Fiscal Competition and Public Debt*

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Abstract

The implications of high indebtedness for strategic tax setting in internationally integrated capital markets have found little attention so far. We analyze when and how changes in initial debt levels affect the distribution of economic activity across space. When public borrowing is constrained, a rise in a country's initial debt level lowers investment in public infrastructure and makes tax setting more aggressive in that country, while the opposite occurs elsewhere. On net a country with higher initial debt becomes a less attractive location. Our model is consistent with the observation that highly indebted countries have decreased corporate tax rates over-proportionally. It sheds light on proposals to devolve taxing power to lower levels of governments which differ in initial debt levels.

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1 Introduction

The recent economic and financial crisis has led to substantial increases in government debt levels in many countries, which has raised concerns about the sustainability of government finances in general and fears about default in some countries (IMF, 2015). In the short-run, governments may need to increase taxes or cut spending to counter high indebtedness. At the same time fiscal policy also needs to stabilize output and must not become pro-cyclical. While academic research has extensively covered the effect of fiscal policy on economic stabilization and solvency (see DeLong & Summers, 2012; Auerbach & Gorodnichenko, 2012), the implications of high indebtedness for tax policy and strategic tax setting in internationally integrated capital markets have found much less attention.

In this paper, we propose a novel channel through which changes in initial debt levels, like the major pile up of debt during the recent economic and financial crisis, affect the distribution of economic activity across space. In particular, we show that in case of a binding constraint on public borrowing, a rise in a country's initial debt level leads to lower investment in public infrastructure and more aggressive tax setting in that country, while in other countries the opposite policy response occurs under some mild assumptions, that is, more public infrastructure investment and higher taxes on mobile firms. On net, however, a country with higher initial debt becomes an unambiguously less attractive location for firms, and thus economic activity is shifted to less indebted countries.

The result is not driven by crowding out of private investment via higher interest rates, but rather by a government's limited inability to shift resources across time: A higher level of legacy debt reduces *ceteris paribus* a government's spending on public goods in the present. If taking on new public debt is not constrained by possible default, the optimal policy response is to increase public borrowing to smooth consumption across periods without affecting investment in public infrastructure. However, when default on new debt is an issue, the government's second best response is to partially reduce public infrastructure spending relative to the no default case. This affects the region's attractiveness for firms in the long-run due to the durable goods nature of public infrastructure. In addition, the government responds with a cut in its business tax to partially make up for the loss in competitiveness. Conceptually, our analysis is in the spirit of Cai & Treisman (2005) who argue that asymmetries in certain jurisdictional characteristics may have a substantial effect on how these jurisdictions behave in fiscal competition and how they react to an increase in tax base mobility. In this regard, initial debt levels may constitute an important but so far largely neglected factor.

Our mechanism assumes a direct link between the choice of government borrowing and adjustment of public investment in infrastructure (and a public consumption good). In principle, the government could adjust alternative instruments, in particular taxes, to respond to a constraint on borrowing. While we do not explicitly consider other tax instruments than the tax on firms, we believe to capture an important mechanism, as long as other taxes cannot completely make up for the reduced borrowing. Empirically, this appears to be a reasonable approximation. For example, Trabandt & Uhlig (2013) report that shortly after the start of the economic and financial crisis in 2010 many industrialized countries were near the peaks of the Laffer curve regarding their labor income tax (while being further away with regard to their capital taxes). In addition, Servén (2007) shows evidence for fiscal rules that limit government borrowing or debt to reduce spending on public infrastructure. This observation is in line with a political economy explanation: Politicians reduce spending on durable goods like public infrastructure that has only long-term consequences in order to please voters.

Cursory evidence points to the relevance of the proposed channel. While most governments decreased corporate tax rates from 2002 to 2012, the cuts tend to be more substantial in countries with high levels of public debt at the beginning of the period. For example Greece and Cyprus, both highly indebted countries in 2002, had decreased their corporate tax rates by more than 40 percent by 2012. The debt-to-GDP ratios on the central government level in 2002 were 123 and 159 percent for Greece and Cyprus, respectively, and thus much higher than in most other countries. At the same time, economic activity has shifted in the wake of the crisis to less indebted countries like Germany.

The link between initial debt and fiscal competition is further strengthened when firm location choices become more flexible. This is a novel indirect effect which we identify in this paper. Specifically, an increase in capital mobility (by loosening firm attachment to a specific jurisdiction) does not only drive down tax rates on firms, a direct effect that is well known in the literature, but also tends to reinforce the impact of initial debt on fiscal competition. Thus higher initial debt levels are more problematic when international capital markets are more integrated.

Our analysis contributes also to the debate on the merits of fiscal decentralization (Besley & Coate, 2003; Oates, 2005; Janeba & Wilson, 2011; Asatryan *et al.*, 2015). Many countries consider or have recently devolved powers from higher to lower levels of government, including the right to tax mobile tax bases like capital (Dziobek *et al.*, 2011). In Germany, for instance, federal states (Länder) may be granted the right to supplement the federal income tax with a state specific surcharge. Critics often fear that devolving taxation power leads to “unfair” fiscal competition and may aggravate existing spatial economic inequalities if regions differ economically and fiscally. We provide a rigorous framework to analyze this concern and show that it is justified if initial debt levels are so high that the default constraint on government borrowing is binding.

In this context, we show that the origin of higher initial government debt matters, and thus we also complement the literature on the composition of public expenditure (e.g. Keen & Marchand, 1997). If higher legacy debt is the result of higher government consumption expenditure in the past - and thus less initial public infrastructure - the effect of legacy debt on fiscal competition is reinforced. Jurisdictions with high initial public debt and low public infrastructure become even more aggressive in subsequent tax competition. By contrast, if higher legacy debt is due to spending on initial public infrastructure the negative effect of legacy debt is mitigated and possibly overturned.

It is perhaps surprising that despite the large body of research on inter-jurisdictional competition in taxes (see Keen & Konrad, 2013) and public infrastructure investment (e.g. Noiset, 1995; Bucovetsky, 2005), the theoretical literature in this field has mostly ignored public debt levels as a factor in inter-jurisdictional competition for business investment. One possible reason is that in the absence of government default there is no obvious reason why governments cannot separately optimize public borrowing and fiscal incentives for private investment, thus precluding any interaction between the initial debt level and business taxes. This notion also underlies the results of more comprehensive general equilibrium models such as in Mendoza & Tesar (2005).[1] However, in the light of public defaults and a surge in policy measures, such as fiscal rules designed to limit deficits and government debt, unconstrained public borrowing is an unrealistic assumption for some jurisdictions.[2]

There are two exceptions. Arcalean (Forthcoming) analyzes the effects of financial liberalization on capital and labor taxes as well as budget deficits in a multi-country world linked by capital mobility. In contrast to our analysis, he focuses on endogenous budget deficits that are affected by financial liberalization because permanently lower tax rates on capital due to more intensive tax competition lead to higher capital accumulation. This in turn makes it attractive for the median voter, who is a worker by assumption, to bring forward the higher benefits of capital taxation through government debt. The mechanism works at the early stages of financial liberalization when capital taxes are relatively high.

Jensen & Toma (1991) show in a two-period, two-jurisdiction model that a higher level of first-period debt leads to an increase in taxation in the following period and a lower level of public good provision in that jurisdiction. In the other jurisdiction, either a higher or a lower tax rate is set depending on whether tax rates are strategic complements or substitutes.[3] The present paper differs from this setting in three important aspects: First, we allow for a default on government debt which endogenously limits the maximum level of public debt. Second, we introduce public infrastructure investment, which is shown to play a key role. Finally, we assume a linear within-period utility function, which allows us to abstract from the intra-period transmission mechanism identified by Jensen & Toma (1991).

The paper is structured as follows. In Section 2, we describe the model framework. We then proceed to the equilibrium analysis in Section 3, which contains the main results for the situation with symmetric countries. In Section 4, we consider asymmetries that are due

[1] Mendoza & Tesar (2005) show in a setting without borrowing constraints that legacy debt provides an incentive for large economies to use capital taxes to manipulate interest rates but does not directly affect tax competition.

[2] By "unconstrained" we mean that the government can borrow as much as it wants at the current interest rate assuming no default.

[3] An interesting empirical application for this model in the case of interactions in borrowing decisions can be found in Borck *et al.* (2015). Krogstrup (2002) also analyzes the role of government debt in an otherwise standard ZMW (Zodrow & Mieszkowski, 1986; Wilson, 1986) model of tax competition. Higher interest payments on exogenous public debt lead to lower spending on public goods and higher taxes, similar to Jensen & Toma (1991).

to differences in initial debt levels or initial public infrastructure. Section 5 provides the conclusion.

2 The Model

We start with a brief overview of the model. The world consists of two jurisdictions, $i = 1, 2$, linked through the mobility of a tax base. The tax base is the outcome of the location decisions of a continuum of firms and generates private benefits and tax revenues that are used by the government for spending on a public consumption good, a public infrastructure good, and debt repayment. Better infrastructure makes a jurisdiction more attractive, while taxes work in the opposite direction. The economy lasts for two periods. Both jurisdictions start with an initial (legacy) debt level b_{i0} and issue new debt in the first period in an international credit market at a given interest rate r. We pay particular attention to a government's willingness to repay its debt in period 2, which endogenously limits the maximum available credit.

The government is assumed to maximize a linear combination of the number of firms in its jurisdiction and the level of the public consumption good. There are two inter-temporal decisions for a government to be made in period 1: the level of borrowing and the spending on public infrastructure. The latter is modeled as a long-term decision to capture the durable good nature of infrastructure projects. Public investment is costly in period 1, but carries benefits only in period 2.

Fiscal competition has two dimensions: tax rate competition in periods 1 and 2, where governments set a tax on each firm in their jurisdiction, and competition in infrastructure spending. We consider a fiscal policy game between the two governments without commitment, that is, governments choose fiscal policy in each period non-cooperatively and cannot commit in period 1 to fiscal policy choices in period 2.

In our analysis, we first assume that jurisdictions are completely symmetric and consider an infinitesimal change in one jurisdiction's legacy debt. We later relax this assumption and allow for asymmetries with regard to the default payoff and initial infrastructure level.

2.1 Firms

We begin the description of the model with the location of the tax base, which follows a simple Hotelling (1929) approach.[4] In each period, there is a continuum of firms. Each firm chooses a jurisdiction to locate in. Firms are heterogeneous in terms of their exogenous bias towards one of the two jurisdictions, which is captured by the firm-specific parameter $\alpha \in [0, 1]$. They can switch their investment location between periods at no cost. Thus, in every period, a firm of type α receives a net benefit $\varphi_i(\alpha)$ in jurisdiction i given by

[4] Our model shares some features with classical models of tax competition as, for example, Zodrow & Mieszkowski (1986) and Wilson (1986). Our approach is analytically simpler to handle which is crucial in the in the presence of many government instruments including public infrastructure and government debt.

$$\varphi_i(\alpha) = \begin{cases} \psi + \alpha\nu + \rho q_i - \tau_i & \text{for } i = 1 \\ \psi + (1-\alpha)\nu + \rho q_i - \tau_i & \text{for } i = 2, \end{cases} \tag{1}$$

respectively. The terms $\psi + \alpha\nu$ and $\psi + (1-\alpha)\nu$ represent the exogenous returns received. The general return ψ is assumed to be sufficiently positive so that overall returns φ_i are non-negative and the firm always prefers locating in one of the two jurisdictions rather than not operating at all. The second component of the private return is the firm-specific return in each jurisdiction weighted by $\nu > 0$. The parameter ν allows us to capture the strength of the exogenous component relative to the policy-induced component. Variation in ν changes the degree of fiscal competition which we analyze below in more detail. The overall return to investment in a jurisdiction i further increases when the jurisdiction has a stock of public infrastructure in place at level $q_i \geq 0$. The effectiveness of public infrastructure is captured by the parameter $\rho \geq 0$ and is not firm-specific.[5] Finally, the uniform tax τ_i reduces the return. We assume that the tax is not firm-specific, perhaps because the government cannot determine a firm's type or, for administrative reasons, cannot choose a more sophisticated tax function.

Let $\alpha \in [0,1]$ be uniformly distributed on the unit interval. There exists a marginal firm of type $\tilde{\alpha}$ that is indifferent between the two locations for the given policy parameters, that is $\varphi_1(\tilde{\alpha}) = \varphi_2(\tilde{\alpha})$. Under the assumption that the marginal firm is interior, $\tilde{\alpha} \in (0,1)$,[6] the number of firms in each jurisdiction is then given by $N_1 = 1 - \tilde{\alpha}$ and $N_2 = \tilde{\alpha}$ or, more generally,

$$N_i(\tau_i, \tau_j, q_i, q_j) = \frac{1}{2} + \frac{\rho\Delta q_i - \Delta\tau_i}{2\nu}, \tag{2}$$

where $\Delta q_i = q_i - q_j$ and $\Delta\tau_i = \tau_i - \tau_j$. Note that the number of firms in a jurisdiction is a linear function of the tax and public infrastructure differentials which is a convenient property. In addition, the sensitivity of firm locations with respect to both tax rates and infrastructure spending depends on the parameter ν. Higher values of ν represent less sensitivity. Finally, firms split evenly between the two jurisdictions when both policies are symmetric across jurisdictions, that is $\Delta q_i = \Delta\tau_i = 0$.

2.2 Governments

A jurisdiction's government takes several decisions in each period. In both periods, it sets a uniform tax τ_{it} and provides a public consumption good g_{it}, which can be produced by transforming one unit of the private good into one unit of the public consumption good. In

[5] In principle, we could let the firm-specific component and the effectiveness of public infrastructure interact. This would lead to a less tractable framework, however, without providing additional insights for the purpose of our analysis.

[6] Similarly to Hindriks *et al.* (2008), we make this assumption to avoid the less interesting case of a concentration of all firms in one of the two jurisdictions.

the first period, the government pays back initial debt b_{i0} (no default by assumption), and decides on public infrastructure investment m_{it} as well as the level of newly issued debt b_{i1}. If the government honors the debt contract, b_{i1} is repaid in period 2.

Public investment raises the existing stock of public infrastructure q_{it}. In each period, a share $\delta \in [0,1]$ of q_{it} depreciates so that the law of motion for q_{it} is denoted by

$$q_{it} = (1-\delta)\, q_{it-1} + m_{it-1}. \tag{3}$$

In our two-period model, jurisdictions are endowed with an exogenous level of public infrastructure $q_{i0} = \bar{q}_i$ in period 1.[7] The cost for public infrastructure investment is denoted by c, which is an increasing function of m_i and strictly convex with $c'(m_i) > 0$, $c''(m_i) > 0$. To simplify notation, we suppress the time subscript in m_i, since it is effectively only chosen in period 1.

Using g_{it} and b_{it} to denote the quantity of the public consumption good provided and the debt level, respectively, in jurisdiction i in period t, the period-specific budget constraints for the government in $i = 1, 2$ can be stated as follows:

$$g_{i1} = \tau_{i1} N_{i1} - c(m_i) - (1+r)\, b_{i0} + b_{i1} \tag{4}$$

$$g_{i2} = \tau_{i2} N_{i2} - (1+r)\, b_{i1}. \tag{5}$$

In these expressions, the set of available revenue-generating instruments is limited to business taxes. In practice, governments may use a wide range of taxes, including levies on consumption and labor. In this paper, however, we focus explicitly on the taxation of capital to isolate the effect of legacy debt on tax competition for a mobile tax base and therefore ignore other forms of taxation. The underlying assumption for this approach is that governments have already exhausted their political and administrative capacity to tax immobile factors.

Government borrowing takes place on the international credit market at the constant interest rate r. Regarding the budget constraints shown above, we assume for the time being that government debt is repaid and therefore no default is considered. In our subsequent analysis, we pay attention to the possibility of default in period 2.[8]

Each government is assumed to maximize the discounted benefit arising from attracting firms and government spending on a public consumption good according to the following specification:

$$U^i = h_1(u_{i1}) + \beta h_2(u_{i2}) = h_1(N_{i1} + \gamma g_{i1}) + \beta h_2(N_{i2} + \gamma g_{i2}). \tag{6}$$

We think of (6) as the utility function of a representative citizen who benefits from attracting

[7] A jurisdiction's level of public infrastructure may be correlated with its initial level of government debt. We consider this aspect in Section 4.

[8] We ignore the possibility of bailouts, which have been relevant in the financial crisis in some cases, but go beyond the scope of this paper.

firms or capital because this generates private benefits such as income and employment. Here, we simply use the number of firms in jurisdiction i, N_i, as an indicator of this benefit. In addition, attracting firms increases the tax base and generates higher tax revenues. The marginal benefit of the public good, $\gamma > 1$, implicitly determines the relative weight attached to the private benefit and public consumption. The linear structure of the within-period utility function is in line with earlier literature (e.g. Brueckner, 1998) in order to solve for Nash tax rates explicitly. This assumption makes the model different from Jensen & Toma (1991) who assume a strictly concave function for the benefit of the public good (within the function h_2). As mentioned earlier, our approach is more tractable in the context of multiple government instruments and possible default on debt, and allows us to demonstrate the novel mechanism at work. β is the discount factor which we set equal to $\frac{1}{1+r}$. The intertemporal structure of the utility function assumes that the functions h_1 and h_2 are concave, and at least one of them is strictly concave. We assume this for h_1, such that $h_1' > 0$, $h_2' > 0$, $h_1'' < 0$, $h_2'' \leq 0$.

So far, we have implicitly assumed that public debt is repaid in both periods, such that creditors have no reason to restrict lending to the government. We now consider default on debt in period 2 through a willingness-to-pay constraint. A government honors the debt contract when the net benefit of defaulting is smaller than the net benefit of paying back the debt. While the former is related to the size of the existing debt level, the latter involves a loss of access to the international credit market and possibly other disturbances. The two-period time horizon allows us, similar to Acharya & Rajan (2013), to take a shortcut for modeling such disturbances. Default in period 2 causes a utility loss of size z in that period, representing the discounted value from being unable to borrow in the future. We denote the government's default decision with the binary variable $\kappa_i = \{0, 1\}$, where 0 stands for no default and 1 for default. Then the period 2 utility in jurisdiction i is given by

$$u_{i2} = N_{i2} + \gamma \left(\tau_{i2} N_{i2} - (1 - \kappa_i)(1 + r) b_{i1}\right) - \kappa_i z.$$

Two comments are in order. First, we do not model the default decision on government debt regarding initial (legacy) debt b_{i0} in period 1. Legacy debt levels may accumulate due to unforeseen shocks as in the recent European financial and economic crisis, or may play a role when switching to a more decentralized tax system (as is considered in the reform debate on fiscal federalism in Germany). Our assumption of repayment of legacy debt is reasonable if its size is small enough so that default in period 1 is not attractive. Even if a government default was attractive in period 1, it would not occur in equilibrium, since creditors would not have given any loans in the first place.[9]

In a second comment we like to highlight a particular modeling choice. In our model, the fixed interest rate and the binary government default decision are separated. Alternatively, one could assume that the interest rate on debt depends positively on the size of debt b_{i1},

[9]For completeness we have checked that there exists a set of sufficiently small initial debt levels that does not lead to default but still influences the subsequent choice of fiscal instruments.

which would have to be motivated by the risk of default. In that case the government would face an increasing marginal cost of borrowing. By contrast, in our model default prohibits any borrowing beyond a certain level. This approach has certain advantages in terms of tractability, but also captures explicitly that the rising cost of borrowing originates from the possibility of default.

2.3 Equilibrium

The equilibrium definition has two components. The economic equilibrium is straightforward, as this refers only to the location decision of firms. There is no linkage across periods because relocation costs for firms are zero. An economic equilibrium in period $t = 1, 2$ is fully characterized in Section 2.1 as a profit-maximizing location choice of each firm for given levels of taxes and infrastructure in that period.

The second component comprises the policy game between governments. We assume the following timing of events. In period 1, governments simultaneously decide on how much to invest (i.e. set m_i), set new debt b_{i1}, and choose the tax rate τ_{i1}, as well as, the public good g_{i1}, assuming that it pays back the legacy debt b_{i0}. Then firms decide where to invest. In period 2, governments simultaneously choose tax rate τ_{i2}, as well as the public good g_{i2}, and decide on the default of existing debt b_{i1}. Subsequently, firms again make their location choices. At all times, we assume that governments observe all previous decisions and no commitment is possible. We consider a sub-game perfect Nash equilibrium and solve the model by backward induction.

3 Results

3.1 Period 2

We begin with analyzing the government decision making in period 2. At that stage, a government decides on its tax rate, the public consumption good level and default, taking as given the policy choices of period 1, that is, the debt levels b_{i1} and the public infrastructure q_{i2} in both jurisdictions $i = 1, 2$. A period 2 Nash equilibrium is a vector of tax rates, public good levels and default decisions such that each government maximizes its period 2 sub-utility, taking the other government's fiscal policy decisions in that period as given.

Government i maximizes period 2 utility as given by equation (6). We analyze the tax and default decisions sequentially, making sure that in the end a global maximum is reached. We start with the choice of the tax rate, which affects the number of firms N_{i2}, given by (2) adding appropriate time subscripts. The first-order condition is given by

$$U^i_{\tau_{i2}} := \frac{\partial U^i}{\partial \tau_{i2}} = h_2' \frac{\partial \left(N_{i2}\left(1 + \gamma\tau_{i2}\right)\right)}{\partial \tau_{i2}} = 0. \tag{7}$$

For the period 2 decision the outer utility function h_2 can be ignored as long as $h_2' > 0$, which we assume. Solving the system of two equations (one for each jurisdiction) with two unknowns given by condition (7), we obtain τ_{12} and τ_{22}.[10]

Next, we analyze the default decision in period 2, holding tax rates in both jurisdictions constant. For this purpose, we need to compare the utilities under default and under no default, which defines a willingness-to-pay threshold b^{wtp} at which the government is indifferent:

$$\begin{aligned} u_{i2}\left(\kappa_i = 1\right) = u_{i2}\left(\kappa_i = 0\right) \Leftrightarrow & N_{i2} + \gamma N_{i2}\tau_{i2} - z = N_{i2} + \gamma\left(N_{i2}\tau_{i2} - b^{wtp}\left(1+r\right)\right) \\ \Leftrightarrow & b^{wtp} = \frac{z}{\gamma\left(1+r\right)}. \end{aligned}$$

If $b_{i1} > b^{wtp}$, a jurisdiction does not repay its debt as the benefits from default outweigh the related costs, and vice versa.[11]

The additive structure of the within period 2 utility allows us to separate the tax and default decisions. The government could choose a different tax rate in case of default than when honoring debt contracts. There is no incentive to do so, however, as tax rate choices are best responses that do not depend on default, as long as the level of public good provision is strictly positive, that is, tax revenue exceeds the repayment burden resulting from debt in period 1. The latter holds as long as the willingness-to-pay threshold is sufficiently strict, which requires a sufficiently small z.[12]

Taken together, the first-order conditions (7) and the willingness-to-pay condition define the government's optimal decision in period 2. Inserting these candidate tax rates into (2), we find the marginal firm to be of type $\tilde{\alpha} = \frac{1}{2} - \frac{\rho\Delta q_{i2}}{6\nu}$, from which we can derive the number of firms $N_{i2} = \frac{1}{2} + \frac{\rho\Delta q_{i2}}{6\nu}$. Note that $\Delta q_{i2} = \Delta q_{i2}\left(m_i, m_j\right) = \Delta\bar{q}_i\left(1-\delta\right) + \Delta m_i$ is a linear function of the inter-jurisdictional differences in existing public infrastructure $\Delta\bar{q}_i = \bar{q}_i - \bar{q}_j$ and additional investment in public infrastructure $\Delta m_i = m_i - m_j$. We summarize the results for period 2 in the following Proposition.

Proposition 1. *Let $2 > \gamma\nu > 1$. For given public infrastructure investment levels (m_1, m_2) and borrowing in period 1 (b_{i1}), there exists a unique Nash equilibrium for the period 2 fiscal policy game with*

[10] The second-order condition is fulfilled because N_{i2} is a linear function of tax rates and depends negatively on the own tax rate.

[11] b^{wtp} is identical across jurisdictions because they face the same z. Heterogeneous utility losses in case of default would imply heterogeneous willingness-to-pay thresholds, an asymmetry which we address in Section 4.

[12] When inserting b^{wtp} as the maximum debt level for b_{i1} into (5), it becomes obvious that $g^*_{i0} > 0 \Longleftrightarrow \frac{z}{\gamma} < \tau^*_{i2}N^*_{i2}$.

$$\tau_{i2}^{*}\left(m_i, m_j\right) = \nu + \frac{\rho \Delta q_{i2}}{3} - \frac{1}{\gamma},$$

$$\kappa_i^{*}\left(b_{i1}\right) = \begin{cases} 0 & \textit{if } b_{i1} \leq b^{wtp} \\ 1 & \textit{if } b_{i1} > b^{wtp} \end{cases}$$

$$g_{i2}^{*}\left(m_i, m_j, b_{i1}\right) = \tau_{i2}^{*} N_{i2}^{*} - (1-\kappa^{*})(1+r)b_{i1},$$

and the number of firms in i given by $N_{i2}^{*}\left(m_i, m_j\right) = N_{i2} = \frac{1}{2} + \frac{\rho \Delta q_{i2}}{6\nu}$ *where* $\Delta q_{i2} = \Delta \bar{q}_i \left(1-\delta\right) + \Delta m_i$*.*

Proposition 1 has several interesting implications. First, the equilibrium tax rate of jurisdiction i increases with the value of the gross location benefit ν, the own investment in infrastructure m_i and the marginal benefit of the public good γ, while the tax rate decreases with infrastructure spending by the other government m_j. Better infrastructure provides more benefits to firms that are partially taxed. The tax rate is positive if ν and γ are sufficiently large ($\gamma\nu > 1$). Moreover, any divergence in tax rates stems solely from differences in public infrastructure, Δq_{i2}. Second, the average tax rate across jurisdictions $\bar{\tau}_2 = \frac{\tau_{12}^{*}+\tau_{22}^{*}}{2} = \nu - \frac{1}{\gamma}$ is independent of public infrastructure levels, as the terms involving public infrastructure offset each other, but decreases when the general location benefit ν declines, making firms more sensitive to policy differences.

3.2 Period 1

When analyzing the Nash equilibrium in period 1, we first abstract from any confounding asymmetries and consider an infinitesimal change in the initial debt level b_{i0}, starting from a symmetric equilibrium. In particular, we let initial levels of public infrastructure be the same ($\bar{q}_i = \bar{q}_j$). Furthermore, jurisdictions are symmetric with respect to the willingness-to-pay condition, that is, it is either binding in both jurisdictions or in neither of the two. We relax both symmetry assumptions below.

Beginning with the second stage of period 1, we note that firms choose their location in the same way as in period 2 because location decisions are reversible between periods at no cost. In the first stage of period 1, fiscal policy is determined. Recall that we assume that default on debt from period 0 is not an issue because legacy debt is sufficiently small. However, new borrowing in period 1 is constrained by default in period 2. Proposition 1 shows that a government defaults when its debt level exceeds b^{wtp}. Therefore, no lender gives loans above this threshold. We thus have an upper limit on borrowing in the form of a willingness-to-pay condition which is defined as follows.

Condition 1 (Willingness-to-pay Condition). $b_{i1} \leq b^{wtp} = \frac{z}{\gamma(1+r)}$.

The advantage of Condition 1 is its simplicity as it does not depend on earlier public investment decisions or the level of existing debt.

Let us denote by b_{i1}^{des} the desired level of borrowing in period 1 if the default problem in period 2 is ignored. If utility is strictly concave in b_{i1}, and assuming an interior level of the public consumption good, the optimal period 1 debt is given by

$$b_{i1}^{*} = \min \left\{ b_{i1}^{des}, b^{wtp} \right\}.$$

We now consider two separate cases. First, we assume that the willingness-to-pay condition is not binding in either of the jurisdictions. The assumption is correct if, for example, the cost of punishment (z) in the form of a loss of access to credit and thus b^{wtp} is very large, so that $b_{i1}^{*} = b_{i1}^{des} < b^{wtp}$. In this case we can derive and use the first-order conditions for all fiscal variables in period 1, taking into account the variables' impact on period 2 equilibrium values. In a second step, we turn to the case where Condition 1 is binding in both jurisdictions, that is $b_{i1}^{*} = b^{wtp}$. A government's set of first-order conditions is reduced by one if the jurisdiction is constrained in its borrowing (or more precisely, the first-order condition for b_{i1} does not hold with equality). To illustrate the working of the model and to check the consistency of the results, we complement the general analysis by a numerical example based on quasi-linear utility functions in Appendix A.4.

Case I: The Willingness-to-pay Condition is not binding in both jurisdictions

After inserting budget constraints, government i solves the following maximization problem

$$\begin{aligned} \max_{\tau_{i1}, m_i, b_{i1}} U^i = & \, h_1 \left(N_{i1} + \gamma \left(\tau_{i1} N_{i1} - c - (1+r) \, b_{i0} + b_{i1} \right) \right) \\ & + \beta h_2 \left(N_{i2}^{*} + \gamma \left(\tau_{i2}^{*} N_{i2}^{*} - (1+r) \, b_{i1} \right) \right) \text{ s.t. } g_{i1} \geq 0, \, m_i \geq 0. \end{aligned} \tag{8}$$

As before, we implicitly assume a positive level of public good provision $g_{i1} \geq 0$.[13] The values for period 2 (τ_{i2}^{*}, κ^{*}, N_{i2}^{*}) as given in Proposition 1 are correctly anticipated. Condition 1 ensures that debt contracts are always honored, as shown in expression (8). The first-order conditions for $i = 1, 2$ are

$$\frac{\partial U^i}{\partial \tau_{i1}} = h_1' \frac{\partial \left(N_{i1} \left(1 + \gamma \tau_{i1} \right) \right)}{\partial \tau_{i1}} = 0, \tag{9}$$

$$\frac{\partial U^i}{\partial m_{i1}} = -h_1' \gamma c' + \beta h_2' \frac{\partial \left(N_{i2} \left(1 + \gamma \tau_{i2} \right) \right)}{\partial m_i} = 0, \tag{10}$$

$$\frac{\partial U^i}{\partial b_{i1}} = \gamma h_1' - \beta \gamma (1+r) h_2' = h_1' - h_2' = 0. \tag{11}$$

[13]The relevant parameter restriction depends on the functional form of U^i. For example, if U^i is quasi-linear, that is $h_2'' = 0$, one obtains $g_{i1}^{*} = \frac{1}{2\gamma} > 0$ in equilibrium, which makes public good provision always positive.

In the first-order condition (11), we make use of the assumption $\beta = \frac{1}{1+r}$. We derive the full set of second-order conditions in Appendix A.1.[14] Note that U^i is strictly concave in b_{i1}, as long as at least one of the two functions h_1 or h_2 is strictly concave.

We solve the system of six first-order conditions (three for each jurisdiction) as follows: Assuming that public consumption good levels are strictly positive, the first-order conditions for tax rates (9) for both jurisdictions are independent of infrastructure investment as well as debt levels, and can be solved separately in a similar way as above in period 1, yielding

$$\tau_{i1}^* = \nu - \frac{1}{\gamma},\ N_{i1}^* = \frac{1}{2}. \tag{12}$$

Since by assumption the public infrastructure differential is zero in period 1, the tax base is split in half between the two jurisdictions. As in period 2, the more footloose firms are (i.e. the lower ν is), the lower are equilibrium tax rates. This corresponds to the standard result that increasing capital mobility drives down equilibrium tax rates.

Using the condition for period 1 borrowing (11), $h_1' = h_2'$, we can simplify the condition for optimal infrastructure investment (10) to $\frac{\partial(\beta N_{i2}^*(1+\gamma\tau_{i2}^*))}{\partial m_i} = \gamma c'$. We use the period 2 equilibrium values to obtain

$$c'(m_i) = \frac{\beta\rho}{3}\left(1 + \frac{\rho\Delta m_i}{3\nu}\right). \tag{13}$$

A symmetric equilibrium $m_i = m_j = m^*$ always exists. It is unique if the cost function for public infrastructure c is quadratic because then the first-order conditions are linear. Asymmetric equilibria may exist though.[15] The combined results from the first-order conditions for taxes and infrastructure spending can now be used to determine the optimal borrowing level, as all other variables entering the arguments of h_1 and h_2 are determined via (10) and (11).

An interesting property of (13) is that it is independent of the initial debt level which leads us to our first important neutrality result: The choice of m_i is not affected by b_{i0} if the willingness-to-pay condition is not binding. We summarize our insights from the equilibrium under non-binding debt constraints in the Proposition below.

Proposition 2. *Let $2 > \gamma\nu > 1$. Assume Condition 1 is not binding in both jurisdictions and initial public infrastructure levels are symmetric $\bar{q}_i = \bar{q}_j$.*

a) A subgame perfect Nash equilibrium with symmetric infrastructure spending exists, in which tax is $\tau_{i1}^* = \nu - \frac{1}{\gamma}$ and infrastructure spending and first period borrowing are implicitly given by $c'(m^*) = \frac{\beta\rho}{3}$ and condition (11), respectively.

[14] The second-order conditions are always satisfied if U^i is quasi-linear (i.e. $h_1'' > 0$, $h_2'' = 0$) and the cost function for infrastructure investment is sufficiently convex.

[15] For example, a corner solution with one jurisdiction not investing at all exists if $c(m_i) = \frac{m_i^2}{2}$ and $2\beta\rho^2 > 9\nu > \beta\rho^2$. The first inequality ensures that one jurisdiction cannot benefit from infrastructure investment, while the second inequality makes sure that the jurisdiction finds a positive level of infrastructure $m_i^* = \frac{3\beta\rho\nu}{9\nu-\beta\rho^2}$ optimal.

b) Changes in a jurisdiction's legacy debt (b_{i0}) affect its period 1 borrowing and its period 2 public consumption good, but do not affect fiscal competition (tax rates and public infrastructure), and thus leave firm location decisions in both periods unaffected.

c) A decrease in ν (i.e. firms become more footloose) lowers tax rates in both periods.

Underlying the neutrality result with respect to legacy public debt is a straight-forward intuition. When governments can choose their desired borrowing level, the initial debt levels have no effect on fiscal competition in taxes and additional public infrastructure spending. The unconstrained decision on period 1 debt leads to the equalization of marginal utilities across periods. The infrastructure spending decision then equalizes the benefits and costs from induced changes in public good consumption in periods 1 and 2. The result can be viewed as a neutrality theorem with respect to inter-temporal aspects of fiscal competition,[16] which may explain why the existing literature has not much addressed the link between fiscal competition and public legacy debt. However, endogenous constraints on borrowing change this conclusion.

Case II: The Willingness-to-pay Condition is binding in both jurisdictions

We now turn to the case where Condition 1 is binding in the two jurisdictions. In this scenario, a jurisdiction would like to run a higher debt level than lenders are willing to provide, as the latter correctly anticipate the default problem in period 2, that is $b_{i1}^{des} > b^{wtp}$. In equilibrium, the first-order condition for period 1 debt (11) does not hold with equality. Instead the optimal borrowing level equals the maximum feasible level given by b^{wtp} due to the strict concavity of U^i with respect to b_{i1}. Condition (9) still holds and together for both jurisdictions the two conditions determine the Nash tax rates in period 1, which are identical to Case I. As before, we assume that the level of the public consumption good is positive and thus an interior solution is obtained. In this case, legacy debt does not affect period 1 taxes.

We are left with the two jurisdictions' first-order conditions for public infrastructure investment (10). The absence of condition (11), however, now implies that the marginal utilities in periods 1 and 2 are not equalized, that is, one may have $h_1' \neq h_2'$. In particular, h_1' in (10) depends on the level of infrastructure investment. This is the key difference to Case I.

We are interested in the effect of legacy debt on fiscal competition, that is period 2 taxes and public infrastructure. We cannot solve explicitly for public investment levels, as the two conditions are nonlinear functions of m_i and m_j and thus examine comparative statics by totally differentiating the first-order conditions for public infrastructure.[17] The sign of the comparative static effects can be partially determined when we assume that the Nash

[16] Note that we abstract from inefficiencies in the public good provision and thus ignore the intra-period transmission channel highlighted by Jensen & Toma (1991) to focus on the inter-temporal effect of initial public debt.

[17] This is a legitimate approach if we have an interior solution for the public consumption good and the tax rates for period 1 are determined in isolation from the other relevant first-order conditions.

equilibrium is stable, as suggested by Dixit (1986). In this case, the sign of the own second-order derivative regarding infrastructure spending is negative, $\frac{\partial^2 U^i}{\partial m_i^2} < 0$, and importantly, the direct effects dominate the indirect effects, that is $\frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 U^j}{\partial m_j^2} > \frac{\partial^2 U^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j}$. A detailed derivation of the comparative statics is relegated to Appendix A.2. Making use of the Dixit (1986) stability assumptions, we obtain

$$\frac{\mathrm{d}m_i}{\mathrm{d}b_{i0}} = -\frac{1}{\phi}\frac{\partial^2 U^j}{\partial m_j^2}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} < 0, \tag{14}$$

$$\frac{\mathrm{d}m_j}{\mathrm{d}b_{i0}} = \frac{1}{\phi}\frac{\partial^2 U^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} \gtreqless 0, \tag{15}$$

with $\phi = \frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 U^j}{\partial m_j^2} - \frac{\partial^2 U^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j} > 0$ and $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} = h_1''\frac{\gamma^2}{\beta}c' < 0$. The latter inequality means that the incentive to invest in infrastructure declines with higher legacy debt, as the marginal utility of consumption rises when $h_1'' < 0$. Thus, solution (14) contains our second important result: An increase in legacy debt in jurisdiction i leads unambiguously to a decline in infrastructure investment in i. The effect of i's legacy debt on the infrastructure investment in the other jurisdiction is less clear cut and depends on the functional form of the utility. Furthermore, since $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}$ depends on ν, capital mobility clearly affects the size of the effect of legacy debt on public infrastructure investments. We summarize these results in the following proposition and discuss them in detail below.

Proposition 3. *Let $2 > \gamma\nu > 1$. Assume that jurisdictions are constrained in their borrowing decision in period 1 and initial public infrastructure levels are symmetric $\bar{q}_i = \bar{q}_j$.*

a) If the Nash equilibrium in infrastructure spending is stable, an increase in jurisdiction i's legacy debt (b_{i0}) leads to a decline in infrastructure investment (m_i) and also reduces i's period 2 tax rate (τ_{i2}). In the other jurisdiction j, it raises the tax rate (τ_{j2}) and, assuming quasi-linear preferences, increases infrastructure spending in j (m_j). As a consequence, more firms locate in the less indebted region j than in i.

b) A decrease in ν (i.e. firms become more footloose) lowers tax rates in both jurisdictions in both periods. In addition, if $h_1''' > 0$, higher ν increases the negative effect of legacy debt on the public investment level and period 2 tax rates.

The interaction of public infrastructure investment and tax setting both within jurisdictions and over time, as well as, between competing governments implies that an increase in legacy debt in one jurisdiction affects various fiscal policy instruments. Table 1 summarizes these effects for unrestricted (Case I) and restricted (Case II) public borrowing in period 1.

The main reason for the negative effect of legacy debt b_{i0} on public investment m_i is that borrowing cannot be increased to smooth consumption if the willingness-to-pay condition is binding. The burden from higher legacy debt falls *ceteris paribus* on period 1 and raises the marginal utility of consumption in period 1, thus making a transfer of resources from period 2 to period 1 more desirable. Because higher government debt is impossible, a

Table 1: Change in Legacy Debt (b_{i0}), Impact on Fiscal Policy

Willingness-to-pay Condition	Jurisdiction i ($db_{i0} > 0$)				Jurisdiction j ($db_{j0} = 0$)			
	Period 1		Period 2		Period 1		Period 2	
	m_i	b_{i1}	τ_{i2}	N_{i2}	m_j	b_{j1}	τ_{j2}	N_{j2}
Case I (non-binding)	-	$\uparrow$	-	-	-	-	-	-
Case II (binding)	$\downarrow$	-	$\downarrow$	$\downarrow$	$\uparrow$ ($\downarrow$)	$\uparrow$ ($\downarrow$)	$\uparrow$	$\uparrow$

second best government response is to reduce investment in public infrastructure in that jurisdiction. This in turn lowers spending in period 1 and increases the space for public good consumption.

How the other jurisdiction j reacts to a change in b_{i0} depends on the strategic interaction of public infrastructure investment. If public investments are strategic substitutes[18] jurisdiction j reacts to jurisdiction i's decrease in m_i with an increase in m_j. Such an unambiguous result is, for example, obtained if we assume that the inter-temporal utility function is of the quasi-linear type, that is, $h_2'' = 0$. In this case $\frac{\partial^2 U^j}{\partial m_j \partial m_i}$, which is the change in the net benefit of public infrastructure investment in one jurisdiction if the government in the other jurisdiction invests more (or less), is negative.

A divergence occurs also in the period 2 tax equilibrium. Starting in a symmetric situation (i.e. with equal legacy debt and infrastructure levels), an increase in a jurisdiction's initial debt leads to a lower tax rate for this jurisdiction in period 2, while the opposite holds in the other jurisdiction. The latter can now afford a higher tax because the better relative standing in public infrastructure partially offsets higher taxes. Legacy debt therefore affects fiscal competition when a government is constrained in borrowing.

The second part of Proposition 3 refers to the impact of capital mobility. As in the case with no restriction on public borrowing, higher capital mobility, captured by a decrease in ν, puts downward pressure on equilibrium tax rates. However, in addition to this direct effect, an additional indirect effect from capital mobility arises when public borrowing in period 1 is restricted. Intuitively, higher capital mobility reduces the government's revenue from taxing firms in period 1. This makes the government even more sensitive in period 1 to increases in legacy debt. It becomes even less attractive to shift resources to the future by investing in public infrastructure. Consequently, a government sets an even lower tax rate in period 2. Analytically, by affecting the level of tax rates in period 1, ν changes $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}$. In particular, $\frac{d}{d\nu}\left(\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}\right) = h_1'''\,(1+r)\,\gamma^3 c'$ is positive if and only if $h_1''' > 0$, which holds for several strictly concave functions.

It is interesting to put our main results in the context of the scarce literature on tax competition and public debt. As noted in the introduction, Arcalean (Forthcoming) is close to but different from our work. In his model government, debt is always repaid. Financial

[18] This a standard feature in fiscal competition models (e.g. Hindriks *et al.*, 2008). For a discussion on the role of public inputs in fiscal competition, see Matsumoto (1998).

liberalization puts pressure on tax rates which in turn leads to more capital accumulation. The gains from an increase in future tax bases can be brought forward through higher initial budget deficits. This incentive works because the median voter, who by assumption is a worker with labor income only, redistributes income through capital taxation to herself intra-temporally and through debt intertemporally. In our paper, we emphasize the role of initial (legacy) debt and focus on a different inter-temporal mechanism through investment in public infrastructure. Our results can also be related to Jensen & Toma (1991), who show that period 1 debt affects period 2 capital tax rates even in the absence of default. While the models are different in some other aspects, the linear within-period utility function in our model drives this difference. Our simplifying assumption is useful in order to clearly identify the role of default which we obtain by comparing the results from Case I and Case II, respectively.

4 Asymmetries

So far, we have assumed that jurisdictions differ only in the level of legacy debt and are completely symmetric otherwise. This is a convenient approach, since it allows us to isolate the effect of initial public debt differentials from other confounding asymmetries that are unrelated to government debt. However, structural differences between countries are interesting and relevant. They could either affect the impact of legacy debt differentials on the fiscal competition game, or structural differences could be a consequence of differentials in legacy debt which in turn feed back into fiscal policy.

An example for the former is jurisdictional heterogeneity in the consequences of government default. Jurisdictions which are more dependent on external credit provision can convince potential lenders more easily that they are willing to repay the debt to keep their access to the credit market. Alternatively, jurisdictions may differ in their vulnerability to shocks following a default decision. In our model, this implies that jurisdictions face different levels of z. If these differences are large enough, one jurisdiction may face a binding willingness-to-pay condition while the other can freely chose public debt in period 1.

A potential feed-back mechanism of legacy debt differentials may occur if these are related to differences in initial infrastructure levels, $\bar{q}_i \neq \bar{q}_j$. An asymmetric level of initial public infrastructure has two implications. First, *ceteris paribus* it causes the better endowed and thus generally more attractive jurisdiction to set higher taxes because its better infrastructure offsets weaker tax conditions. This effect takes place in period 1, and also in period 2 if public infrastructure does not fully depreciate ($\delta < 1$). Second, asymmetric equilibria in the tax competition game feed into the inter-temporal fiscal variables. A higher level of public infrastructure attracts more firms, which in turn raises the incentive for additional public infrastructure spending. More public infrastructure investment also raises the level of desired public borrowing in period 1, b_{i1}^{des}, both in order to compensate for an otherwise lower public good provision in that period, and because the better endowed jurisdiction intertemporally shifts part of the benefits from a higher level of period 2 tax revenues to period 1. A higher level of existing public infrastructure thus improves a jurisdiction's position in the subsequent fiscal competition game. This relates to the polarization effect described by Cai & Treisman (2005). Of particular interest for our analysis is the situation in which the initial asymmetry in public infrastructure is directly related to legacy debt. Public debt that results from large public infrastructure investments in the past has a different impact on the subsequent fiscal competition game than one that has mostly been caused by public consumption.

In the following, we discuss the implications of each of the asymmetries described above for our results. We summarize the main findings and relegate a more formal derivation to the Appendix.

4.1 Heterogeneous Consequences of Government Default

We first analyze differences in the damage faced by a jurisdiction that opts for default on period 1 debt. In particular, we let $z = z_i$ differ between jurisdictions and assume that this difference is large enough such that Condition 1 is binding in jurisdiction i, but not in j. Then, after substituting the government budget constraint in period 1 into the objective function, as before, the Nash equilibrium is characterized by five first-order conditions, two for i (w.r.t. m_i and τ_i) and three for j (w.r.t. m_j, τ_j and b_{j1}). The two first-order conditions for the tax rates in period 1 can still be solved separately.

While we cannot explicitly solve the remaining first-order conditions, we can undertake comparative static analysis with respect to the legacy debt levels. In Appendix A.3, we show that the case where Condition 1 is only binding in one jurisdiction can be treated as a combination of Cases I and II.[19] There are three important implications. First, an increase in legacy debt in jurisdiction i leads to opposite effects on infrastructure investment in the two jurisdictions. Second, the effects of such an increase on period 1 debt and infrastructure investment in the unconstrained jurisdiction j go in the same direction: j spends more on public infrastructure and borrows more at the same time. Finally, a change in legacy debt in jurisdiction j is neutral with regard to fiscal competition, as in Case I. The unconstrained jurisdiction can still shift resources across periods as it desires. Therefore, the marginal cost of increasing public infrastructure spending in period 1 depends only on the cost function $c(m)$, but not on the level of borrowing. The main insight from Case II carries over: An increase in legacy debt in a jurisdiction that faces a binding constraint in public borrowing leads to a decrease in period 2 tax rates of this jurisdiction.

[19]Note that this setting has some similarities with the one analyzed by Bolton & Scharfstein (1990) where financially unconstrained firms enjoy a strategic advantage because their "deeper pockets" allow them to out-spend their competitors with credit constraints.

4.2 Asymmetries in Initial Public Infrastructure

We now allow for an additional asymmetry in initial infrastructure ($\bar{q}_i \neq \bar{q}_j$) that is caused by legacy debt differentials. In particular, let us suppose that the initial level of public infrastructure is a function of legacy debt,

$$\bar{q}_i = f(b_{i0}). \tag{16}$$

Intuitively, there are two forms in which such a relation appears reasonable. For example, Poterba (1995) points out that the possibility of debt financing of public investment spending can make it easier to obtain support for government investment projects as they appear less costly to the public. Thus, if higher legacy debt levels are an indicator of more public infrastructure spending in the past, the relationship is positive, that is, $f' > 0$. High legacy debt levels may, however, also be caused by excessive public consumption spending. In this case, the level of existing infrastructure may be negatively related to the observed legacy debt, and therefore $f' < 0$.

Inserting (16) into our model, we analyze the equilibria for Cases I and II. An increase in legacy debt now affects the marginal utility of public infrastructure investment not only by raising the repayment burden in period 1, as shown before, but also through a change in initial infrastructure investment. For the latter channel to be relevant in our framework, it must dominate the main effect described in Proposition 3. We can clearly sign the effect of initial public infrastructure if an increase in $\bar{q}_i$ raises the marginal utility of infrastructure investment in period 1. In Appendix A.5 we show that the latter holds if the inter-temporal utility function is quasi-linear.[20] We assume this in the following in order to focus on an interesting and novel effect arising from asymmetry. In addition we make a further assumption.

Assumption 1. *An increase in initial public infrastructure $\bar{q}_i$ raises the marginal utility of public infrastructure investment in period 1 at a rate greater in magnitude than the coinciding marginal change in the repayment burden.*

Under Assumption 1 it is straightforward to show that the negative effect of an increase in initial public debt on infrastructure investment in period 1 is reinforced when there is a negative relationship between legacy debt and initial public infrastructure ($f' < 0$). For the more interesting case when a higher level of legacy debt implies that a government has invested more in public infrastructure in the past, we summarize our findings in the following Proposition.

Proposition 4. *Let existing public infrastructure be a continuously differentiable function of legacy debt, $\bar{q}_i = f(b_{i0})$, and initial debt be positively related to initial public infrastructure*

[20]Quasi-linear preferences simplify the derivation because this assumption ensures that more initial infrastructure installments always increases the benefit of additional public investment.

, $f' > 0$. *Under Assumption 1, a rise in jurisdiction i's legacy debt* (b_{i0}) *leads to an increase in i's infrastructure investment* (m_i) *and period 2 tax rate* (τ_{i2}).

Note that our finding in the Proposition is independent of Condition 1, as it holds in Cases I and II. Different mechanisms apply in each situation however. If legacy debt has no effect on inter-temporal redistribution (Case I), only the polarization effect of public infrastructure spending is present. This implies in the case of unrestricted public borrowing that the choice of m_i is no longer independent onb_{i0}, but is indirectly linked to it through $\bar{q}_i$. If higher legacy debt is associated with more public investment in the past ($f' > 0$), then higher b_{i0} leads to more infrastructure spending in period 1.[21]

Inter-temporal considerations are relevant, however, if public borrowing is restricted (Case II). In addition to the polarization effect, the government's incentive to redistribute between periods is affected. Under Assumption 1, both effects work in the same direction. To illustrate this point, assume that high legacy debt indicates a higher level of public infrastructure in the past. The jurisdiction with a higher initial debt level faces a weaker incentive to redistribute resources to period 1 because the coinciding higher level of existing public infrastructure also implies more tax revenue in period 1. As a consequence, the government chooses a higher level of new infrastructure spending and also taxes more in period 2. In general, the additional asymmetry may mitigate the effect described in Proposition 3. Under Assumption 1, the sign of the effect is even reversed. We illustrate this qualitative finding in a numerical example in the Appendix.

The intuition behind the result stated in Proposition 4 is that public debt is not a structural problem as long as a government uses the funds from borrowing to generate higher revenues in a later period (by effectively improving public infrastructure). Yet, we note that even in case of favorable environment where initial debt and initial infrastructure are positively correlated, the mechanism described in Proposition 3 is still present and not necessarily overturned. A higher repayment burden in period 1 always incentivizes inter-temporal redistribution either via additional borrowing or lower infrastructure spending and thus has implications for public investment and tax policy in period 2.

5 Conclusion

In this paper, we have used a two-jurisdiction, two-period model to analyze a fiscal competition game with asymmetric initial public debt levels. We first show that, with unlimited government borrowing, the level of legacy public debt does not affect the fiscal competition game. Governments merely shift the repayment burden to future generations by increasing additional borrowing one by one. We then allow for government default which endogenously imposes an upper bound on public debt. This restricts inter-temporal redistribution of governments and provides an important theoretical link between legacy debt and fiscal

[21] This result is formalized in condition (A.15) in the Appendix.

competition.

We show that in the presence of restricted public borrowing the government's decision on long-term infrastructure investment is shaped by its desire to optimally allocate resources between periods. A higher level of legacy debt causes the government to decrease public investment in the first period, making the jurisdiction a less attractive location for private investment in the following period. Governments partly compensate this disadvantage by setting lower tax rates in the second period. In our two-jurisdiction model, the more indebted jurisdiction (in terms of legacy debt), therefore, invests less and sets a lower tax on capital. Under mild assumptions, this mechanism is the stronger the higher is the level of capital mobility. Capital mobility, therefore, leads not only to downward pressure on tax rates, as is well known from the literature, but tends to reinforce the effect of initial debt.

Besides developing a theoretical framework for the analysis of fiscal competition in the presence of government debt levels, the theoretical results might be helpful in providing clearer predictions for the empirical analysis of fiscal competition. In particular, our findings suggest a link between the heterogeneity of debt levels and the variation in taxes on mobile tax bases. In the sense of Cai & Treisman (2005), debt levels constitute a potential source of initial asymmetry that may induce an asymmetric equilibrium in the fiscal competition game. In particular, larger differences in debt levels across jurisdictions are expected to lead to tax divergence which is reinforced by greater capital mobility.

This result also provides important insights into current policy debates. For example, in Germany the federal states (Länder) have little tax autonomy. Some policy makers and many academics strongly support more tax autonomy for states (income tax, business tax). Given that states differ widely in existing debt levels, it is not clear whether and how existing debt would influence the competitiveness in a subsequent fiscal competition game. Our model suggests that default on government debt might play a crucial role. If states gain not only more tax autonomy, but also obtain more responsibility for ultimately balancing their budget, initial debt levels matter.

On the other hand, inter-jurisdictional harmonization efforts in the area of business taxation may prove difficult as long as there are great differences in public debt levels. The problem is that jurisdictions with a high debt repayment burden may have very different fiscal policy strategies than governments with a low level of consolidation requirement.

We believe that our work contributes to clarifying the effect of government debt on fiscal competition. While we consider our mechanism to be relevant, it is by no means the only channel through which public debt may matter. In an interesting complementary work, Arcalean (Forthcoming) considers the link between tax competition and endogenous debt levels, both as functions of the degree of financial liberalization. In contrast to his work, we emphasize the role of default which appears to be relevant in many situations. Following our approach, future work could consider the effects of bailouts when default occurs, or the effect of fiscal rules that are currently widespread. Both of these extensions would add more realism to the analysis.

Throughout our analysis we have focused on the positive aspects of changes in capital mobility and legacy debt. Normative issues are clearly relevant. However, the current model is probably not ideal for analyzing welfare. For example, the total number of firms is fixed and thus independent of tax rates and public infrastructure. This appears quite special, but the setup turns out to be tractable this way. Future work should also address the welfare implications of fiscal competition when government debt matters.

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Appendix

A.1 Second-Order Conditions for Case I

The Hessian for the system of first-order conditions (9) to (11) for jurisdiction i is given by

$$H = \begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i^2} & \frac{\partial^2 U^i}{\partial \tau_{i1} \partial m_i} & \frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} \\ \frac{\partial^2 U^i}{\partial m_i \partial \tau_i} & \frac{\partial^2 U^i}{\partial \tau_{i1}^2} & \frac{\partial^2 U^i}{\partial b_{i1} \partial \tau_i} \\ \frac{\partial^2 U^i}{\partial m_i \partial b_{i1}} & \frac{\partial^2 U^i}{\partial \tau_{i1} \partial b_{i1}} & \frac{\partial^2 U^i}{\partial b_{i1}^2} \end{pmatrix} = \begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i^2} & 0 & \frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} \\ 0 & \frac{\partial^2 U^i}{\partial \tau_{i1}^2} & 0 \\ \frac{\partial^2 U^i}{\partial m_i \partial b_{i1}} & 0 & \frac{\partial^2 U^i}{\partial b_{i1}^2} \end{pmatrix}$$

In the second term, we insert the first-order condition for taxes (9) to verify that $\frac{\partial^2 U^i}{\partial m_i \partial \tau_i} = -h''_{i1} \frac{\partial (N_{i1}(1+\gamma\tau_{i1}))}{\partial \tau_{i1}} \gamma c' = 0$ and $\frac{\partial^2 U^i}{\partial b_{i1} \partial \tau_i} = \gamma h''_{i1} \frac{\partial (N_{i1}(1+\gamma\tau_{i1}))}{\partial \tau_{i1}} = 0$. For (9)-(11) to yield a maximum, H must be negative definite which is the case if and only if

$$\frac{\partial^2 U^i}{\partial m_i^2} = h''_{i1} (\gamma c')^2 - h'_{i1} \gamma c'' + \beta h''_{i2} \left(\frac{\partial N_{i2} (1 + \gamma \tau_{i2})}{\partial m_i} \right)^2 + \beta h'_{i2} \frac{\gamma \rho^2}{9\nu} < 0, \tag{A.1}$$

$$\frac{\partial^2 U^i}{\partial m_i^2} \frac{\partial^2 U^i}{\partial \tau_{i1}^2} > 0, \tag{A.2}$$

$$\frac{\partial^2 U^i}{\partial \tau_{i1}^2} \left(\frac{\partial^2 U^i}{\partial m_i^2} \frac{\partial^2 U^i}{\partial b_{i1}^2} - \left(\frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} \right)^2 \right) < 0. \tag{A.3}$$

Condition (A.1) is fulfilled for any sufficiently convex public investment cost function c. In particular, noting from (11) that $h'_{i2} = h'_{i1}$, we know that $c'' > \frac{\beta\gamma\rho^2}{9\nu}$ is a sufficient condition for (A.1) to be satisfied. This relation holds for a wide range of parameters and functional forms that includes the quasi-linear case which we explore in our numerical example (see Appendix A.4). Since $\frac{\partial^2 U^i}{\partial \tau_{i1}^2} = -h'_{i1} \frac{\gamma}{\nu} < 0$, (A.2) must hold whenever (A.1) holds. Furthermore, note that $\frac{\partial^2 U^i}{\partial b_{i1}^2} = \left(h''_{i1} + \frac{1}{\beta} h''_{i2} \right) \gamma < 0$ and $\frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} = -\gamma^2 h''_{i1} c' - \gamma h''_{i2} \left(\frac{\partial N_{i2}(1+\gamma\tau_{i2})}{\partial m_i} \right) > 0$ such that for (A.3) to hold, we must have $\frac{\partial^2 U^i}{\partial m_i^2} \frac{\partial^2 U^i}{\partial b_{i1}^2} > \left(\frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} \right)^2$.

It is straight forward to show that in the quasi-linear case this condition is always satisfied if $c'' > \frac{\beta\gamma\rho^2}{9\nu}$ (i.e. the cost function must be sufficiently convex) such that condition (A.3) holds whenever (A.1) holds.

A.2 Comparative Statics for Case II

Taking the total differential of the first-order conditions we arrive at the following system of equations

$$\begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i^2} & \frac{\partial^2 U^i}{\partial m_i \partial m_j} \\ \frac{\partial^2 U^j}{\partial m_j \partial m_i} & \frac{\partial^2 U^j}{\partial m_j^2} \end{pmatrix} \begin{pmatrix} \mathrm{d}m_i \\ \mathrm{d}m_j \end{pmatrix} + \begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} \\ 0 \end{pmatrix} \mathrm{d}b_{io} = 0$$

which can be rearranged to yield equations (14) and (15). Since $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} < 0$, the Dixit (1986) stability conditions $\frac{\partial^2 U^i}{\partial m_i^2} < 0$, $\frac{\partial^2 U^j}{\partial m_j^2} < 0$ and $\frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 U^j}{\partial m_j^2} > \frac{\partial^2 U^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j}$ imply $\frac{\mathrm{d}m_i}{\mathrm{d}b_{i0}} < 0$. If $h_2'' = 0$ such that U^i is quasi-linear, we can show that $\frac{\mathrm{d}m_j}{\mathrm{d}b_{i0}} < 0$ by verifying that in this case

$$\frac{\partial^2 U^j}{\partial m_j \partial m_i} = -\beta h_{j2}'' \left(\frac{\rho}{6\nu} + \frac{\gamma\rho}{3} \left(\frac{1}{2\nu}\tau_{i2} + N_{i2} \right) \right)^2 - \frac{\gamma\rho^2}{9\nu}\beta h_{j2}' = -\frac{\gamma\rho^2}{9\nu}\beta h_{j2}' < 0.$$

From Proposition 1 we know that, the effect of a change in b_{i0} on τ_{i2}^* and N_{i2}^* is given by

$$\frac{d\tau_{i2}^*}{db_{i0}} = \frac{\rho}{3}\frac{d\Delta q_{i2}}{db_{i0}} = \frac{\rho}{3}\left(\frac{dm_i}{db_{i0}} - \frac{dm_j}{db_{i0}} \right), \tag{A.4}$$

$$\frac{dN_{i2}^*}{db_{i0}} = \frac{\rho}{6\nu}\frac{d\Delta q_{i2}}{db_{i0}} = \frac{\rho}{6\nu}\left(\frac{dm_i}{db_{i0}} - \frac{dm_j}{db_{i0}} \right), \tag{A.5}$$

where $\Delta q_{i2} = m_i - m_j$ (assuming that $\bar{q}_i = \bar{q}_j$). Substituting from (14) and (15) and noting that

$$\begin{aligned} \frac{\partial^2 U^j}{\partial m_j \partial m_i} &= -\beta h_{j2}' \frac{\gamma\rho^2}{9\nu} - \beta h_{j2}'' \left(\frac{\rho}{6\nu}(1 + \gamma\tau_{j2}) + \frac{\rho}{3}N_{j2} \right)^2 \\ \frac{\partial^2 U^j}{\partial m_j^2} &= h_{j1}''(\gamma c')^2 - h_{j1}'\gamma c'' - \frac{\partial^2 U^j}{\partial m_j \partial m_i} \end{aligned}$$

allows us to rewrite the effect of a marginal increase in legacy debt on taxes and the number of firms in period 2 as

$$\frac{d\tau_{i2}^*}{db_{i0}} = -\frac{1}{\phi}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}\frac{\rho}{3}\left(h_{j1}''(\gamma c')^2 - h_{j1}'\gamma c'' \right) < 0, \tag{A.6}$$

$$\frac{dN_{i2}^*}{db_{i0}} = -\frac{1}{\phi}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}\frac{\rho}{6\nu}\left(h_{j1}''(\gamma c')^2 - h_{j1}'\gamma c'' \right) < 0, \tag{A.7}$$

where $\phi = \frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 U^j}{\partial m_j^2} - \frac{\partial^2 U^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j} > 0$. The inequality is a result of the convexity of c and the strict concavity of h_1.

A.3 Condition 1 Binding in Only One Jurisdiction

We assume that Condition 1 is binding in i but not in j. Then the system of first-order conditions is given by

$$\frac{\partial U^i}{\partial \tau_{i1}} = h'_{i1}\frac{\partial \left(N_{i1}\left(1+\gamma\tau_{i1}\right)\right)}{\partial \tau_{i1}} = 0 \tag{A.8}$$

$$\frac{\partial U^j}{\partial \tau_{j1}} = h'_{j1}\frac{\partial \left(N_{j1}\left(1+\gamma\tau_{j1}\right)\right)}{\partial \tau_{j1}} = 0 \tag{A.9}$$

$$\frac{\partial U^i}{\partial m_{i1}} = -h'_{i1}\gamma c' + \beta h'_{i2}\frac{\partial \left(N_{i2}\left(1+\gamma\tau_{i2}\right)\right)}{\partial m_i} = 0 \tag{A.10}$$

$$\frac{\partial U^j}{\partial m_{j1}} = -h'_{j1}\gamma c' + \beta h'_{j2}\frac{\partial \left(N_{j2}\left(1+\gamma\tau_{j2}\right)\right)}{\partial m_j} = 0 \tag{A.11}$$

$$\frac{\partial U^j}{\partial b_{j1}} = \gamma h'_{j1} - \beta\gamma(1+r)h'_{j2} = h'_{j1} - h'_{j2} = 0. \tag{A.12}$$

The requirements for the second-order conditions in each jurisdiction are identical to those derived for Case I. The first-order conditions for taxes, (A.8) and (A.9), yield again (12). Substituting (A.12) into (A.11), we can rewrite the first-order condition for public investment in j to $\frac{\partial \tilde{U}^j}{\partial m_{j1}} = -\gamma c' + \beta\frac{\partial(N_{j2}(1+\gamma\tau_{j2}))}{\partial m_j} = 0$. The Dixit (1986) stability conditions are then written as

$$\frac{\partial^2 U^i}{\partial m_i^2} < 0, \;\; \frac{\partial^2 \tilde{U}^j}{\partial m_{j1}^2} < 0, \;\; \frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 \tilde{U}^j}{\partial m_j^2} > \frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j}.$$

Taking the total differential of the first-order conditions with respect to b_{i0} we arrive at the following system of equations

$$\begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i^2} & \frac{\partial^2 U^i}{\partial m_i \partial m_j} \\ \frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i} & \frac{\partial^2 \tilde{U}^j}{\partial m_j^2} \end{pmatrix}\begin{pmatrix} \mathrm{d}m_i \\ \mathrm{d}m_j \end{pmatrix} + \begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} \\ 0 \end{pmatrix}\mathrm{d}b_{i0} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

which can be rearranged to yield

$$\frac{\mathrm{d}m_i}{\mathrm{d}b_{i0}} = -\frac{1}{\tilde{\phi}}\frac{\partial^2 \tilde{U}^j}{\partial m_j^2}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} < 0,$$

$$\frac{\mathrm{d}m_j}{\mathrm{d}b_{i0}} = \frac{1}{\tilde{\phi}}\frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} > 0,$$

with $\tilde{\phi} = \frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 \tilde{U}^j}{\partial m_j^2} - \frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_j} > 0$. The second effect can be clearly signed because $\frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i} = -\frac{\gamma\rho^2}{9\nu} < 0$. Taking the total differential of the first-order conditions with respect to b_{j0} we obtain

$$\begin{pmatrix} \frac{\partial^2 U^i}{\partial m_i^2} & \frac{\partial^2 U^i}{\partial m_i \partial m_j} \\ \frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i} & \frac{\partial^2 \tilde{U}^j}{\partial m_j^2} \end{pmatrix} \begin{pmatrix} \mathrm{d}m_i \\ \mathrm{d}m_j \end{pmatrix} + \begin{pmatrix} 0 \\ \frac{\partial^2 \tilde{U}^i}{\partial m_i \partial b_{i0}} \end{pmatrix} \mathrm{d}b_{j0} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

which we rearrange to

$$\begin{aligned} \frac{\mathrm{d}m_i}{\mathrm{d}b_{i0}} &= -\frac{1}{\tilde{\phi}} \frac{\partial^2 \tilde{U}^j}{\partial m_j^2} \frac{\partial^2 \tilde{U}^i}{\partial m_i \partial b_{i0}} = 0, \\ \frac{\mathrm{d}m_j}{\mathrm{d}b_{i0}} &= \frac{1}{\tilde{\phi}} \frac{\partial^2 \tilde{U}^j}{\partial m_j \partial m_i} \frac{\partial^2 \tilde{U}^i}{\partial m_i \partial b_{i0}} = 0, \end{aligned}$$

where the equality follows from $\frac{\partial^2 \tilde{U}^i}{\partial m_i \partial b_{i0}} = 0$.

A.4 Numerical Example

Table A.1: Numerical Solution

		Symmetry				Asymmetry			
		Case I		Case II					
	Jurisdiction	1	2	1	2	1	2	1	2
Condition 1 binding		No	No	Yes	Yes	Yes	No	Yes	No
Debt	b_{i0}	0.06	0.05	0.20	0.10	0.20	0.05	0.20	0.06
	b_{i1}^{des}	0.18	0.17	0.31	0.22	0.31	0.17	0.31	0.18
	b^{wtp}	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Period 1	b_{i1}^*	0.18	0.17	0.19	0.19	0.19	0.17	0.19	0.18
	m_i^*	0.23	0.23	0.19	0.22	0.19	0.23	0.19	0.23
	τ_{i1}^*	0.63	0.63	0.63	0.63	0.63	0.63	0.63	0.63
	N_{i1}^*	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	g_{i1}^*	0.38	0.38	0.27	0.35	0.27	0.38	0.27	0.38
Period 2	τ_{i2}^*	0.63	0.63	0.62	0.65	0.61	0.65	0.61	0.65
	N_{i2}^*	0.50	0.50	0.49	0.51	0.49	0.51	0.49	0.51
	g_{i2}^*	0.13	0.14	0.11	0.13	0.11	0.15	0.11	0.15

The numerical analysis is conducted for quasi-linear utility functions with $h_1(x) = \ln(x)$ and $h_2(x) = x$. The investment cost function is quadratic, $c(m_i) = m_i^2$. We set $\rho = 1.4$,

$\nu = 1.4$, $\gamma = 1.3$, $\delta = 1$, $z = 0.25$, $r = 0.01$ such that $\beta = 0.99$ and $b^{wtp} = 0.19$. We solve the model using a simple iterative algorithm. In a first step, we compute the equilibrium with symmetric initial infrastructure levels ($\bar{q}_i = \bar{q}_j$). Solutions for the key variables are displayed in Table A.1.

Table A.2: Numerical Solution for Asymmetric Initial Public Infrastructure

		$\epsilon = 0.2$				$\epsilon = 0.4$		$\epsilon = 2$	
		Case I		Case II		Case II		Case II	
	Jurisdiction	1	2	1	2	1	2	1	2
Condition 1 binding		No	No	Yes	Yes	Yes	Yes	Yes	Yes
Debt	b_{i0}	0.06	0.05	0.20	0.10	0.20	0.10	0.20	0.10
	b_{i1}^{des}	0.18	0.17	0.31	0.22	0.31	0.22	0.31	0.22
	b^{wtp}	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Period 1	b_{i1}^*	0.18	0.17	0.19	0.19	0.19	0.19	0.19	0.19
	m_i^*	0.23	0.23	0.20	0.22	0.20	0.22	0.23	0.19
	τ_{i1}^*	0.63	0.63	0.64	0.62	0.64	0.61	0.72	0.54
	N_{i1}^*	0.50	0.50	0.50	0.50	0.51	0.50	0.53	0.47
	g_{i1}^*	0.39	0.38	0.27	0.35	0.28	0.34	0.32	0.30
Period 2	τ_{i2}^*	0.63	0.63	0.62	0.64	0.63	0.63	0.70	0.57
	N_{i2}^*	0.50	0.50	0.50	0.50	0.50	0.50	0.52	0.48
	g_{i2}^*	0.13	0.14	0.12	0.13	0.12	0.12	0.17	0.08

In a second step, we introduce a positive relation between legacy debt and initial infrastructure installments by assuming that $\bar{q}_i = \epsilon b_{i0}$. The depreciation rate is $\delta = 0.5$. All other parameters and functional form specifications remain as above. Results for different levels of ϵ are presented in Table A.2.

A.5 Asymmetries in Initial Public Infrastructure

Unrestricted Borrowing Let $\bar{q}_i = \bar{q}_i(b_{i0})$. (13) must then be modified and reads

$$c'(m_i) = \frac{\beta\rho}{3}\left(1 + \frac{\rho}{3\nu}\Delta m_i + \frac{\rho}{3\nu}\Delta\bar{q}_i(1-\delta)\right). \tag{A.13}$$

Taking the total differential of (A.13) with respect to m_i and b_{i0} we obtain

$$\frac{dm_i}{db_{i0}} = \frac{\frac{\beta\rho^2}{9\nu}(1-\delta)}{c''(m_i) - \frac{\beta\rho^2}{9\nu}}\bar{q}_i' \tag{A.14}$$

where $\bar{q}_i' = \frac{\partial \bar{q}_i'}{\partial b_{i0}}$. Again, we assume that the cost function is sufficiently convex, $c'' > \frac{\beta\gamma\rho^2}{9\nu}$, such that the second-order conditions are fulfilled. Then (A.14) implies

$$\frac{dm_i}{db_{i0}} \lesseqgtr 0 \Longleftrightarrow \bar{q}_i' \lesseqgtr 0. \tag{A.15}$$

Restricted Borrowing The sign of (14) depends on $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}}$. Let $\bar{q}_i = \bar{q}_i(b_{i0})$ and differentiate (A.10) w.r.t b_{i0} to obtain

$$\begin{aligned} \frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} &= h_{i1}'' \frac{\gamma^2}{\beta} c' + (\beta(1-\delta)\eta_{i2} + \eta_{i1}) \bar{q}_i', \\ \eta_{i1} = -h_{i1}''\gamma c' \frac{\partial(N_{i1}(1+\gamma\tau_{i1}))}{\partial \bar{q}_i} > 0, \ \eta_{i2} &= h_{i2}'' \left(\frac{\partial(N_{i2}(1+\gamma\tau_{i2}))}{\partial m_i}\right)^2 + h_{i2}' \frac{\gamma\rho^2}{9\nu}. \end{aligned} \tag{A.16}$$

The first term in (A.16) captures the effect of b_{i0} on the marginal utility of public infrastructure investment ($\frac{\partial U^i}{\partial m_i}$) that results from its impact on the incentives for inter-temporal redistribution as described in Proposition 3. The second term $(\beta(1-\delta)\eta_{i2} + \eta_{i1})\bar{q}_i'$ represents the change in $\frac{\partial U^i}{\partial m_i}$ caused by a change in $\bar{q}_i = \bar{q}_i(b_{i0})$ that is due to the variation in the marginal utility of public infrastructure investment in period 1, η_{i1}, and period 2, η_{i2}. The effect of initial infrastructure investment depends on the sign of this term which is assumed to be positive in the first part of Assumption 1. This always holds in the quasi-linear case with $h_{i2}'' = 0$ as in this case $\eta_{i2} = h_{i2}' \frac{\gamma\rho^2}{9\nu} > 0$. If $(\beta(1-\delta)\eta_{i2} + \eta_{i1})\bar{q}_i' > 0$, and $\left|h_{i1}'' \frac{\gamma^2}{\beta} c'\right| < |(\beta(1-\delta)\eta_{i2} + \eta_{i1})\bar{q}_i'|$, as stated in the second part of Assumption 1, we have

$$\frac{dm_i}{db_{i0}} \lesseqgtr 0 \Longleftrightarrow \bar{q}_i' \lesseqgtr 0. \tag{A.17}$$