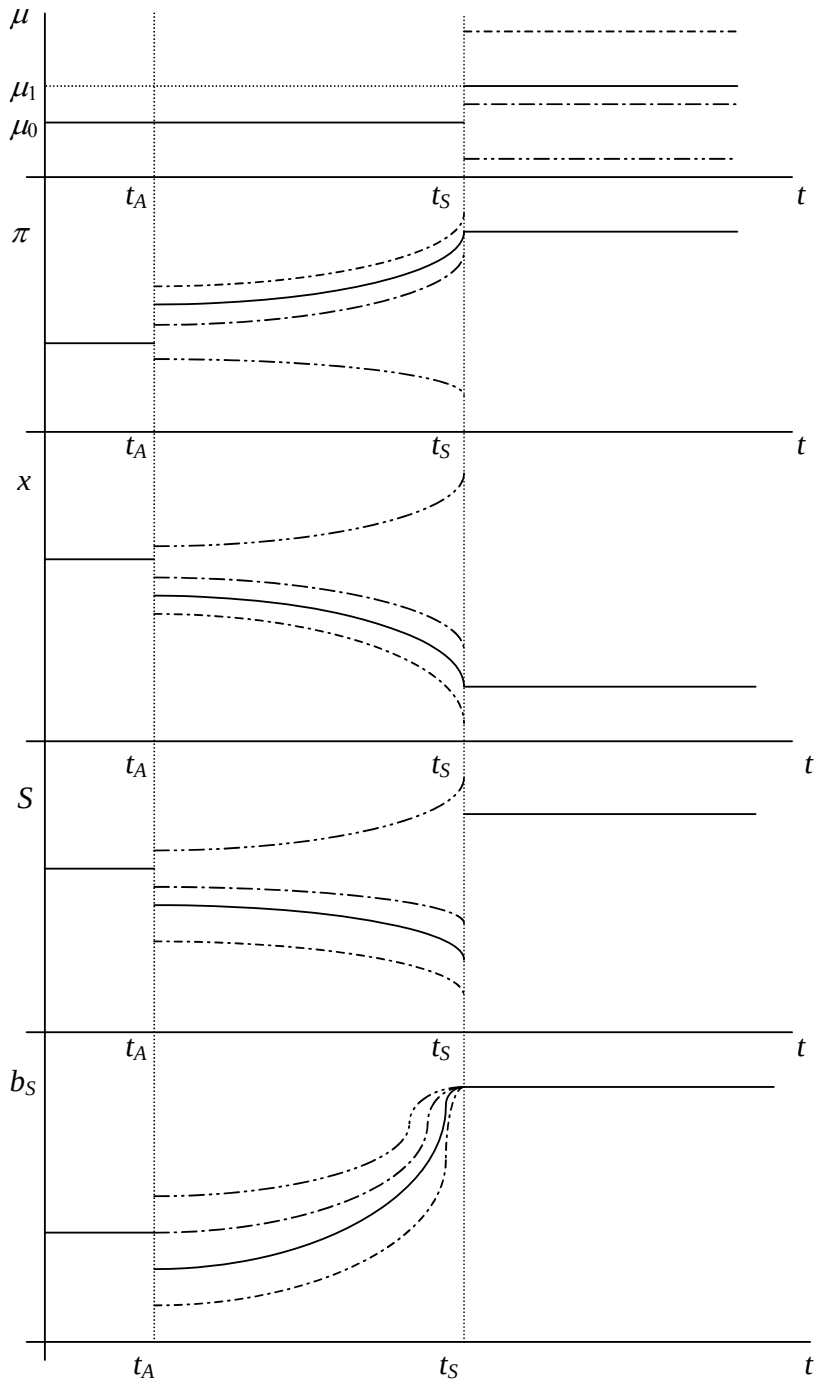


Fig. 5.18. Dynamics of inflation, the log of real money balances, seigniorage, and the sustainable level of public debt for the case of a permanent increase in growth rate of base money of uncertain magnitude

In the second case, $\mu_0 < E_{t_A}[\mu_1] < \mu_1$, 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, $E_{t_A}[\mu_1] < \mu_0 < \mu_1$, 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.[32] As an extreme case, the best way to increase the present value of future seigniorage revenues, given that the economy is on the increasing branch 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.[33]

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 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 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 $\mu_0 < E_{t_A}[\mu_1] < \mu_1$, 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.[34]

5.12 Uncertainty about the type of change in macroeconomic policy

Because 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 moment, the government increases the primary budget deficit. This moves the public debt off its sustainable path. Hence, either the

[32] However, one must be careful about extra jumps in inflation. Such shocks have a negative effect on the economy for many reasons. See, e.g., Beckerman (1992), Heymann and Leijonhufvud (1995).
[33] In general, this can lead to the dynamic inconsistency problem (Kydland and 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.
[34] Here we have considered only the case when the economy is on the increasing branch of the inflation tax Laffer curve. One can easily consider the other case as well.

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, a policy mix is also possible.[35]

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 information about the change in the fiscal policy was revealed earlier, at time t_A). Assume the economy is functioning on the increasing branch 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 future seigniorage revenues 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} ($\mu_{L_2} \le \mu_{L_1} < \mu_0$). Fig. 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.

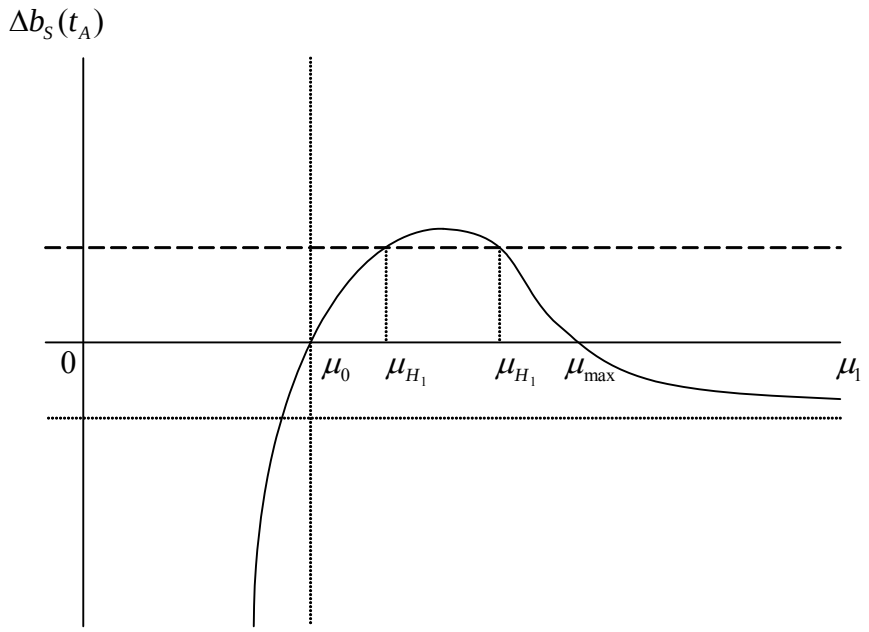


Fig. 5.19. Discrete change in the sustainable level of public debt
as a function of the future growth rate of base money given a low interest rate

[35] 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.

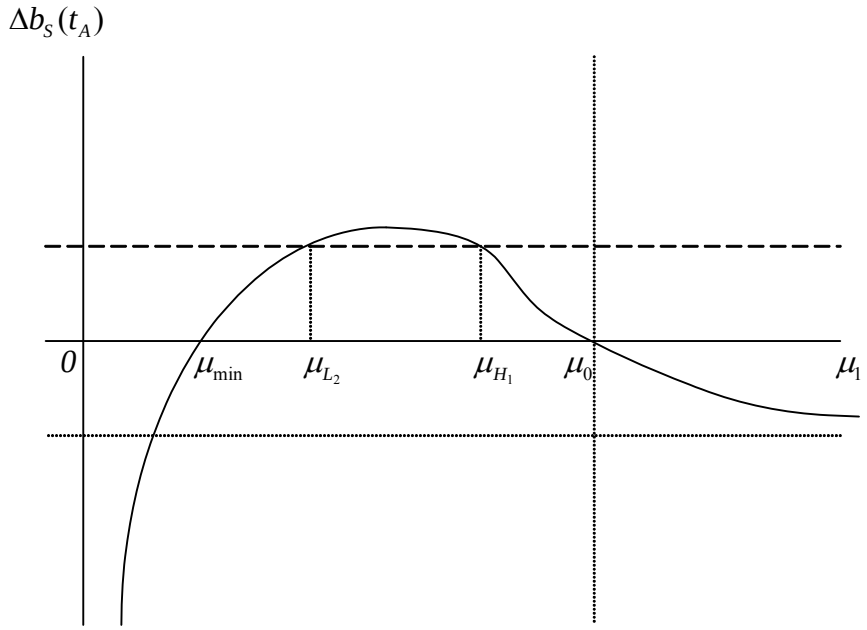


Fig. 5.20. Discrete change in the sustainable level of public debt as a function of the future growth rate of base money given a high interest rate

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 ($\mu_{\max}$ in Fig. 5.19 and $\mu_{\min}$ in Fig. 5.20, respectively). If the interest rate is relatively 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 $\Delta b_S(t_A)$ 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.[36]

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 future seigniorage revenues any more than needed, then expectations concerning the future growth rate of base money can only be either $E_{t_A}[\mu_1] = \mu_{L_i}$, or $E_{t_A}[\mu_1] = \mu_{H_i}$, $i = 1,2$, depending on the possibilities of the central bank (i.e., depending on interest rate). On one hand, private agents should

[36] The shape of the curves depicted in Fig. 5.19-5.20 was derived by numerical calculations in MathCad®. The parameterization of the calculations is the same as in the examples considered in Sections 5.3-5.4.

not expect that the central bank would choose μ_1, which does not correspond to the required change in the present value of future 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 future seigniorage revenues 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.[37] 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".[38]

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.

5.13 Uncertainty about the timing of the 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

[37] 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 influence the fiscal sphere in a particular way.

[38] See reviews of this problem in Azariadis (1993) and Farmer (1999), among others.

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.[39] Equations (5.16)-(5.18) describe the dynamics of the money market.

$$x(t)=\begin{cases}-\alpha\mu_0, & t<t_A,\\ =-\alpha\mu_0-\big(\alpha\big[p\mu_1+(1-p)\mu_0\big]-\mu_0\big)e^{-\frac{1}{\alpha}(t_{S_1}-t)}- & \\ \quad -\alpha\big(\mu_1-\big[p\mu_1+(1-p)\mu_0\big]\big)e^{-\frac{1}{\alpha}(t_{S_2}-t)}= & \\ =-\alpha\mu_0-\alpha(\mu_1-\mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)}+(1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right], & t_A\le t<t_{S_1},\\ \left\{\begin{matrix}-\alpha\mu_0-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}, & \mu(t)=\mu_0\\ -\alpha\mu_1, & \mu(t)=\mu_1\end{matrix}\right\}, & t_{S_1}\le t<t_{S_2},\\ -\alpha\mu_1, & t\ge t_{S_1}.\end{cases} \tag{5.16}$$

$$\pi(t)=\begin{cases}\mu_0, & t<t_A,\\ \mu_0+(\mu_1-\mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)}+(1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right], & t_A\le t<t_{S_1},\\ \left\{\begin{matrix}\mu_0+(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}, & \mu(t)=\mu_0\\ \mu_1, & \mu(t)=\mu_1\end{matrix}\right\}, & t_{S_1}\le t<t_{S_2},\\ \mu_1, & t\ge t_{S_1}.\end{cases} \tag{5.17}$$

$$S(t)=\begin{cases}\mu_0e^{-\alpha\mu_0}, & t<t_A,\\ \mu_0e^{-\alpha\mu_0-\alpha(\mu_1-\mu_0)\left[pe^{-\frac{1}{\alpha}(t_{S_1}-t)}+(1-p)e^{-\frac{1}{\alpha}(t_{S_2}-t)}\right]}, & t_A\le t<t_{S_1},\\ \left\{\begin{matrix}\mu_0e^{-\alpha\mu_0-\alpha(\mu_1-\mu_0)e^{-\frac{1}{\alpha}(t_{S_2}-t)}}, & \mu(t)=\mu_0\\ \mu_1e^{-\alpha\mu_1}, & \mu(t)=\mu_1\end{matrix}\right\}, & t_{S_1}\le t<t_{S_2},\\ \mu_1e^{-\alpha\mu_1}, & t\ge t_{S_1}.\end{cases} \tag{5.18}$$

Fig. 5.21 illustrates the dynamics. As long as there is no uncertainty after time t_{S_1}, the dynamics of inflation, real money balances, and seigniorage during the time interval $\lfloor t_{S_1}, t_{S_2}\rfloor$ are determined only by the actual 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

[39] This illustrative example is rather standard. See, e.g., Bertola and Drazen (1993), Miller and Zhang (1997).

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). After a gradual decrease on the interval $\lfloor t_{S_1}, t_{S_2} \rfloor$ seigniorage will undergo an upward jump at time t_{S_2}.

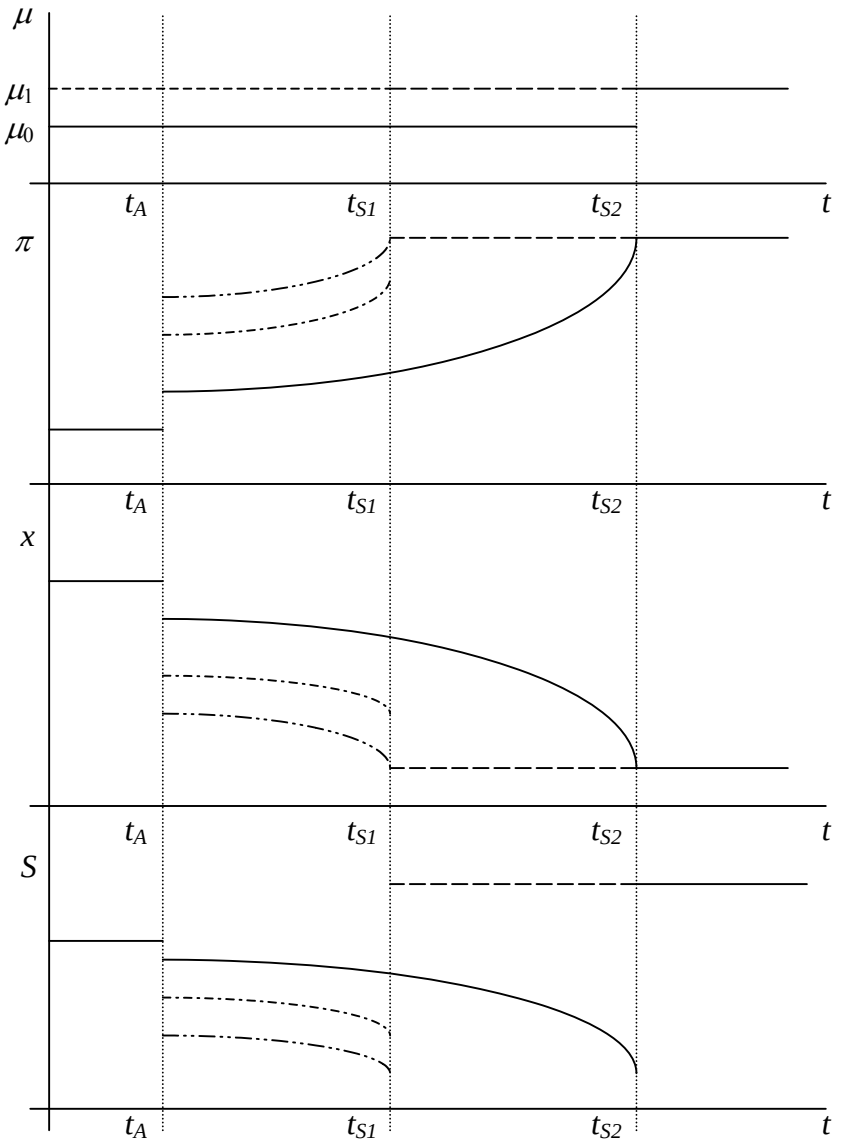


Fig. 5.21. Dynamics of inflation, the log of real money balances, and seigniorage for a permanent increase in the growth rate of base money at an uncertain time

During the interval $\lfloor t_A, t_{S_1} \rfloor$, 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}, that is when $p = 0$, inflation (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 (t_A, t_{S_2}) the dynamics of all variables will be smoothened. However, if the growth rate of base money increases at the ear-

lier time t_{S_1}, then inflation and seigniorage jump up, while 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}, that is $p = 1$, inflation (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 future seigniorage revenues 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 fall) in the present value of seigniorage revenues. This conclusion is important with regard to the sustainability of the fiscal sphere. However, we should 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 $\lfloor t_{S_1}, t_{S_2} \rfloor$, and thus in a decrease in its present discounted value.

Fig. 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 future seigniorage revenues if the interest rate is relatively high. Ceteris paribus, the increase in the present value 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 $\lfloor t_{S_1}, t_{S_2} \rfloor$ the temporary increase in seigniorage will not be as large as possible, and this will have a negative effect upon its present value.

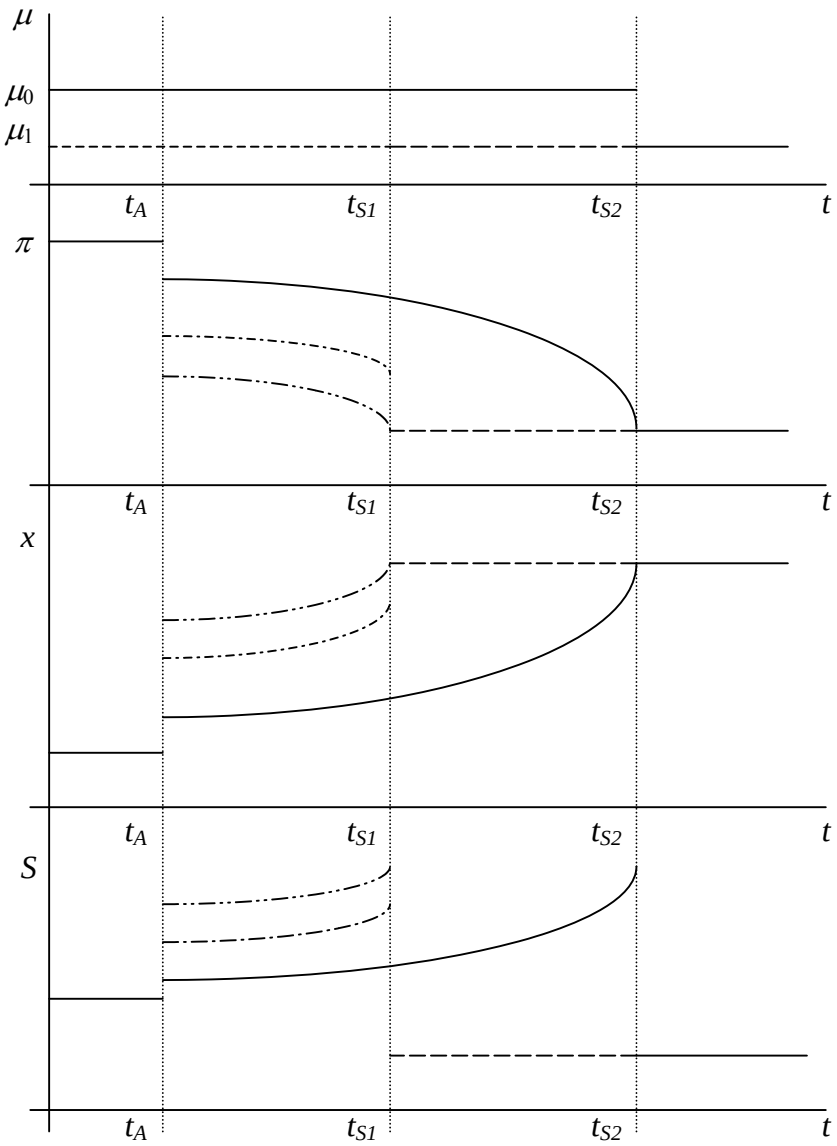


Fig. 5.22. Dynamics of inflation, the log of real money balances, and seigniorage for a permanent decrease in the growth rate of base money at an uncertain time

5.14 Sustainability and feasibility of macroeconomic policy

Keeping the public debt on a sustainable path given any changes in 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 Chapter 4, 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 level of debt. 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 debt. In an economy with rational agents, this criterion determines when the government will face a confidence crisis.

In Chapter 4, 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 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 seigniorage revenues is bounded from above as well. In the steady state, the maximum seigniorage coincides with the maximum of the inflation tax. 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 present value of future 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 increase the present value of future seigniorage revenues only by a limited amount. In the general case, an increase in the 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 the most important explanations for the theoretical results we have arrived at. The principle of sustainable macroeconomic policy, which is central to the research given in this chapter, requires that the public debt at each date 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 present value of future seigniorage revenues 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 inflation regime in the economy, and the interest rate on the public debt.

Throughout our analysis, we have used the following interesting property of an economic system: if the economy is on the increasing branch of the inflation 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 future seigniorage revenues, 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 have 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.[40] Their integration into the analysis that is given above seems to be a promising avenue for further research. 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 level 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 design of monetary policy (and its coordination with fiscal policy) under high inflation is cardinally different from that 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 future seigniorage revenues 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 its steady state, the central bank may be able to achieve an increase in the present value of future seigniorage revenues 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-run dynamics of seigniorage are of most im-

[40] See, for example, an overview of these problems in Drazen (2000), and Persson and Tabellini (2000).

portance and a monetary policy that is meant to increase the present value of future seigniorage revenues 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 policy, monetary policy cannot be tighten in the long run, is not universal. If the interest rate is relatively high, then a temporary increase in the 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 state seigniorage) to a level that is higher than the initial one. In other words, for a dominant fiscal policy, a tight money policy *may* be credible.

Just as one can discuss high or low inflation in an economy, by analogy we may discuss different fiscal-monetary 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 inflation regimes, the principles of interaction between fiscal and monetary policies are determined largely by this fiscal-monetary regime.

Appendix. Numerical examples

Here we give numerical examples for the parameterization of our model that confirm the main results[41]. 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 ratios to 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 percent. In other words, for low-inflation regime (the increasing branch of the inflation tax Laffer curve) the inflation rate must be below 10 percent, while for high-inflation regime (the "wrong side" of the inflation tax Laffer curve) the inflation rate must be greater than 10 percent.[42] 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-monetary regimes with low and high interest rates, we choose correspondingly 1 percent и 10 percent. The length of all time intervals is 10 years.

[41] All calculations were implemented in MathCad®.

[42] 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).

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 $t = t_{S_1-}, t = t_{S_2-}$).

Table A5.1.1. Permanent increase in the growth rate of base money*

$\alpha = 10, \quad d = 0.01, \quad t_A = 1, \quad t_S = 11, \quad \mu_0 = 0.05, \quad \mu_1 = 0.07$

	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
$t = t_{S-}$			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*

$\alpha = 10, \quad d = 0.01, \quad t_A = 1, \quad t_S = 11, \quad \mu_0 = 0.07, \quad \mu_1 = 0.05$

	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
$t = t_{S-}$			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*

$\alpha = 10, \quad d = 0.01, \quad t_A = 1, \quad t_{S_1} = 11, \quad t_{S_2} = 21,$

$\mu_0 = 0.05, \quad \mu_1 = 0.04, \quad \mu_2 = 0.09$

	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*

$\alpha = 10, \quad d = 0.01, \quad t_A = 1, \quad t_{S_1} = 11, \quad t_{S_2} = 21,$

$\mu_0 = 0.05, \quad \mu_1 = 0.03, \quad \mu_2 = 0.07$

	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*

$\alpha = 10, \quad d = 0.01, \quad t_A = 1, \quad t_{S_1} = 11, \quad t_{S_2} = 21,$

$\mu_0 = 0.09, \quad \mu_1 = 0.07, \quad \mu_2 = 0.08$

	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.