Eliminating the Inflationary Finance Trap in a Politically Unstable Country: Domestic Politics versus International Pressure

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Abstract

This paper presents an intertemporal political economy model of public finance relevant for developing and transition countries where there is inherent political instability. As in Cukierman et al. (1992), it is shown that political instability causes myopic behaviour by a rational government resulting in high levels of revenue from seigniorage. It is then argued that inflationary finance also increases barter and currency substitution, but if the government tries to suppress them, seigniorage taxation rises even more. Only international financial pressure can help eliminate the inflationary finance trap, but becomes less effective as the instability increases.

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1. Introduction

Political instability is known to produce myopic behaviour by the incumbent government. There are two scenarios. In the first one a government attempts to raise its chances for re-election by obtaining support through short term measures. This is the argument of the traditional political business cycle literature (e.g. Nordhaus, 1975) as well as the modern political instability literature where instability originates in electoral uncertainty (e.g. Tabellini and Alesina, 1990)[1]. In the second scenario a government faces an exogenous chance of loosing power (for instance, due to the threat of a coup d'état). In this situation, the incumbent government highly discounts the future in favour of short term gains (for instance, Cukierman, Edwards and Tabellini, 1992). More cynically, one could say that the government tries to secure the spoils for as long as possible. This second scenario (of *exogenous* political instability) is particularly relevant for unstable and authoritarian developing countries as well as for countries in transition.

In terms of public finance, such countries typically face at least two fundamental problems which reinforce one another. First, there is virtually no domestic bond market, because potential bondholders (both foreign and domestic) do not have confidence in any form of debt issue. To obtain credit they depend on international loans. Yet these loans are typically curtailed because of bad macroeconomic performance and allegations of mismanagement and corruption. Second, given that existing tax collection problems cannot be overcome in the short run (even in an authoritarian country), it is tempting for the government to use seigniorage to finance government expenses. However, not only do high levels of inflation entail a deadweight loss, but they also lead to a loss in confidence in the national currency. This results in currency substitution and/or a large share of transactions between firms being conducted by barter. The amount of real money balances held by the public is reduced and inflationary finance becomes even more costly.

This paper investigates a government's optimal fiscal policy choice under political instability. It is appropriate to use a short run analysis because we want to study the consequences of myopic behaviour produced by political instability. Since long term considerations only have a small or negligible effect, they are excluded from the analysis to limit the complexity of the model. In particular, we consider a no-growth economy. Furthermore, tax rate changes can be ignored, because they would take too long to be

[1] Here, as in Perrson and Svensson (1989), the focus is on fiscal policy in a two-party system. More recent papers incorporate, for instance, voter uncertainty about the economy (Roemer, 1994, and Schultz, 1999 and 2002).

implemented. Similarly, loan repayment obligations are irrelevant, if they are expected to occur in some distant future.

In the analysis, it is first shown that inflationary finance increases with political instability, a result already obtained by Cukierman, Edwards and Tabellini (1992). Political instability typically leads to higher discounting of the future in favour of the current period. Consequently, an optimising government behaves myopically and increases seigniorage taxation in the current period. It also refrains from investing in the tax collection technology (as in this paper) or eliminating inefficiencies in the tax system (as in Cukierman et al.). This pattern of short-sighted behaviour is henceforth referred to as the inflationary finance trap.

Can the inflationary finance trap be overcome? Who can help the government? These are the questions raised in the ensuing analysis. It is investigated whether the inflationary finance trap can be overcome either by domestic policies directed at fighting barter and/or currency substitution or, alternatively, by international financial institutions threatening to withdraw international loans in response to monetary instability (i.e. high levels of inflationary finance). Given that measures against barter and currency substitution only affect the symptoms of inflationary finance, such policies will actually reduce the deadweight loss caused by inflation. But it is then optimal for the government not to reduce, but instead to further increase the level of inflationary finance. Even in the most optimistic case, namely that anti-barter and anti-currency substitution measures are costless, it is shown that such policies are counterproductive in terms of seigniorage reduction. By itself the government cannot overcome the inflationary finance trap.

In contrast, under international financial pressure it is shown that a rational government is compelled to reduce its level of inflationary finance. However, this effect gradually vanishes under increasing political instability. International financial pressure turns ineffective in very heterogeneous societies with frequent changes of government. In such highly unstable countries, the more myopic government expands its revenues directly by increasing seigniorage ignoring the effect on international credit. This is so, because it heavily discounts the potential future benefits it could have accrued by reducing seigniorage today.

This paper is part of a growing literature which acknowledges that political instability may be exogenous to government choices on fiscal policy. As in Alesina and Tabellini (1989), Cukierman, Edwards and Tabellini (1992), Devereux and Wen (1998), and Svensson (1998), for instance, government change is modelled as a Markov chain. This approach also allows to incorporate an exogenous degree of political polarisation (or social heterogeneity), i.e. to account for conflicting interests within society. There are two types of governments, but their

objectives are identical except that they (symmetrically) either provide two different kinds of public goods or, as in this paper, support different group interests. In all these models, optimal government behaviour is driven by the political instability itself, not by differences in preferences.

This paper contributes to the existing literature in three respects. First, it offers a more complete treatment of the public finance problem under myopia (which is caused by political instability). Rational governments optimise given that there are both consumptive and investment expenditures as well as three alternative sources of revenue: net gains from taxation (losses are associated, for instance, with tax collection costs), net benefits from foreign debt (depending, for instance, on interest rates and debt repayment conditions), and seigniorage[2]. In contrast, the previous literature captures, in each case, only a selection of aspects of the government finance problem. Those papers incorporate *either* domestic debt creation and taxation (as, for instance, in Devereux and Wen, 1998) *or* foreign debt and taxation (as in Alesina and Tabellini, 1989) *or* infrastructure investment and taxation (as in Svensson, 1998) *or* seigniorage and taxation (as in Cukierman, Edwards and Tabellini, 1992).

As a second extension, the paper incorporates the effects of inflationary finance on barter and currency substitution, which in turn affect the deadweight loss of inflation. By allowing the government to take administrative measures against barter and currency substitution, the government is now given an additional tool for reducing the deadweight loss of inflationary finance, not just by reducing seigniorage taxation, the original cause of the deadweight loss.

As a third extension, this paper captures the joint effects of foreign debt and so-called debt conditionality on optimal government behaviour under exogenous political instability. Thus, two aspects of many developing or early transitional countries are modelled in one and the same framework: the exogenous nature of their political instability and the key role of foreign debt in their public finance. Despite this fact, thus far (except for Alesina and Tabellini, 1989), the exogenous political instability literature has either discussed domestic debt only or ignored debt altogether. In the real world, the amount of available debt typically depends on World Bank or IMF conditionality. Whereas Bank conditionality is less clear cut, IMF conditionality refers to “performance criteria (e.g., fiscal deficit to GDP ratio, growth of money supply, etc.)” (Ray, 1998). In this paper, revenue deriving from foreign debt is modelled to depend only on debt conditionality based on monetary stability (i.e. the growth of money supply criterion).

Sections 2 and 3 present the intertemporal model and discuss its economic and political components. Section 4 presents the solution. The findings are discussed in section 5 and section 6 concludes.

2. Model Structure

The model consists of two periods: period 1 (current period) and period 2 (next period). There are two sectors in the economy: (i) the government; and (ii) the private sector. The model is specified in real terms. An overview of the model is given below and details concerning taxation, seigniorage and government borrowing are provided in section 3.

Government Budget Constraints

The government budget constraints for periods 1 and 2 are:

$$\begin{aligned} G_1 + F_1 \quad + \quad R_1 \quad &\leq \quad (1-\theta) \quad T_1(\overline{R}_0) \quad + \quad S_1 \quad + \quad \varphi_1(\overline{S}_0) \\ G_2 + F_2 \qquad\quad &\leq \quad (1-\theta) \quad T_2(R_1) \quad + \quad S_2 \quad + \quad \varphi_2(S_1). \end{aligned} \qquad \textbf{(1)}$$

The right hand side specifies the three sources of government revenue. First, *taxation* at time t, T_t, depends on previous period tax investments R_{t-1}, i.e. there is a taxation technology (discussed further down). Taxation in period 1 is exogenous since any tax investment prior to period 1 is already bygone. Taxation in period 2 is determined by endogenous first period tax investment R_1 which is a government instrument. A fraction θ of tax revenues is lost due to inefficiencies related to information costs, tax collection costs, etc.[3]

Second, *seigniorage S* in each period is the other government instrument. In many developing countries it is not unrealistic to assume that there is no distinction between the central bank and the government. The link to the rate of monetary growth and the deadweight loss of seigniorage taxation is discussed further down. Third, the availability of international loans φ hinges on the government's monetary stability stance which is expressed by the level

[2] As for seigniorage, the political instability approach here can be viewed as an extension to the optimal inflation literature (for instance, Phelps, 1973, and Mundell, 1965), in particular to Ferreira (1999) where inflationary finance can be used for public investment.

[3] This is a standard assumption to capture (avoidable and unavoidable) inefficiencies, but it is not crucial for the results.

of seigniorage taxation in the previous period S_{-1} (also discussed further down). φ_1 is exogenous as seigniorage prior to period 1 is already bygone.

Government expenditure consists of two kinds: *investment R* in the taxation technology; and consumptive spending *F* and *G* (henceforth *partial interest spending*). In most of the aforementioned models of political instability, government consumption is interpreted as expenditure for public goods. In this model, *F* and *G* are interpreted as provisions for two distinct groups of clients (but the difference in interpretation does not affect the results). The common feature is that they do not enter the private sector budget constraint. Partial interest spending *F* and *G* may be either eaten up directly or taken outside of the country. An example for the former is soup kitchens for the poor. An example for the latter, *F* and *G* could be viewed as subsidies or bribes diverted from the government budget to members of the ruling classes (or near government institutions or firms).[4]

Government Preferences and Political Instability

Government preferences over periods 1 and 2 are given by the following utility function:

$$W = V_1(C_1) + H_1(G_1, F_1) + E\left[\rho\left(V_2(C_2) + H_2(G_2, F_2)\right)\right] \quad . \qquad \textbf{(2)}$$

The *V.(·)* functions are concave and twice continuously differentiable utility functions in private sector consumption C. The *H.*(·) functions are the (partial interest) utility functions in government provision G and F for the two partial interest groups. *E* is the expectation operator and ρ is the government's discount rate. Total government utility is additively separable in two senses: first, with respect to periods; and second, with respect to utility derived either from private consumption or from partial interest provision.

Assuming two types of governments (i.e. policymakers) political instability means: (i) the probability of government change and (ii) political polarisation. After the first period the incumbent government may lose office to the other set of policymakers with a fixed probability π and it stays in power with probability (*1* - π).[5] Each of the two types of

[4] Clans surrounding Mobutu in Zaïre, various segments of the Suharto family in Indonesia, or various groups of the so-called oligarchs in Russia are historical examples in question. In the real world, a large proportion of these funds were and are still (illegally) transferred to foreign bank accounts.

[5] Technically, this random change of government at fixed intervals is a Markov chain. If several time periods were considered and their lengths were fixed, for instance, at six months, some governments would only be in power for half a year, fewer would last for a year, and fewer yet for any longer period of time. This is a simple way of describing political instability, but it matches the situation in many developing or transition countries. In

government cares for both partial interest groups, but to differing degrees. Political polarisation then depends on the differences of policymakers' preferences with respect to partial interests. The government utility function *H* for partial interest spending is specified for one type of government (for the other type, α must be replaced by (*1-*α)):

$$H(F,G) = \frac{1}{\alpha(1-\alpha)} \min[\alpha G,(1-\alpha)F] \quad . \qquad \textbf{(3)}$$

For simplicity, their disagreement in partial interest spending is parameterised symmetrically by α which is exogenous. Without limiting the general validity of the analysis, it is assumed that $1 \geq \alpha \geq \frac{1}{2}$. When α equals half, the two types of government have identical preferences; the more distant α is from half, the more they disagree on how much to spend on each of the two partial interest groups. If preferences of both policymaker types are very dissimilar, political polarisation is large. Thus political polarisation measured by α contributes to political instability because it accounts for the extent of preference changes given a change in government. For α equal to one half, the instability effect of a government change is eliminated.

Private Sector Budget Constraints

The private sector budget constraint determines real private consumption *C* in each period:

$$\begin{aligned} C_1 &\leq 1 - T_1(\bar{R}_0) - S_1 - \delta\left(T_1(\bar{R}_0)\right) - \gamma_1\left(S_1, \bar{S}_0\right) \\ C_2 &\leq 1 - T_2(R_1) - S_2 - \delta\left(T_2(R_1)\right) - \gamma_2\left(S_2, S_1\right). \end{aligned} \qquad \textbf{(4)}$$

Real private consumption depends on real income net of all taxes and deadweight losses. Each period the private sector is endowed with some fixed income, for simplicity taken to be 1.[6] The government collects tax $T(R_{-1})$ and seigniorage revenue *S*. In addition, the private

Russia, for instance, there were 5 changes of government in 1998 and 1999 despite the fact that no Duma or presidential elections were held. President Yeltsin alternately replaced representatives of the nomenclature (Chernomyrdin, Primakov, Putin) with so-called reformist Prime Ministers (Chubais, Stepashin) in arbitrary and irregular intervals.

[6] Alternatively, the model could be interpreted in per capita terms.

sector must bear deadweight losses for both tax and seigniorage, equal to $\delta(T(R_{-1}))$ and $\gamma(S, S_{-1})$, respectively. They are specified in the next section.

A fixed endowment implies there is no growth and the private sector is passive in the sense that it cannot take optimising decisions on labour, savings or investment (as, for instance, in Cukierman, Edwards, and Tabellini, 1992). Thus the two budget constraints are not directly linked intertemporally. These assumptions allow us to focus on the government and its decision problem. This simplification may be justified in two ways: first, this is a short run model; and, second, growth in transition and developing countries is largely determined by other factors, for instance, foreign direct investment.

3. A Closer Look at Government Revenue

The aforementioned three types of revenue are motivated and their implications are discussed: (i) the link between seigniorage and money supply growth as well as the deadweight loss of seigniorage; (ii) income taxation and its deadweight loss; and (iii) government borrowing as well as the functional format of net credit in period 2.

Money Supply Growth, Inflation and Seigniorage

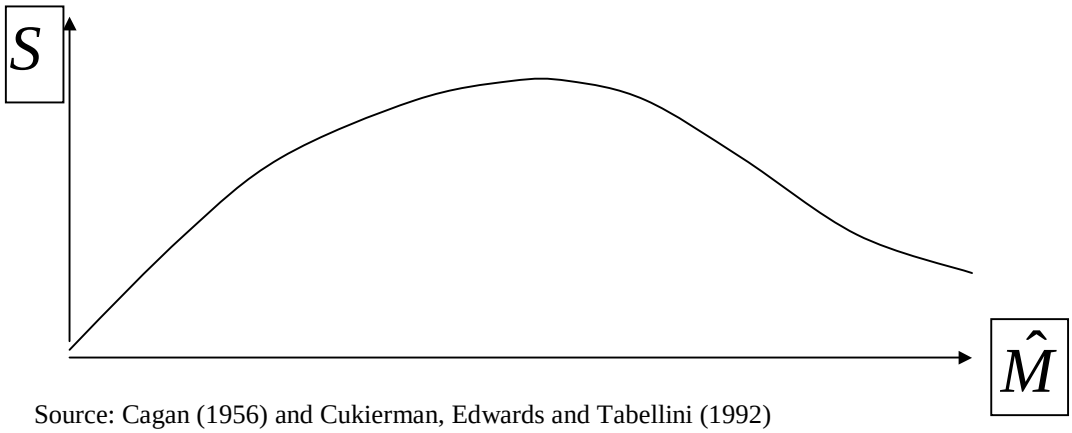
The discussion in this subsection is beyond the formal model presented in the paper. Only real seigniorage is captured in the model, but there is an implicit link to money, prices and inflation. (Real) seigniorage taxation is the financing of government spending by means of new base money injection, i.e. the change in real money (the change in nominal money, $\dot{M}$, divided by price level *P*):

$$S \equiv \frac{\dot{M}}{P} = \frac{\dot{M}}{M}\,\frac{M}{P} = \hat{M}\; L\left(\hat{P}^e\right) \quad . \tag{5}$$

Real seigniorage revenues *S* can be rewritten in terms of the rate of monetary growth $\frac{\dot{M}}{M}$ ($=\hat{M}$) and the real supply of money $\frac{M}{P}$. In *equilibrium*, money supply equals the demand for real base money balances $L\left(\hat{P}^e\right)$, where $\hat{P}^e$ is the expected rate of inflation and *L* decreases in $\hat{P}^e$. It is well established that there is a strong link between the expected rate of inflation and the actual rate of monetary growth (in the steady state they are identical). In his

study of hyperinflations, Cagan (1956) showed empirically that there is a Laffer-type trade-off between the seigniorage tax rate $\hat{M}$ and the seigniorage tax base $L\left(\hat{P}^e\right)$. This implies a maximum value for *S* as shown in the figure depicting seigniorage and monetary growth. Later, Sargent (1977) and Christiano (1987), for instance, confirmed this result.

Figure: Seigniorage



Source: Cagan (1956) and Cukierman, Edwards and Tabellini (1992)

As the relationship between seigniorage and inflation is not modelled explicitly in this paper the implicit assumption is that the government chooses an optimal rate of monetary growth, i.e. a growth rate on the rising branch in the figure. In terms of model results, this means that there may be situations in which the level of seigniorage cannot be raised any more. In more technical terms, this implies that the results only apply, if there is no corner solution, i.e. if *S* has not reached its maximum.

Deadweight Loss of Seigniorage

Seigniorage taxation produces welfare losses for the private sector. This so-called deadweight loss traditionally includes at least three types of costs: First, higher inflation leads to lower levels of real money holdings, thereby raising the cost of keeping a certain level of liquidity (the shoe leather argument). Second, inflation produces a loss of regular tax revenue (the so-called Olivera-Tanzi-effect), if there is no base structure indexation. There are costs involved in preserving the same level of government tax revenues, which must be born by the private

sector in the end. Third, various redistribution effects, for instance between debtors and creditors, also cause welfare losses.[7]

The deadweight loss can be expressed by the following function:

$$\gamma_t = \gamma_t(S) \quad . \qquad \textbf{(6)}$$

Deadweight loss γ is rising and convex ($\gamma_t' > 0$, $\gamma_t'' > 0$, t=1,2). Intuitively, this is a reasonable assumption because the marginal increase in seigniorage at a higher level of seigniorage is typically associated with a more substantial rise in inflation compared to the rise of inflation at a lower level of seigniorage (as suggested by the rising branch of the figure). Thus it suffices that the effect of inflation on welfare costs is linear, it may even be slightly concave.

In the context of developing and transition economies, the concept of deadweight loss must be extended, because high levels of inflation typically erode the trust of the private sector in using the national currency for transactions. Thereby, the levels of barter trade and currency substitution in the economy are raised. Currency substitution has been a wide-spread problem, for instance, in Eastern European as well as Latin American countries. Barter trade amounted to an estimated 50% of all industry transactions in Russia at the end of the 1990s. Formally, the deadweight loss γ could be depicted by $\gamma = \eta(S,b,c)$. Welfare losses are caused by seigniorage directly – as discussed in the previous paragraph – as well as through its effect on barter b and currency substitution c (where b and c, in turn, are functions of seigniorage: $b=b(S)$ and $c=c(S)$). Combining these three equations and allowing for intertemporal links, the deadweight loss γ can be expressed by:

$$\gamma = \gamma(S, S_{-1}) \qquad \textbf{(7)}$$

It is typically assumed that γ is rising and convex in both arguments ($\gamma' > 0$, $\gamma'' > 0$). This is a reasonable assumption because, intuitively, the effect of inflation on welfare costs directly and through barter trade and currency substitution may be slightly decreasing (almost linear) or even increasing. However, it takes larger increases of inflation to produce the same amount of additional seigniorage for higher levels of inflation (cf. the rising branch in the figure).

[7] Note that there is no positive effect for the country as a whole due to a reduction of the real value of debt, because foreign debt is typically denominated in foreign currency.

Taken together, this means that an additional rise of seigniorage causes a stronger and stronger increase of the deadweight loss for higher and higher levels of seigniorage.

For obtaining answers on some issues, it is necessary to further specify the functional format of deadweight loss equation (7):

$$\gamma = \mu \quad (\nu_2 S^2 + \nu_1 S_{-1}^2) \qquad \mu, \nu_2 > 0, \quad \nu_1 \geq 0 \qquad \textbf{(8)}$$

Exogenous parameters ν_2 and ν_1 specify the relative impact of both periods' seigniorage. Coefficient μ is an exogenous scale parameter capturing the effect of behavioural or policy changes that do not affect the relative impact. A reduction means a fall in the total deadweight loss. Raising the trust of the public in the government's medium or long term monetary strategy could bring this about. However, the decline of μ may also represent an administrative intervention to suppress barter and currency substitution. It may be difficult to curb barter trade because it is always possible formally to make out two separate contracts. It is, however, possible to prohibit the use of foreign currency and to act against black markets for it, even though this may not be totally costless as assumed in this paper.

Taxation and Its Deadweight Loss

In this paper, the government income tax revenue[8] is not affected by income because a no-growth economy is modelled. Nonetheless, total tax receipts could change, at least in principle, because both the tax rate and the tax base could vary. As for the tax rate, it is typically assumed in the literature that it cannot be altered in the short run. It takes a while to pass legislation and enact tax rate changes, even in an authoritarian regime. In developing and transition countries with some degree of political instability parliamentary opposition is often stiff and policy changes involving taxation are not feasible in what would be one or two model periods. Thus tax rate changes are ruled out here. As for the tax base, it depends on the tax morale and tax enforcement. In many transition and developing countries only a rather small fraction of income enters the tax base. However, increased spending on enforcement *R*, for instance training of additional tax inspectors, should raise next period's tax base and,

[8] Implicitly, it is assumed that there are no indirect consumption or capital taxes.

therefore, tax revenue T in the next period. The model accounts for such a taxation technology[9]:

$$T = T\left(R_{-1}\right) \qquad \textbf{(9)}$$

with $T'>0$ and $T''<0$. The tax investment function is concave due to decreasing returns to scale.

Similar to seigniorage revenue, taxation also carries a welfare loss for the private sector because the introduction of non-lump sum taxes causes a departure from Pareto-optimality. In particular, the distortions affect the allocation decisions of consumers (not modelled), thereby affecting the total amount of consumption. The deadweight loss (or excess burden) of taxation is given by:

$$\delta = \delta\left(T(R_{-1})\right) \quad . \qquad \textbf{(10)}$$

The deadweight loss of taxation is assumed to be increasing (in tax revenue T) at an increasing rate, i.e. $\delta'>0$ and $\delta''>0$ (convex).[10] Intuitively, this makes sense. For instance, consider the large disincentive impact on labour supply when progressive income taxes bite. When the tax rate is already high, a relatively small rise of the tax rate has over-proportional effects on the willingness to work, thus over-proportionally increasing the deadweight loss of taxation.

The opposite curvature of $T(R_{-1})$ and of $\delta(T(\cdot))$ requires additional assumptions to ensure that the model specified further down has a well-defined maximum (i.e. to guarantee that the government utility function is concave). To satisfy semi-definiteness conditions, it is a sufficient condition that $T(R_{-1})+\delta(T(R_{-1}))$ be convex in R_{-1}. Less restrictive assumptions are possible, but this (technical) assumption simplifies the analysis considerably.

[9] The taxation technology modeled here as well as in Cukierman, Edwards and Tabellini (1992) capture the time lag between investment and its effect. But there are two differences: First, those authors model the reduction of inefficiencies in the tax collection process (θ in equation 1), whereas here a widening of the tax base is accounted for. In both cases additional investment leads to higher tax revenue net of tax collection costs. However, second and more crucially, their tax investment (which they call "tax reform") is costless, whereas here costs of an investment are explicitly considered.

[10] This corresponds to the assumption made for seigniorage. The same concept is used by Cukierman, Edwards and Tabellini (1992).

Government Borrowing

Generally speaking, the monetary stability stance of the government affects both government borrowing opportunities and private sector decisions on barter and currency substitution (the latter influencing the deadweight loss of seigniorage as already discussed). In both cases, credibility is at stake. In the case of barter and currency substitution, it is the trust of the domestic private sector only. As for government borrowing, credibility refers to domestic and foreign agents. Hence the government budget constraint should be affected by the private sector's decisions on holding bonds and by foreigners' willingness to give aid or loans. But foreign creditors and private individuals will only make their funds available, if they have sufficient trust in the government.

Here it is assumed that the government has already lost most of its credibility and can only obtain funds from foreign financial institutions like the International Monetary Fund (IMF) or the World Bank. Their willingness to lend depends on criteria referred to as debt conditionality. The principle aim of such credit is not to make a profit (which would imply some conditionality to avoid default and ensure full repayment); instead, debt conditionality is typically motivated by more general considerations such as economic and political stability or long run growth. Whereas World Bank conditionality is less clear cut, IMF conditionality refers to "performance criteria (e.g., fiscal deficit to GDP ratio, growth of money supply, etc.)".[11]

In this paper, revenue deriving from foreign debt is modelled to depend only on debt conditionality based on monetary stability (i.e. the growth of the money supply). To operationalise the criterion, we derive from equation (5) together with the quantity equation ($M*V=Y*P$, V being velocity and Y being output) and the exogeneity of Y (normalised at unity): $S = \hat{M}/V$.[12] Instead of basing the criterion on the money supply growth rate, it can also be based on seigniorage S (while acknowledging that fluctuations in V would affect S).

In principle, every credit contract includes repayment obligations. This is also true for loans given by international financial institutions, even though credit conditions are not

[11] Ray (1998). On IMF and World Bank conditionality, cf. also Guitián (1995), Goldstein (2001), The Economist (2001) and Bhagwati (2002).

[12] Real seigniorage is given by $S \equiv \frac{\dot{M}}{P} = \hat{M}\ \frac{M}{P} = \hat{M}\ \frac{Y}{V} = \frac{\hat{M}}{V}$, where P is the price level, V is velocity, M is nominal money, and Y is nominal output.

determined by the perceived chances of repayment. International financial institutions try to get their money back, for instance, by debt rescheduling agreements in case of difficulties faced by the recipient country. Nonetheless, they accept that part of their loans will never be paid back. From the perspective of the developing or transition country, debt repayment only starts after several years and, in case of default and rescheduling, it may be postponed to a distant future. In fact, most developing countries receive net credit for an extended period of time.

In this paper, it is not obvious how to model debt repayment so that it is both realistic and consistent with the short run perspective taken to capture the consequences of myopic behaviour produced by political instability. A theoretically clean solution is to assume that the government in question repays debt only as long as there is a positive stream of net credit (i.e. in the second model period), but plans to renege on its debt otherwise (the argument is similar to the one in Cohen and Sachs, 1986). However, the government intentions are assumed to be private information so that the willingness of international financial institutions to supply debt is not affected.[13]

Net Credit

Formally, the second model period features net credit φ (in real terms). φ is modelled to depend on previous period seigniorage only:

$$\varphi = \varphi\left(S_{-1}\right) \qquad \textbf{(11)}$$

The government can choose a certain level of seigniorage which corresponds to some level of inflation and results in some degree of monetary stability (and international credibility). If this period's level of seigniorage taxation is high, foreign financial institutions will reduce the amount of available funds. This is special form of ex ante conditionality suitable for the short run analysis presented here.[14] Credibility (and hence international net credit) does not depend on a government's promise or, indeed, on its reputation, say to be a reformist or pro-market government. Instead, it is solely the monetary policy decision taken last period.

[13] In principle, capturing both debt conditionality and debt repayment requires a three period model where the third period would be interpreted as the long run. Such an approach would render the model intractable without depicting reality more closely.

[14] Think of the IMF freeing a loan installment once a pre-specified performance criterion (like a certain growth rate of the money supply) has been met.

Moreover, it is assumed that φ is decreasing and concave ($\varphi' < 0$, $\varphi'' < 0$). This is not very restrictive. Given that the increase of inflation for a certain rise in seigniorage is larger for higher levels of seigniorage, the concavity assumption even includes the case of φ being weakly convex in inflation. Intuitively, net credit φ should, however, decrease more and more sharply for the loss of credibility reflected in higher and higher levels of inflation.

For obtaining answers on some issues, it is necessary to introduce a specific assumption for φ:

$$\varphi = \kappa - \sigma S_{-1}^2 \qquad \kappa > 0, \quad \sigma \geq 0 \qquad \textbf{(12)}$$

Constant κ represents the maximum amount of net credit which can only be achieved for no seigniorage (and zero inflation) in the previous period. Parameter σ reflects the 'punishment' for monetary instability. σ incorporates the exogenously determined pressure put on the government by, say, foreign financial institutions. Hence a policy change at the IMF towards requiring higher standards for monetary stability could be captured by an exogenous increase in σ.

4. Model Solution

The maximisation problem of the government is formulated in full first, but then a trick is used to decompose it into two separate problems: (i) the distribution of the total partial interest spending between the two groups; and (ii) the fundamental revenue and expenditure problem of the government.

Government Maximisation Problem

Given the specifications in the last section the current government must solve the following maximisation problem with budget constraints *(i)* and *(ii)* for the public sector and budget constraints *(iii)* and *(iv)* for the private sector:

$$
\begin{aligned}
\max_{\substack{G_1,F_1,G_2,F_2\\ S_1,S_2,R_1}} \quad & V_1(C_1) + H(G_1,F_1) + E\left\langle \rho \left\{ V_2(C_2) + H(G_2,F_2) \right\} \right\rangle \\
s.t. \quad (i) \quad & G_1 + F_1 + R_1 \leq (1-\theta)\ T_1(\bar{R}_0) + S_1 + \varphi_1(\bar{S}_0) \\
(ii) \quad & G_2 + F_2 \leq (1-\theta)\ T_2(R_1) + S_2 + \varphi_2(S_1) \\
(iii) \quad & C_1 \leq 1 - T_1(\bar{R}_0) - S_1 - \delta\left(T_1(\bar{R}_0)\right) - \gamma_1\left(S_1,\bar{S}_0\right) \\
(iv) \quad & C_2 \leq 1 - T_2(R_1) - S_2 - \delta\left(T_2(R_1)\right) - \gamma_2\left(S_2,S_1\right).
\end{aligned}
\qquad \textbf{(13)}
$$

The problem exhibits several intertemporal links. Let us look at the government budget constraints first. Higher tax investment increases tax revenues in the following period, thus requiring less net credit next period, which, in turn, means that higher levels of seigniorage would be possible this period. Conversely, higher seigniorage this period causes lower revenues next period (due to reduced net credit opportunities), but enables higher tax investment this period, thus leading to higher tax revenues next period. Essentially, the government budget constraint exhibits a trade-off between the intertemporal effects of seigniorage and taxation. In addition, every increase in taxation and/or seigniorage adversely affects the private sector budget constraint (both directly and through its deadweight loss). Thus an increase in public spending and the utility derived thereof entails a decrease in private sector spending and the utility obtained from private consumption. These prima facie considerations are confirmed by the first order conditions (presented in appendix B).

Potentially, there is a time-inconsistency problem. In period 1 the incumbent government optimises based on expectations for period 2, in which the government changes with probability π. In principle, a new government could re-optimise in period 2 – once the uncertainty is resolved. However, it will be clear from the discussion in the next subsection that, under assumption (3), both governments always choose the same level of *total* partial interest spending ($F+G$). Hence the fundamental decision on the sources of revenue and on the division between tax investment and total partial interest spending will not be affected by a government change.

Partial Interests and Government Utility

Government problem (13) is made tractable because of three assumptions: (i), partial interest spending F and G does not appear in the private sector budget constraint; (ii), government objective function (2) is additively separable; (iii), the polarisation assumption embedded in

equation (3), the government utility function *H* for partial interest spending, has a special functional format. Due to assumptions (i) and (ii) government optimisation problem (13) can be decomposed into two problems: first, the optimal *distribution* of the total partial interest spending between *F* and *G*; and second, the *fundamental* revenue and expenditure problem of the government.

The optimal distribution problem is not really interesting since its results hinge on specific (though quite sensible) assumptions for partial interest utility *H* (assumption (iii)). Indeed, the mathematical solution of the distribution problem for partial interest spending (cf. appendix A) is only required for being able to solve the fundamental revenue and expenditure problem of the government. Due to assumption (iii) – i.e. the special format of partial interest utility function H – the fundamental problem of the government is independent of the actual government in power. Nonetheless, the fact that there are two potential governments does have crucial implications for any government decision on the total amount of partial interest spending, on tax investment and on seigniorage financing. In fact, the model is constructed that way to allow the analysis of political instability by itself as opposed to analysing the effect of different types of government with different objectives.

As shown in appendix A, assumption (iii), which refers to the functional format of utility function *H*, has three specific implications. First, the optimal distribution of the total partial interest spending between *F* and *G* is crosswise symmetrical for both types of governments (when in power). Second, government utility *H* derived from type i's choice of *F* and *G* (when in power) is equal to government utility derived from type k's choice (when in power):

$$H^i(F^i,G^i) = F^i + G^i = X^i = X = X^k = F^k + G^k = H^k(F^k,G^k) \quad . \qquad \textbf{(14)}$$

In either case, the marginal utility of partial interest spending is unity. Third, the (real) total value of partial interest spending *H* is normalised – for each government – by the sum of its arguments (*F*+*G*), when chosen optimally by any incumbent government. For *i* and *k* representing different governments and $\alpha > \frac{1}{2}$ being assumed (without loss of generality), note, however, that government *k*'s optimal choice for F and G is, of course, suboptimal for government *i*: $X^i = H^i(F^i,G^i) > H^i(F^k,G^k) = \frac{1-\alpha}{\alpha} X^i$.

On this basis, the government utility function (2), can be simplified. For each period separately, utility derived from private consumption and from partial interest spending is considered for the government *in power in period 1* only. Superscripts are only used for the other government (marked by k). In period 1, this government's optimal choice for *F* and *G* results in $H(F_1, G_1) = X_1$. Thus first period utility is

$$V_1(C_1) \quad + \quad H(G_1, F_1) \quad = \quad V_1(C_1) \quad + \quad X_1 \quad . \tag{15}$$

If this government is still in power in period 2 (with probability (1-π)), it will choose *F* and *G* such that $H(F_2, G_2) = X_2$. If, however, this government looses power in period 2 (with probability π), it has to put up with the partial interest spending chosen by the other government, i.e. $H(F_2^k, G_2^k) = \frac{1-\alpha}{\alpha} X_2$. Hence its second period total expected utility is:

$$\begin{aligned} E \left\langle \rho \left\{ \quad V_2(C_2) \quad + \quad H(G_2, F_2) \quad \right\} \right\rangle & \\ = \rho \left\{ \quad (1-\pi)\left[V_2(C_2) \quad + \quad X_2 \right] \quad + \quad \pi\left[V_2(C_2) + \frac{1-\alpha}{\alpha} X_2 \right] \right\} & \\ = \rho \left\{ \quad V_2(C_2) \quad + \quad \beta(\alpha, \pi) X_2 \quad \right\} \quad . & \end{aligned} \tag{16}$$

Thus government utility depends on two exogenous parameters, political polarisation α and the probability of loosing power π, which are subsumed under quasi-exogenous parameter β, which is to represent political instability: $0 \leq \beta(\alpha, \pi) = (1-\pi) + \pi \frac{1-\alpha}{\alpha} \leq 1$. Obviously, $\beta = 1$ if both governments have identical preferences ($\alpha = \frac{1}{2}$) or if the government stays in power with certainty ($\pi = 0$). For $\alpha = 1$ and $\pi = 1$, $\beta = 0$. In other words, β decreases with more political diversity (polarisation $\alpha\uparrow$) and/or more political uncertainty (probability of government change $\pi\uparrow$).

The Fundamental Problem of the Government

The fundamental revenue and expenditure problem of the government can now be specified on the basis of the original government problem (13) and equations (15) and (16).

Remembering that $F_t + G_t = X_t$ (t=1,2) the government budget constraints *(i)* and *(ii)* can be substituted into equations (15) and (16). Equally, private sector budget constraints (iii) and (iv) for C_t (t=1,2) can be inserted into (15) and (16). Then the new objective function is:

$$\max_{S_1,S_2,R_1} \quad W(S_1,S_2,R_1) \quad \text{with}$$

$$\begin{aligned} W(S_1,S_2,R_1) \;=\; & V_1\left[1-T_1(\bar{R}_0)-S_1-\delta(T_1(\bar{R}_0))-\gamma_1(S_1,\bar{S}_0)\right] \\ + \; & \left[(1-\theta)T_1(\bar{R}_0)+S_1+\varphi_1(\bar{S}_0)-R_1\right] \\ + \; & \rho V_2\left[1-T_2(R_1)-S_2-\delta(T_2(R_1))-\gamma_2(S_2,S_1)\right] \\ + \; & \rho\beta\left[(1-\theta)T_2(R_1)+S_2+\varphi_2(S_1)\right] \end{aligned} \qquad \textbf{(17)}$$

The formal solution is quite technical and will only be sketched out here. Basically, one must proceed in three steps. First, first order conditions (FOCs) with respect to policy variables S_1, S_2, R_1 must be obtained. These necessary conditions for an optimum are presented in appendix B. To ensure that they are also sufficient conditions, the concavity properties of the problem must be scrutinised by checking the Hessian for semi-definiteness. Finally, results are obtained for the four exogenous parameters which were discussed in sections 2 and 3.

The probability of government change π and political polarisation α are represented by β, the political instability parameter, which was introduced in equation (16). Scale parameter μ captures exogenous government policies aimed at curbing barter and currency substitution. Parameter σ refers to the 'punishment' for monetary instability exogenously set by international financial institutions. For all of these, perturbation results around the equilibrium can be obtained by deriving total differentials and using the Cramer Rule or by applying the inverted Hessian. Findings of the analysis are discussed in the next section.

5. Discussion

The findings are discussed with respect to the three parameters referring to: (i) political instability; (ii) domestic politics; and (iii) foreign agents' policies. They are summarised in the Table of Results further down.

Political Instability

As stated before, exogenous political instability takes two forms: political polarisation and/or uncertainty about the future government. An increase in polarisation means that policy choices of the other government, if in power in the second period, produce more undesirable results. A higher chance of government change means that it is less likely that policy choices which are optimal for the current government will be implemented in the future. In both cases, this causes the government to value the present more highly than an uncertain and undesirable future. This is the basis for the result of myopic government behaviour in the literature. In Cukierman, Edwards and Tabellini (1992) political instability leads to less structural change and higher seigniorage, in Devereux and Wen (1998) to higher government spending and lower growth, in Svensson (1998) to lower investment in property rights and lower private investment, and in Alesina and Tabellini (1989) to lower capital formation, higher external debt and capital flight.

The well-established result of myopic government behaviour is confirmed in this paper. If there is a higher probability of government change and/or more polarisation in the national political system, the government becomes more concerned about the short term. The revenue effects of increased seigniorage in period 1 are exploited, and less public funds are spent on tax investments. Partial interest spending is shifted from period 2 to period 1 because second period expected partial interest utility is reduced with the increased risk of loosing power to a government which will choose a less desirable partial interest distribution.

Table of Results

		S_1	R_1	S_2
Political instability ↑:	**β↓**	**↑**	**↓**	**?**
- government change probability ↑	π↑			
- political polarisation ↑	α↑			
Anti-barter & currency substitution policies ↑	**μ↓**	**?**	**↓**	**?**
- last period S <u>does not</u> affect deadweight loss	under $\nu_1=0$	↑	↓	↑
International financial pressure ↑	**σ↑**	**↓**	**↑**	**↑**
- under more political stability	under β high	⇓	⇑	⇑
- under more political instability	under β low	(↓)	(↑)	(↑)

Even though we are mainly interested in the short run effects, it is instructive to look at effects on second period seigniorage. On the one hand, one might expect a reduction of seigniorage revenue in period 2 due to the intertemporal reallocation of resources. Second period seigniorage revenue is evaluated less highly than revenue from seigniorage in period 1. On the other hand, there are two reasons why a higher amount of seigniorage may, nonetheless, be required in period 2. First, the elevated level of seigniorage in period 1 produces negative credibility effects leading to reduced credit opportunities in period 2. Second, reduced tax investments causing lower tax revenues in period 2 can only be compensated by raising seigniorage revenues. The overall effect is, therefore, ambiguous; hence the question mark in the table of results.

Domestic Policies

Next, consider active domestic policies to curb barter and currency substitution administratively (henceforth anti-b&c-policies). They are represented by a reduction of μ. As mentioned before, an exogenous change of μ could also be interpreted as an increase of trust in the government's (medium to long term) monetary policy stance. In any case, if the private sector's (voluntary or forced) acceptance of the domestic currency increases, the real money demand, i.e. the seigniorage tax base, is not so much reduced for a given level of seigniorage. Even though this is not explicit to the model, we can see from equation 5 that the money supply growth rate (i.e. the seigniorage tax *rate*) can be lower when the seigniorage tax *base* is higher (reduced by less). Inflation would be expected to be lower in the long run. As a consequence, the deadweight loss of seigniorage is reduced. The effect of μ on the deadweight loss γ is captured directly by equation (8).

Since the effects of seigniorage are not so bad any more, the government will be inclined to increase revenues derived from seigniorage while reducing tax investments. Model results are unambiguous, if barter and currency substitution decisions, hence the deadweight loss, do not determined by previous period seigniorage (cf. table of results for $\nu_1 = 0$). For $\nu_1 > 0$, however, results depend on the responsiveness of the deadweight loss on seigniorage in both periods. Under certain parameter constellations, it may be optimal for the government to decrease the level of seigniorage revenues at least in one period. Under all circumstances, it remains optimal, however, to reduce tax investments.

Since anti-b&c-policies tend to produce higher levels of seigniorage, one might be tempted to conclude that a lower level of barter and currency substitution must be undesirable. In the

context of the model analysed here, this is not true for two reasons. First, less barter and currency substitution means a reduction of welfare losses, because the deadweight loss of seigniorage is reduced. Second, despite the rise of seigniorage, inflation may still be reduced as the seigniorage tax base increases. These favourable effects would, however, be diminished (or there could be an overall welfare loss), if the costs involved in anti-b&c-policies were included in the analysis.[15] Moreover, high levels of seigniorage may cause a future dependence on seigniorage revenues (which is also not captured in the model).

So far, we have seen that a politically unstable country cannot by itself get rid of its dependence on seigniorage. Due to its short-sightedness, the government is stuck in the inflationary finance trap. The question arises, if foreign involvement can remedy the situation. This is discussed in the next subsection.

International Financial Pressure and the IMF Dilemma

If the government is faced with foreign agents who can credibly commit to 'punishing' the government for monetary instability (i.e. ex ante conditionality based on high seigniorage), any government will try to avoid the loss of aid or foreign loans.[16] With σ rising in equation (12), period 2 net credit is reduced for any given level of seigniorage. As a consequence, the optimising government chooses a reduction of seigniorage revenues in period 1 (cf. Table of Results) to limit the negative effect on net credit. But this does not completely offset the reduction of second period revenues. Despite its myopic behaviour, in principle, it is now optimal for the government to shift revenue incomes to the second period. First, second period seigniorage can be increased without doing harm to future borrowing opportunities (since period 2 is the end period of the model). Only the private sector budget constraint is (negatively) affected. Second, tax revenues in period 2 are raised due to additional tax investment in period 1. This is so despite the fact that (seigniorage) revenues in period 1 are already reduced compared to a situation without international financial pressure.

Qualitatively, these results are valid under more and under less political stability. However, if political polarisation or the probability of government change rise (lower β), international financial pressure has smaller effects on seigniorage and taxation. In particular, international

[15] Another view on the welfare effects of currency substitution is taken in Morrien (1996). Depending on the start situation, it may be favorable to increase currency substitution, if the position of the mainly used currency is strengthened. Hayashi and Matsui (1996) present a specific model on barter equilibria.

[16] This is consistent with the earlier assumption that the repayment of loans is either not considered by the government or only plays a negligible role. In a more general framework, one would have to assume that there are sufficient profitable investment opportunities the government could seize.

pressure is less effective in reducing a government's willingness to use seigniorage for financing its revenues in period 1. For β approaching zero the effect vanishes.

This is bad news for international financial institutions. Setting a priori conditions for monetary stability as a precondition for giving aid or loans may be ineffective. Political polarisation and/or the chance of government change makes current governments behave myopically so that incentives for the future may only have little effect. The upshot is that prior to solving the *monetary* stability problem, the *political* stability problem must be overcome.

In a more general context, the conditionality of loans given by the IMF or the World Bank should be put under scrutiny. The dilemma of these international institutions is that they are economic institutions, but political considerations may prove more effective than economic ones. Nonetheless, these institutions have already moved away from the so-called Washington consensus with its one-sided emphasis on macroeconomic stabilisation. In recent years, they have acknowledged the important role played by institutions. What remains to have to be recognised is that the political conditions, too, are decisive.

In the short term in may be prudent to stabilise the current political system. It may be necessary to supply immediate loans, even if a lot of funds are used inefficiently. The withdrawal of financial support (in other words, exerting financial pressure) may not affect government policies, but may well contribute to a weakening or ousting of the present government and/or destabilise the system as a whole. In the medium term, funds should be given for building up and strengthening legal, political, and social institutions to obtain more political stability (both in terms of government continuity and in terms of society cohesiveness). Ideally, support should be tied to specific tasks. But even if this is not entirely possible, it may be sensible to give aid or loans for building up institutions.

6. Conclusion

This paper introduces a simple framework for studying the problem of optimal government finance under political instability. It is suited to analyse the case of developing and transition countries, where political instability is inherent to the political structure of the country rather than caused by electoral uncertainty as in Western democracies. A country's political situation is characterised by its uncertainty about government change and its political polarisation within society. Alternative means for financing government spending are considered. Seigniorage, taxation, and government borrowing are analysed in the context of barter and currency substitution, taxation investment, and foreign financial pressure, respectively.

Three main conclusions emerge from the analysis. First, Cukierman, Edwards and Tabellini's (1992) theoretical result that political instability increases the optimal level of seigniorage chosen by the government is substantiated. In this paper, as in theirs, political instability leads to higher discounting of the future in favour of the current period. Consequently, the government increases seigniorage taxation in the current period and refrains from investing in the tax collection technology. Due to political instability the government is caught in an inflationary finance trap.

The second conclusion is that a government cannot overcome the inflationary finance trap by using domestic policies directed at alleviating the negative effects of seigniorage. The model incorporates the feature that inflationary finance typically produces barter and currency substitution, which in turn affect the deadweight loss of seigniorage. By allowing the government to take administrative measures against barter and currency substitution, this paper opens an alternative channel for reducing the deadweight loss to merely reducing seigniorage itself. However, even in the most optimistic case, namely that such measures are costless, it is shown that they are counterproductive in terms of seigniorage reduction.

Altogether, it is shown that domestic policies aimed at curing the symptoms of inflationary finance may be ambiguous. On the one hand, private agents' trust in the own currency and thus the predominant role of the national currency is restored. Welfare losses caused by barter and currency substitution are reduced, and inflation may go down despite higher seigniorage revenues (because the tax base is larger again). On the other hand, it could be argued that high levels of seigniorage cause a future dependence on seigniorage revenues. Hence it is argued that the government cannot overcome the inflationary finance trap by itself.

The third conclusion is that the international community can help, if the domestic political situation is not extremely unstable. The model accounts for ex ante conditionality with respect to monetary instability. International financial institutions give net credit to the country in question dependent on its previous period level of seigniorage taxation. It is shown that foreign financial pressure causes utility maximising governments to scale down on seigniorage taxation, thus achieving a higher level of monetary stability.

However, ex ante conditionality based on monetary stability turns ineffective in very heterogeneous societies with highly unstable governments, i.e. it does not prompt such governments to reduce seigniorage. The argument is based on the fact that more political instability means a relatively higher valuation of the current period. A rational government is so myopic that it prefers to increase present period revenue by raising its seigniorage tax

instead of fulfilling conditions (low level of seigniorage) required for obtaining foreign debt in the future.

This problem has a more general dimension. In highly polarised countries with a high probability of government change, the government heavily discounts potential future benefits it could accrue by restraining its behaviour today. The key problem is, therefore, to promote political stability. As a first step, it is crucial to initiate structural reform involving the build-up and strengthening of legal, political, and social institutions. International financial institutions may have ignored this aspect in their transformation and development strategies far too long. Fortunately, an international consensus on the need for institution-building strategies seems to be developing.

A natural complement to this short run model is a long run perspective including, nonetheless, political instability. This could be done in an infinite horizon framework or, possibly, in a three-period model. Not only would additional time periods contribute to a more complex model structure, but a number of additional issues would have to be addressed, for instance: (i) how to include growth in the model and study its impact on political instability; (ii) how to incorporate a government tax instrument; and (iii) how to include debt repayment in such a long run model. In a more extended framework that includes some of the above issues it might be conjectured that a certain initial level of political stability is required as a precondition for getting on a path of recovery. We might, for instance, get a multiple equilibria story for optimal government behaviour under political instability similar to the one obtained by, for instance, Ehrlich and Lui (1999) for optimal rent-seeking behaviour.

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Appendices

Appendix A: Optimal Partial Interest Spending

The following exposition draws from Cukierman, Edwards, and Tabellini (1992). The same approach is also used in Svensson (1998). For convenience, polarisation assumption (3) which is embedded in the government utility function *H* for partial interest spending is restated for the type *i* government:

$$H^i(F^i, G^i) = \frac{1}{\alpha(1-\alpha)} \min\left[\alpha G^i, (1-\alpha)F^i\right]. \qquad \textbf{(A-1)}$$

Since (A-1) contains a minimum function, optimality can only be achieved for

$$(1-\alpha) \quad F^i = \alpha \quad G^i. \qquad \textbf{(A-2)}$$

As the utility function *H* for the type *k* government is symmetrical according to its definition in section 2, so is the optimal distribution between F^k and G^k: $(1-\alpha)G^k = \alpha F^k$.

Government *i*'s optimal total partial interest spending X^i can be written as

$$X^i \equiv F^i + G^i = \frac{G^i}{1-\alpha} = \frac{F^i}{\alpha}. \qquad \textbf{(A-3)}$$

By reinserting in utility function (A-1) the optimal values for *F* and *G* in terms of *X* ($G^i = (1-\alpha)X^i$, $F^i = \alpha X^i$) a simple result for total partial interest utility *H* is obtained:

$$\begin{aligned} H^i(F^i, G^i) &= \frac{1}{\alpha(1-\alpha)} \min\left[\alpha(1-\alpha)X, (1-\alpha)\alpha X\right] \\ &= X = F^i + G^i \end{aligned} \qquad \textbf{(A-4)}$$

Given that utility function (A-1) is symmetrical for both types of government, the optimal values for *F* and *G* are crosswise identical ($F^i = G^k$ and $G^i = F^k$) and

$$H^i(F^i, G^i) \;=\; X \;=\; H^k(F^k, G^k). \qquad \textbf{(A-5)}$$

Appendix B: First Order Conditions

Necessary conditions for a maximum are obtained by setting zero the partial derivative of W (in the government revenue problem 18) with respect to policy variables S_1, S_2, and R_1, respectively:

$$\mathbf{S_1:} \qquad \frac{\partial W}{\partial S_1} \overset{!}{=} 0$$

$$V_1'(c_1)\;\left(-1-\gamma_1'(S_1)\right) \;+\; 1 \;+\; \rho V_2'(c_2)\;\left(-\gamma_2'^{(S_1)}(S_1,S_2)\right) \;+\; \rho\beta\varphi_2'(S_1) \overset{!}{=} 0 \qquad \textbf{(B-1)}$$

$$\mathbf{S_2:} \qquad \frac{\partial W}{\partial S_2} \overset{!}{=} 0$$

$$\rho V_2'(c_2)\;\left(-1-\gamma_2'^{(S_2)}(S_1,S_2)\right) \;+\; \rho\beta \overset{!}{=} 0 \qquad \textbf{(B-2)}$$

$$\mathbf{R_1:} \qquad \frac{\partial W}{\partial R_1} \overset{!}{=} 0$$

$$-1 \;+\; \rho V_2'(c_2)\;\left(-T_2'(R_1)-\delta_2'(T_2(R_1))(T_2'(R_1))\right) \;+\; \rho\beta(1-\theta)\;\; T_2'(R_1) \overset{!}{=} 0 \qquad \textbf{(B-3)}$$

A prime (‘) denotes the derivative with respect to a functions argument. In the only case with two arguments, in $\gamma_2 = \gamma_2(S_1, S_2)$, the argument of differentiation is specified in brackets after the prime, e.g. $\gamma_2'^{(S_1)}(S_1, S_2)$.