Fiscal Competition and Public Debt*

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Abstract

This paper explores the implications of high indebtedness for strategic tax setting when capital markets are integrated. When public borrowing is constrained due to sovereign default or by a binding fiscal rule, a rise in a country's initial debt level lowers investment in public infrastructure and makes tax setting more aggressive in that jurisdiction, while the opposite occurs elsewhere. On net a jurisdiction with higher initial debt becomes a less attractive location. Our analysis is inspired by fiscal responses in severely hit countries after the economic and financial crisis which are are consistent with the theoretical predictions. We find a similar pattern on the sub-national level using administrative data from the universe of German municipalities.

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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). Institutionally, governments have responded to these concerns with additional and tighter fiscal rules such as the Fiscal Compact in 25 European countries. 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 fiscal policies and economic outcome. In particular, we show in a model with two countries which compete for a mobile tax base that in case of a binding constraint on public borrowing in one country, a rise in this country's initial debt level induces it to spend less on investment in public infrastructure and to set a lower business tax. In the other country the opposite occurs, thus leading to public policy divergence. On net the borrowing constrained country which experiences a debt shock becomes an unambiguously less attractive location for firms. The restriction on borrowing may come from either tighter conditions in the financial markets, as government default becomes a concern for lenders, or from supranational institutions like the EU that invoke more stringent fiscal rules.

Our model is inspired by the experience of the economic and financial crisis of 2008. Countries that experienced a substantial downgrade in the rating of their government debt, and thus were presumably constrained in their borrowing, reacted immediately after the crisis with a substantial reduction in public infrastructure spending and only more recently with much lower corporate tax rates. By contrast, the bond rating of government debt of countries like Germany and the Netherlands was very little affected and those countries experienced only modest declines in public infrastructure spending and tax rates. The divergence of fiscal policies between constrained and unconstrained countries mirrors the findings of the theoretical model.

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. The main result in our theoretical model is driven by a government's limited ability 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, the optimal policy response is to increase public borrowing to smooth consumption across periods without affecting investment in public infrastructure. However, when borrowing is restricted either by financial markets or by supranational institutions via fiscal rules, 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.

In our model, higher legacy debt in combination with a constraint on additional borrowing constitutes a competitive disadvantage because an indebted jurisdiction cannot make the necessary investments which are costly in the short run but lead to an increase of overall welfare in the long run. A similar concept is well established in the corporate investment literature: firms with lax financial constraints obtain strategic advantages by undercutting prices or over-investing and thus outbidding their rivals that lack sufficient financial resources (e.g. Bolton & Scharfstein, 1990; Boutin *et al.*, 2013).

Our mechanism assumes a direct link between the choice of government borrowing and adjustment of public investment in infrastructure. One might think that the government could respond to the problem of constrained borrowing by adjusting alternative instruments, in particular taxes. We show that this intuition is not correct because the alternative revenue source is optimally chosen before the debt shock occurs. Limits to taxation are also diagnosed by Trabandt & Uhlig (2013) who 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.[1] In addition, Servén (2007) provides evidence for fiscal rules that limit government borrowing or debt to reduce spending on public infrastructure, a finding that is in line with a political economy explanation: Politicians reduce spending on durable goods like public infrastructure that only create benefits in the long run in order to please myopic voters in the short term.

The mechanism can be reversed, if higher initial debt is correlated with or even caused by a higher level initial public infrastructure installments. In that case, the affected region gains an advantage in fiscal competition early on when debt increases, which makes its government less rather than more constrained in its subsequent borrowing. The opposite holds when higher initial debt is correlated with more government consumption spending and thus less public infrastructure. Our finding thus complements the literature on the composition of public expenditure (e.g. Keen & Marchand, 1997).

While our analysis is motivated by policies of sovereign countries, our results also appear to apply to fiscal competition on the sub-national level. Using administrative data from about 11,000 municipalities in Germany over the period of 1998 until 2013 we observe in an event study how local governments respond to well above average increases of net repayment

[1] Furthermore, quantitative results by Mendoza *et al.* (2014) suggest that capital tax increases would not have been sufficient to restore solvency in Europe after the financial crisis.

burden. In line with the theoretical model, the municipality lowers its contemporaneous spending on public infrastructure by nearly 27%, which recovers within 5 years. In addition, the municipality decreases its local business tax by a small, but significant amount. The opposite behavior is found in neighboring localities which increase their tax rates.

We expand the small literature that investigates the relation between public borrowing and tax competition.[2] For instance, Arcalean (2017) 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. Furthermore, Jensen & Toma (1991) analyze the intra-period relation between public debt and tax rates. A higher level debt repayment leads to an increase in taxation and a lower level of public good provision. The present paper differs from this setting in two important aspects: First, we consider a constraint on government debt due to default or fiscal rules. Second, we introduce durable public infrastructure investment, which offers an additional inter-temporal link that is not accounted for in the model by Jensen & Toma (1991). In particular, we show that high debt burdens affect fiscal policy in the long-run even if the within-period effect analyzed by Jensen & Toma (1991) is absent or cannot be transmitted across periods because of borrowing constraints. This novel inter-temporal mechanism leads to a strategic disadvantage of the initially more indebted government in the second period.

Besides these two papers, the theoretical literature has mostly ignored public debt levels as a factor in inter-jurisdictional competition for business investment.[3] One possible reason is that in the absence of borrowing constraints governments can separately optimize public borrowing and fiscal incentives for private investment, thus precluding an inter-temporal interaction between the initial debt level and business taxes.[4] 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.[5]

Our analysis contributes to the debate on fiscal decentralization (Keen & Kotsogiannis, 2002; Besley & Coate, 2003; Oates, 2005; Janeba & Wilson, 2011; Agrawal, 2012). Many countries have devolved powers from higher to lower levels of government, including the right to tax mobile tax bases like capital (Dziobek *et al.*, 2011). Some critics 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 the constraint on

[2]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.

[3]See Keen & Konrad (2013) for a comprehensive survey of the large body of research on inter-jurisdictional competition in taxes.

[4] This notion also underlies the results of comprehensive general equilibrium models such as Mendoza & Tesar (2005) who show in a setting without borrowing constraints that legacy debt provides an incentive for large economies to use capital taxes to manipulate interest rates.

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

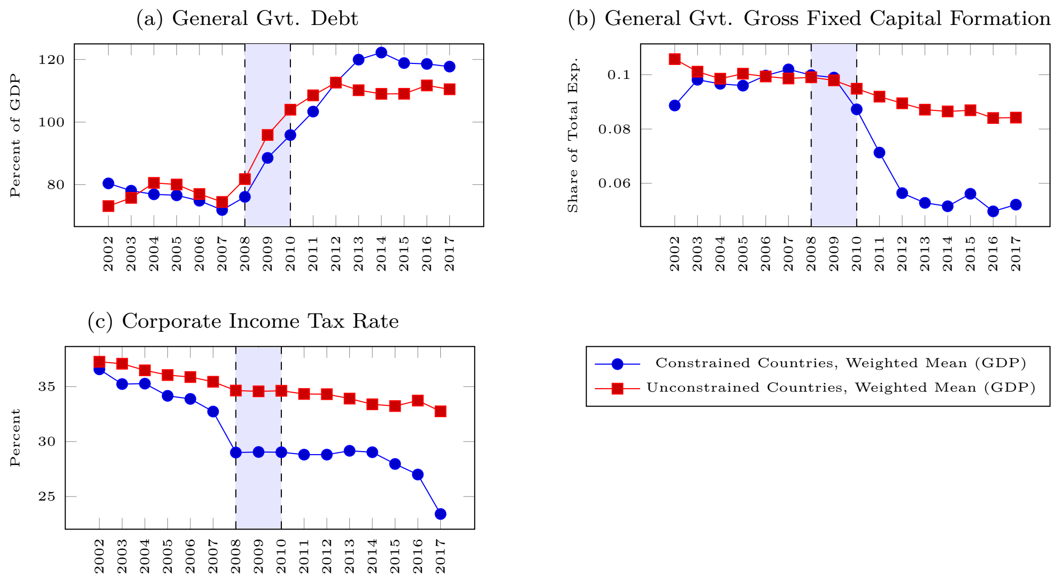
government borrowing is binding.

The paper is structured as follows. In the next section we provide illustrative evidence from the economic and financial crisis to motivate our theory. In Section 3, we describe the model framework. We then proceed to the equilibrium analysis in Section 4, which contains the main results for the situation with symmetric initial public infrastructure but possible differences in the public borrowing constraint. In Section 5, we consider a number of extensions, including an asymmetry that is due to differences in initial public infrastructure. In Section 6, we present further evidence in line with our theoretical findings based on German municipal data. Section 7 provides the conclusion.

2 The Economic and Financial Crisis 2008: Fiscal Responses

The purpose of this short section is to motivate our subsequent theoretical analysis, in which an exogenous increase in initial debt levels leads to an adjustment of fiscal policy, in particular in those instruments that relate to a country‘s attractiveness to firms. We describe the evolution of several fiscal policy indicators of all major OECD and EU member countries.[6] The focus is on the economic and financial crisis starting in 2008, which led to a strong contraction of output in many industrialized countries in 2009, rising debt-to-GDP levels, and for some countries to much higher borrowing costs. While the economic and financial crisis was partially caused and aggravated by policy failures that might have been foreseen, the extent and spread of the crisis was largely unexpected.

Figure 1: Public Debt, Public Investment and Taxation



[6]The exemptions are Chile, Mexico and Turkey for which appropriate data was not available.

Not all countries were affected in the same way, even though a substantial output contraction was common in most industrialized economies. In anticipation of our theoretical model it is interesting to focus on those countries whose governments were substantially constrained with regard to additional borrowing. We define countries with borrowing constraints after the financial and economic crisis as those jurisdictions that experienced a sovereign credit rating downgrade by the rating agency S&P to at least a lower medium grade (e.g. from A to B) in the years 2010-2012. These countries include Cyprus, Spain, Greece, Ireland, Italy and Portugal.[7] In the following, we refer to the six countries as constrained, while all other countries are called non-constrained.[8]

Figure 1 displays the evolution of key fiscal policy indicators (GDP-weighted averages) for constrained and non-constrained countries (EU and OECD member states) separately. It is interesting to note that the debt-to-GDP ratios of all OECD countries moved in the same direction in the 2000s until about 2012 (panel (a)). While in the constrained countries debt-to-GDP ratios continued rising, in the non-constrained countries the ratios stabilized. There is a sharp difference when it comes to public investment, measured as gross fixed capital formation as percentage of total government expenditure and displayed in panel (b) of Figure 1.[9] The six constrained countries saw a drastic fall in public investment starting in 2009, with the percentage share of infrastructure spending in total expenditure reduced by approximately half of its initial value of 10% to around 5% in 2017. In the other countries only a modest and gradual reduction was experienced with the infrastructure spending share remaining above 8% throughout the observation period.

Governments of constrained and unconstrained countries behaved differently also in terms of corporate tax policy as can be seen from panel (c). Statutory corporate tax rates have been on a decline in most countries for a much longer time than the economic and financial crisis, a fact that has been well documented (Devereux *et al.*, 2002; Slemrod, 2004). Constrained countries have always had a lower corporate tax rate than unconstrained ones. The gap widened between 2007 and 2008[10], but then stayed largely constant until 2014, at which point it widened much further from about 5.5 percentage points in 2009 to 9.3 percentage points in 2017: constrained countries cut their tax rates much more than unconstrained countries.

Summarizing these observations, we note that after the economic and financial crisis starting in 2008 six countries saw a downgrade of their public debt rating. Subsequently

[7]Some other countries (Croatia, Hungary, Iceland, Romania, Malta, Croatia) had low sovereign credit ratings through an even longer period (that is even before the crisis) than those six countries. Defining borrowing constrained countries on the basis of a low credit rating rather than a change to a low credit rating does not affect the analysis much. A full list of countries and their classification is displayed in Table A.1 in the Appendix.

[8]In constrained countries interest payments (relative to GDP and as a share of total government expenditure) rose sharply since 2010 and stayed at high levels until recently, while unconstrained countries seemed to have benefited from lower interest rates phasing in over the years due to an expansionary monetary policy. Figures that display this trend are available in the Online Appendix.

[9]A similar picture is obtained when looking at the evolution of general government gross fixed capital as a percentage of GDP which is available in the Online Appendix.

[10]This effect is mainly driven by a substantial corporate income tax cut in Italy.

these countries experienced a longer period of rising debt-to-GDP ratios than unconstrained countries that went hand in hand with rising interest rates and payments on debt. Immediately following the onset of the crisis, constrained countries sharply reduced public investment for a long period of time. Corporate tax rates have been lower in constrained countries beyond the crisis years, but were recently lowered over-proportionally in those countries.

3 The Model

The government is assumed to maximize a combination of the number of firms in its jurisdiction and the benefit from 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 durable public infrastructure. 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 firms 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.

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 ability to borrow in period 1 due to a possible default problem in period 2 or limitations stemming from a fiscal rule.

3.1 Firms

The location of the tax base follows a simple Hotelling (1929) approach.[11] There is a continuum of firms with the total number of firms normalized to 1. Each firm chooses a jurisdiction to locate in and can switch its location between periods at no cost. Firms are heterogeneous in terms of their exogenous bias towards one of the two jurisdictions (due to, say, existing production facilities or requirements for natural resources), which is captured by the firm-specific parameter $\alpha \in [0, 1]$. Omitting the time index for the moment, a firm of type α receives a net benefit $\varphi_i(\alpha)$ in jurisdiction i given by

[11] Our model shares some features with classical models of tax competition as, for example, Zodrow & Mieszkowski (1986), Wilson (1986) and Kanbur & Keen (1993). Our approach is analytically simpler to handle, which is crucial in the presence of many government instruments.

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

The terms $\psi + \alpha\nu$ and $\psi + (1-\alpha)\nu$ represent the exogenous returns. The general return ψ is assumed to be sufficiently positive so that overall return φ_i is 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 one and can be used to model the degree of fiscal competition. The overall return to investment in a jurisdiction i further increases with the stock of public infrastructure $q_i \geq 0$. The effectiveness of public infrastructure is captured by the parameter $\rho \geq 0$ and is not firm-specific. 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 cannot choose a more sophisticated tax function for administrative reasons.

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, $\tilde{\alpha} \in (0,1)$,[12] the number of firms in each jurisdiction is then given by $N_1 = 1 - \tilde{\alpha}$ and $N_2 = \tilde{\alpha}$ or, more generally,

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

where $\Delta q_i = q_i - q_{-i}$ and $\Delta \tau_i = \tau_i - \tau_{-i}$. The number of firms in a jurisdiction is a linear function of the tax and public infrastructure differentials. Firms split evenly when both policies are symmetric, that is $\Delta q_i = \Delta \tau_i = 0$. The sensitivity of a firm's location choice with respect to tax rates and infrastructure spending depends on the parameter ν. Higher values of ν represent less sensitivity.

3.2 Governments

Government i 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 consumption good into one unit of the public consumption good. In the first period, the government pays back initial debt b_{i0}, and decides on public infrastructure investment m_{it} as well as the level of newly issued debt b_{i1}, which may be constrained and is paid back in period 2.

[12] 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.

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 period 1, jurisdictions are endowed with an exogenous level of public infrastructure $q_{i0} = \bar{q}_i$.[13] The cost for public infrastructure investment is denoted by $c(m_i)$, which is an increasing, strictly convex function: $c'(m_i) > 0$, $c''(m_i) > 0$. To simplify notation, we suppress the time subscript in m_i, since it is effectively only chosen in period 1.

Government borrowing takes place on the international credit market at the constant interest rate r. The period-specific budget constraints for the government in $i = 1, 2$ can thus 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 our base version, the set of available revenue-generating instruments is limited to the business tax. In practice, governments may use a wide range of taxes, including levies on consumption and labor. We demonstrate in an Online Appendix that the insights of the base model are qualitatively not affected by introducing a second tax instrument.

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:

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

We think of (6) as the utility function of a representative citizen who gains from attracting firms 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.[14] We assume that the marginal benefit of the public good, $\gamma > 1$, is constant and 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. Beyond the aspect of tractability, our assumption clarifies also the mechanism behind our findings and allows for a comparison to Jensen & Toma (1991), who assume a strictly concave function for the benefit of the public good (within the function h_{i2}). This is discussed in more detail in Section 5.2. β is the discount factor which we set equal to $\frac{1}{1+r}$. The inter-temporal structure

[13] A jurisdiction's level of public infrastructure may be correlated with its initial level of government debt. We consider this aspect in Section 5.1.

[14] Our utility function is qualitatively similar to standard models of tax competition. We argue that a micro-founded model in the spirit of Hindriks *et al.* (2008) generates very similar results and derive our results in such a model in the Online Appendix.

of the utility function assumes that the functions h_{i1} and h_{i2} are concave, and at least one of them is strictly concave. We assume this for h_{i1}, such that $h'_{i1} > 0$, $h'_{i2} > 0$, $h''_{i1} < 0$, $h''_{i2} \leq 0$.

We consider two scenarios affecting a government's borrowing decision in period 1. In the first case the decision is entirely free and hence borrowing is unconstrained. In the second one, we postulate a maximum limit on the amount of borrowing:

$$b_{i1} \leq \bar{b_i}. \tag{7}$$

The limit could be the result of a fiscal rule or the consequence of financial market discipline, as a government default problem restricts lending. In the Online Appendix, we show that the possibility of default leads to an endogenously derived limit on borrowing that depends on the cost of default (and the interest rate as well as the marginal benefit of the public good). The borrowing constraint could be binding for neither, one of, or both countries .[15]

3.3 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 therefore fully characterized by a location decision of the firm such that no firm has an incentive to choose a different location given fiscal policy parameters of both governments and the location decision of all other firms. The equilibrium of the location game was already derived in Section 3.1.

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}, choose the tax rate τ_{i1} and the public good level g_{i1}. 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 governments repay debt b_{i1}. Subsequently, firms again make their location choices. Governments observe previous decisions and no commitment is possible. We consider a sub-game perfect Nash equilibrium and solve the model by backward induction.

[15] In case of a fiscal rule, one could assume the same borrowing limit for both countries, that is not necessarily binding for both simultaneously due to other differences that affect the desired amount of borrowing. In case of endogenous default, the borrowing limit could differ across countries if, for example, the cost of default are not the same.

4 Results

4.1 Period 2

We begin with analyzing the government decision making in period 2. At that stage, a government decides on its tax rate and the public consumption good level, 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 and public good levels such that each government maximizes its period 2 sub-utility, taking the other government's fiscal policy decisions in that period as given, and anticipating correctly the subsequent locational equilibrium.

Government i maximizes period 2 utility as given by equation (6). We start with the choice of the tax rate, which affects the number of firms N_{i2}, given by (2) adding time subscripts. The first-order condition is given by

$$U^i_{\tau_{i2}} := \frac{\partial U^i}{\partial \tau_{i2}} = h'_{i2} \frac{\partial \left(N_{i2}\left(1 + \gamma \tau_{i2}\right)\right)}{\partial \tau_{i2}} = 0, \; i = 1, 2. \tag{8}$$

For the period 2 decision, the outer utility function h_{i2} can be ignored as long as $h'_{i2} > 0$, which we assume. Solving the system of two equations (one for each jurisdiction) with two unknowns, we obtain τ_{12} and τ_{22}.[16]

The first-order conditions (8) define the government's optimal decision in period 2. Inserting these 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 $\Delta q_{i2} = \Delta q_{i2}\left(m_i, m_{-i}\right) = \Delta \bar{q}_i \left(1 - \delta\right) + \Delta m_i$ is a linear function of the inter-jurisdictional differences in existing public infrastructure, $\Delta \bar{q}_i = \bar{q}_i - \bar{q}_{-i}$, and additional investment in public infrastructure, $\Delta m_i = m_i - m_{-i}$. We summarize the results for period 2 in the following Proposition.

Proposition 1. *Let $\gamma\nu > 1$. For given public infrastructure investment levels (m_1, m_2) and borrowing in period 1 (b_{11}, b_{21}), there exists a unique Nash equilibrium for the period 2 fiscal policy game with*

$$\tilde{\tau}_{i2}\left(m_i, m_{-i}\right) = \nu + \frac{\rho \Delta q_{i2}}{3} - \frac{1}{\gamma},$$

$$\tilde{g}_{i2}\left(m_i, m_{-i}, b_{i1}\right) = \tilde{\tau}_{i2} \tilde{N}_{i2} - (1 + r) b_{i1},$$

and the number of firms in $i = 1, 2$ given by $\tilde{N}_{i2}\left(m_i, m_{-i}\right) = \frac{1}{2} + \frac{\rho \Delta q_{i2}}{6\nu}$.

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

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

good γ, while the tax rate decreases with infrastructure spending by the other government m_{-i}. Better infrastructure provides benefits to firms that are partially taxed away by the government. 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}.

4.2 Period 1

We first abstract from any confounding asymmetries and let initial levels of public infrastructure be the same ($\bar{q}_1 = \bar{q}_2$). We relax this assumption below. Beginning with the second stage of period 1, 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. New borrowing in period 1 may be constrained due to either a fiscal rule or indirectly via possible default in period 2. Intuitively, in the latter case borrowing is constrained when the benefits of default in period 2, which depend on the amount of debt, outweigh the cost of default (which are assumed to be be unrelated or less related to the debt level). The maximum feasible debt is determined by the equality of benefits and costs of default. We derive this result formally in the Online Appendix.

We now consider two separate cases. First, we assume that the borrowing constraint is not binding in either of the jurisdictions, for example, because the fiscal rule is fairly loose or the cost of default are very high. 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 the borrowing constraint (7) is binding in jurisdiction 1 only, that is $b_{11} = \bar{b}$. The set of first-order conditions of the government in jurisdiction 1 is reduced by one because it is constrained in its borrowing (or more precisely, the first-order condition for b_{11} does not hold with equality).[17] We denote by b_{i1}^{des} the desired level of borrowing in period 1 if the debt constraint problem 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

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

The following Case I applies when $b_{i1}^{des} < \bar{b}$ for both countries, while Case II refers to $b_{i1}^{des} \geq \bar{b}$ in one of the two countries.

Case I: The borrowing constraint is not binding in either of the two jurisdictions

After inserting budget constraints, both governments $i = 1, 2$ solve the following maximization problem

[17]We have checked the consistency of all assumptions and the working of the model using a numerical example with quasi-linear utility. We let $h_{i1}(u_{i1}) = \ln(u_{i1})$, $h_{i2}(u_{i2}) = u_{i2}$, $c(m_i) = m_i^2$, $\bar{q}_i = \bar{q}_j$ and set parameter values $\rho = 1.4$, $\nu = 1.4$, $\gamma = 1.3$, $\delta = 1$, $z = 0.25$, $r = 0.01$ such that $\beta = 0.99$ and $b^{wtp} = 0.19$. We solve the example using a simple iterative algorithm and obtain results that are consistent with our general analysis. Results are presented in the Online Appendix.

$$\max_{\tau_{i1},m_i,b_{i1}} U^i = h_{i1}\left(N_{i1} + \gamma\left(\tau_{i1}N_{i1} - c - (1+r)\, b_{i0} + b_{i1}\right)\right) \tag{9}$$
$$+ \beta h_{i2}\left(\tilde{N}_{i2} + \gamma\left(\tilde{\tau}_{i2}\tilde{N}_{i2} - (1+r)\, b_{i1}\right)\right) \text{ s.t. } g_{i1} \geq 0,\ m_i \geq 0.$$

This maximization problem is similar to the one discussed by the tax-smoothing literature that also considers inter-temporal aspects of fiscal policy (e.g. Barro, 1979). As before, we assume a positive level of public good provision $g_{i1} \geq 0$.[18] The values for period 2 ($\tilde{\tau}_{i2}$, $\tilde{\kappa}_i$, $\tilde{N}_{i2}$), as given in Proposition 1, are correctly anticipated. Debt contracts are always honored, as shown in expression (9). The first-order conditions for $i = 1, 2$ are

$$\frac{\partial U^i}{\partial \tau_{i1}} = h'_{i1}\frac{\partial\left(N_{i1}\left(1+\gamma\tau_{i1}\right)\right)}{\partial \tau_{i1}} = 0, \tag{10}$$
$$\frac{\partial U^i}{\partial m_{i1}} = -h'_{i1}\gamma c' + \beta h'_{i2}\frac{\partial\left(\tilde{N}_{i2}\left(1+\gamma\tilde{\tau}_{i2}\right)\right)}{\partial m_i} = 0, \tag{11}$$
$$\frac{\partial U^i}{\partial b_{i1}} = \gamma h'_{i1} - \beta\gamma(1+r)h'_{i2} = h'_{i1} - h'_{i2} = 0. \tag{12}$$

In the first-order condition (12), we make use of the assumption $\beta = \frac{1}{1+r}$. We derive the full set of second-order conditions in Appendix A.1.[19] Note that U^i is strictly concave in b_{i1}, as long as at least one of the two functions h_{i1} or h_{i2} 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 (10) for both jurisdictions are independent of infrastructure investment as well as debt levels, and can be solved in a similar way as above in period 1, yielding

$$\tau^*_{i1} = \nu - \frac{1}{\gamma},\ N^*_{i1} = \frac{1}{2},\ i = 1, 2. \tag{13}$$

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 (12), $h'_{i1} = h'_{i2}$, we can simplify the condition for optimal infrastructure investment (11) to $\beta\frac{\partial\left(\tilde{N}_{i2}(1+\gamma\tilde{\tau}_{i2})\right)}{\partial m_i} = \gamma c'(m_i)$. We use the period 2 equilibrium values to obtain

$$c'(m_i) = \frac{\beta\rho}{3}\left(1 + \frac{\rho\Delta m_i}{3\nu}\right),\ i = 1, 2. \tag{14}$$

[18] The relevant parameter restriction depends on the functional form of U^i. For example, if U^i is quasi-linear, that is $h''_{i2} = 0$, one obtains a positive public good level $g^*_{i1} = \frac{1}{2\gamma} > 0$ in equilibrium.

[19] The second-order conditions are always satisfied if the cost function for infrastructure investment is sufficiently convex.

A symmetric equilibrium $m_1 = m_2 = m^*$ always exists. It is unique if the cost function for public infrastructure c is quadratic and ν is not too small. Asymmetric equilibria may exist though.[20] The combined results from the first-order conditions for taxes and infrastructure spending can be used to determine the optimal borrowing level, as all other variables entering the arguments of h_{i1} and h_{i2} are determined via (11) and (12).

An interesting property of (14) is that it is independent of the initial debt level, which leads to a neutrality result: The choice of m_i is not affected by b_{i0} if the borrowing constraint is not binding. We summarize our insights from the equilibrium under non-binding debt constraints in the Proposition below.

Proposition 2. *Let $\gamma\nu > 1$. Assume that the borrowing constraint is not binding in both jurisdictions and initial public infrastructure levels are symmetric, $\bar{q}_1 = \bar{q}_2$.*

(i) A subgame perfect Nash equilibrium with symmetric infrastructure spending exists, in which first-period tax rates are $\tau_{i1}^* = \nu - \frac{1}{\gamma}$ and infrastructure spending and first period borrowing are implicitly given by $c'(m^*) = \frac{\beta\rho}{3}$ and condition (12).

(ii) 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). The firms' location decisions in both periods are unaffected.

Underlying the debt neutrality result is the following intuition: When governments can choose their desired borrowing level, the unconstrained decision on period 1 debt leads to the equalization of marginal utilities across periods, which frees the infrastructure spending decision from doing this. Infrastructure spending serves to equalize the marginal benefit of an improved economic outcome in period 2 (number of firms and public consumption good) and the marginal cost from spending in period 1 that implies forgone public good consumption in that period.

Case II: The borrowing constraint is binding in one jurisdiction

We now turn to the case where condition (7) is binding in jurisdiction 1, but not in 2. In this scenario, jurisdiction 1 would like to run a higher debt level, but is unable to do so. In equilibrium, the first-order condition for period 1 debt, (12), does not hold with equality. Instead the optimal borrowing level equals the maximum feasible level given by $\bar{b}$ due to the strict concavity of U^1 with respect to b_{11}. First-order condition (10) 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 make the appropriate assumption that the level of the public consumption good is positive and thus an interior solution is obtained.[21] In this case,

[20]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.

[21]Using the numerical example described in footnote 17 we verify that such an equilibrium may indeed be obtained.

legacy debt does not affect period 1 taxes.

We are left with the two jurisdictions' first-order conditions for public infrastructure investment, (11). The absence of condition (12), however, now implies that the marginal utilities in periods 1 and 2 are typically not equalized for jurisdiction 1, $h'_{11} \neq h'_{12}$. In particular, h'_{11} in (11) 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_1 and m_2. However, we can undertake comparative statics by totally differentiating the first-order conditions for public infrastructure, assuming an interior solution for the public consumption good and making sure that tax rates for period 1 are determined in isolation from the other relevant first-order conditions.

The sign of the comparative static effects can be partially determined when we assume that the Nash equilibrium is stable, as suggested by Dixit (1986). In this case, the sign of the own second-order derivative regarding infrastructure spending is negative, $\frac{\partial^2 U^i}{\partial m_i^2} < 0,\ i = 1, 2$, and importantly, the own effects dominate the cross effects, that is $\frac{\partial^2 U^i}{\partial m_i^2} \frac{\partial^2 U^{-i}}{\partial m_{-i}^2} > \frac{\partial^2 U^{-i}}{\partial m_{-i} \partial m_i} \frac{\partial^2 U^i}{\partial m_i \partial m_{-i}}$. A detailed derivation of the comparative static analysis is relegated to Appendix A.2. Making use of the Dixit (1986) stability assumptions, we obtain

$$\frac{\mathrm{d}m_1}{\mathrm{d}b_{10}} = -\frac{1}{\phi} \frac{\partial^2 U^2}{\partial m_2^2} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} < 0, \tag{15}$$

$$\frac{\mathrm{d}m_2}{\mathrm{d}b_{10}} = \frac{1}{\phi} \frac{\partial^2 U^2}{\partial m_2 \partial m_1} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} > 0, \tag{16}$$

with $\phi = \frac{\partial^2 U^1}{\partial m_1^2} \frac{\partial^2 U^2}{\partial m_2^2} - \frac{\partial^2 U^2}{\partial m_2 \partial m_1} \frac{\partial^2 U^1}{\partial m_1 \partial m_2} > 0$ and $\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} = h''_{11} \frac{\gamma^2}{\beta} c' < 0$. The latter inequality means that the incentive to invest in infrastructure declines with higher legacy debt, as the marginal utility of consumption rises when $h''_{i1} < 0$. Thus, equation (15) contains our second important result: If a jurisdiction is constrained in its borrowing, an increase in that jurisdiction's legacy debt leads unambiguously to a decline in its infrastructure investment. The cross effect of an increase in legacy debt on the infrastructure investment in the other jurisdiction is positive (see 16). 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 $\gamma\nu > 1$. Assume that only jurisdiction 1 is constrained in its borrowing decision in period 1, that initial public infrastructure levels are symmetric $\bar{q}_1 = \bar{q}_2$, and that a stable Nash equilibrium is obtained. Then, an increase in the legacy debt of jurisdiction 1 (b_{10}) leads to a decline in infrastructure investment (m_1) and also reduces i's period 2 tax rate (τ_{12}). In jurisdiction* 2, *it raises the tax rate (τ_{22}) and infrastructure spending (m_2). As a consequence, the number of firms decreases in jurisdiction* 1 *and increases in jurisdiction* 2.

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.

Table 1: Change in Legacy Debt (b_{10}), Impact on Fiscal Policy

Borrowing Constraint	Jurisdiction 1 ($db_{10} > 0$)				Jurisdiction 2 ($db_{20} = 0$)			
	Period 1		Period 2		Period 1		Period 2	
	m_1	b_{11}	τ_{12}	N_{12}	m_2	b_{21}	τ_{22}	N_{22}
Case I (non-binding)	-	↑	-	-	-	-	-	-
Case II (binding in 1)	↓	-	↓	↓	↑	↑	↑	↑

The main reason for the negative effect of legacy debt b_{10} on public investment m_1 is that borrowing cannot be increased to smooth consumption if the borrowing constraint 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 second best government response is to reduce investment in public infrastructure in that jurisdiction. This in turn lowers government spending in period 1 and increases the space for public good consumption. At the same time, the constrained government makes up for reduced competitiveness in period 2 by lowering its tax rate in the long run.

The increase in b_{10} also affects public investment policy in jurisdiction 2. The decrease in m_1 provides an incentive for jurisdiction 2 to increase public investment because of the strategic advantage arising from this situation.[22] As a consequence, jurisdiction 2 becomes more attractive in period 2.

A policy divergence occurs also in the period 2 tax equilibrium. Starting from a stable equilibrium, 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 afford a higher tax because the better relative standing in public infrastructure partially offsets higher taxes. Overall, we conclude that in the case of constrained borrowing an exogenous increase in government debt leads to policy divergence across jurisdictions regarding fiscal competition instruments.

How are the results from Proposition 3 changed if the borrowing constraint is binding in both jurisdictions? In this case, the set of first-order conditions in period 1 is reduced to (10) and (11). Thus, the maximization problem of each jurisdiction is identical to the constrained jurisdiction in Case II and the direction of the response of jurisdiction 1 to a marginal increase in b_{10} is as described in Proposition 3. The effect of a change in b_{10} on m_2 depends on the strategic interaction of public infrastructure investment. If public

[22]Since jurisdiction 2 is not constrained in its borrowing, the increase in m_2 is financed by an increase in b_{21}, see Appendix A.2.

investments are strategic substitutes, the less indebted jurisdiction 2 reacts to jurisdiction 1's decrease in m_1 with an increase in m_2.[23] However, even if jurisdiction 2 lowers m_2, it will do so only to the extent that it can still afford a higher tax rate than jurisdiction 1 without reducing its mobile tax base. Thus, with regard to tax policy, the increase in initial debt in jurisdiction 1 leads to a divergence in the period 2 tax equilibrium independent of the infrastructure spending response in region 2 (see Appendix A.3).

An interesting additional result refers to the impact of capital mobility. Higher capital mobility, captured by a decrease in ν, puts downward pressure on equilibrium tax rates in both periods. However, in addition to this well known direct effect, an indirect effect arises when public borrowing in period 1 is restricted: Higher capital mobility reinforces the inter-temporal effect described in Proposition 3. Intuitively, higher capital mobility reduces the government's revenue from taxing firms in period 1 and makes the government more sensitive to changes in available resources in this period. An increase in legacy debt then leads to a stronger decrease in public infrastructure investment in period 1 and in tax rates in period 2.[24]

5 Robustness and Extensions

We have made several simplifying assumptions to ease presentation and direct attention to the underlying mechanisms. In this section, we demonstrate that the main insights are robust to a number of model variations. The main findings are summarized and more formal derivation are relegated to the Online Appendix.

5.1 Interaction Between Initial Public Infrastructure and Initial Public Debt

A potential feed-back mechanism of legacy debt differentials may occur if these are related to differences in initial infrastructure levels, $\bar{q}_1 \neq \bar{q}_2$. 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. Suppose that the initial level of public infrastructure is a function of legacy debt, $\bar{q}_i = \bar{q}_i\left(b_{i0}\right)$. Higher legacy debt levels could be an indicator of more public infrastructure spending in the past, for instance, because it is easier to obtain public support for such projects with debt financing (Poterba, 1995), in which case $\bar{q}_i' > 0$. High legacy debt levels may, however, also be caused by public consumption spending such that the level of existing infrastructure is negatively

[23]That is, $\frac{\partial^2 U^2}{\partial m_2 \partial m_1} < 0$, which is, for instance, obtained when the inter-temporal utility function is of the quasi-linear type ($h_{i2}'' = 0$). This is 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).

[24]Analytically, by affecting the level of tax rates in period 1, ν changes $\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}}$. In particular, $\frac{d}{d\nu}\left(\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}}\right) = h_{11}'''\left(1+r\right)\gamma^3 c'$ is positive if and only if $h_{11}''' > 0$, which holds for many strictly concave functions such as natural logarithm and square root.

related to the observed legacy debt, $\bar{q}_i' < 0$.

If we insert $\bar{q}_i = \bar{q}_i(b_{i0})$ into our model, we immediately observe that the neutrality result in Case I is overturned by an additional mechanism that results from the strategic nature of public infrastructure. If public infrastructure investments are strategic substitutes, a higher level of initial debt that is associated with a higher (or lower) level of initial public infrastructure improves (or deteriorates) a jurisdiction's position in the subsequent fiscal competition game. This increases (or decreases) public infrastructure investment in a polarization effect that has also been described in Cai & Treisman (2005).[25] The additional mechanism generates a link between b_{i0} and m_i even in the case of unrestricted public borrowing.

Inter-temporal considerations are relevant, if public borrowing is restricted (Case II). The negative effect of an increase in initial public debt on infrastructure investment in period 1 is reinforced when there is a negative relation between legacy debt and initial public infrastructure ($\bar{q}_i' < 0$). Thus, our results are even strengthened in this case. However, a positive relation between b_{i0} and $\bar{q}_i$ ($\bar{q}_i' > 0$) leads to more nuanced results because it implies that an increase in initial public debt in a jurisdiction has two opposing effects on the competitive position of this jurisdiction. On the one hand, higher legacy debt levels lead to a disadvantage because of the mechanism described in Proposition 3. The benchmark result remains relevant as the government's desire to smooth utility across periods induces it to lower m_i when the legacy debt burden is higher. On the other hand, a higher level of initial debt also implies a higher level of initial infrastructure installments which increases m_i through the polarization effect described above. This mitigates the effect described in Proposition 3. The results may even be reversed. However, we believe that this is rather unlikely because such a scenario requires very strong strategic interactions in infrastructure investments such that the polarization effect dominates the inter-temporal mechanism of Proposition 3. We have checked this using a number of numerical examples, one of which is presented in the Online Appendix.

5.2 Intra-temporal vs. Inter-temporal Effects of Public Debt on Fiscal Policy

Our analysis explores the long-run effect of legacy public debt on fiscal competition. By distorting the incentives for inter-temporal redistribution, higher initial public debt leads to a competition disadvantage of the more indebted jurisdiction. In contrast, Jensen & Toma (1991) highlight the within-period relationship between public debt and tax competition. Additional borrowing increases government resources in period 1 but decreases them in period 2, which induces redistribution between the public and the private good in a different

[25] 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 inter-temporally shifts part of the benefits from a higher level of period 2 tax revenues to period 1.

direction in each period. To focus on the derivation on the inter-temporal channel in the base model, we have muted the within-period effect by assuming a linear intra-period utility function, which holds the marginal benefit of N and the public good, respectively, constant.

If we assume instead that the intra-period utility function is not linear, the intra-temporal and inter-period effects are both at work. Under additional assumptions the results summarized in Proposition 3 can also be established using a within-period utility function of the form $u_{it} = N_{it} + f_{it}(g_{it})$, $f'_{it} > 0$, $f''_{it} \leq 0$. Legacy debt in period 1 can only affect the within-period redistribution between the public and the private good in period 2 if the reduction in government resources is transmitted from period 1 to period 2 via additional borrowing. If such consumption smoothing is constrained, the within-period effect of debt is limited to the period when it has to be repaid and does not affect fiscal competition in the long-run. By contrast, the inter-temporal channel that we derive in this paper is still relevant: higher legacy debt generates a long-run competitive disadvantage for the more indebted jurisdiction.

The neutrality result shown in Proposition 2 does not hold in general when a nonlinear within-period utility function is assumed, but may hold under additional assumptions. If additional borrowing is unconstrained, legacy debt in period 1 may affect fiscal competition in period 2 because part of the corresponding burden on government resources is shifted to period 2. An exogenous reduction in period 2 public resources leads, ceteris paribus, to an increase in tax rates in that period. This has repercussions in the fiscal competition game and also on the level of infrastructure investment in period 1. However, the additional effect is entirely driven by the non-linearity of the within-period utility function in period 2. For instance, if we let $f'_{i1} > 0$, $f''_{i1} \leq 0$, $f'_{i2} = \gamma$, $f''_{i2} = 0$, and thus allow for a strictly concave sub-utility function for the public good in period 1, we obtain the neutrality result described in Proposition 2 for the period 2 fiscal competition game. Strict concave sub-utility in period 1 affects tax competition in period 1 however, and therefore the assumption does not lead to complete neutrality.

5.3 Model Robustness

Several other modeling choices are worth being discussed in more detail. First, while in the base model the number of firms in a region enters directly into the region's utility function, our results continue to hold in a micro-founded model similar to Hindriks *et al.* (2008).[26] Second, we can show that the introduction of a tax on a less mobile base such as labor income does not affect the results with regard to the role of legacy debt in our fiscal competition model. This is true independent of whether or not the base of the additional tax instrument is linked to the base of the capital tax on mobile firms that we study in our model and also holds if the additional tax is distortive. The result is obtained because the additional tax instrument has no effect for the fiscal competition game and is optimized separately in any

[26] Results are available from the authors upon request.

case. We note, however, that the additional revenue from a labor tax can make it less likely that governments face binding constraints with regard to their borrowing.

Another important modeling choice refers to the market for government bonds. Public borrowing is assumed to take place on an international debt market with an exogenous interest rate. Both assumptions may not hold in reality. For example, governments may largely borrow domestically. In this case, the repayment burden in period one is a simple transfer between the government and its citizens. We note, however, that $\gamma > 1$ ensures that an increase in the debt repayment burden affects the marginal utility of public infrastructure investment and thus triggers the mechanism described above. Finally, private borrowing may serve as a substitute for inter-temporal redistribution by the government. This appears feasible with regard to the consumption of the private good. Public goods are, however, generally provided more efficiently by the government[27] such that private borrowing is, at best, an imperfect substitute for public redistribution across periods. Thus, inter-temporal adjustments via reductions in public infrastructure spending remain relevant. Furthermore, some citizens are likely to borrow at a higher cost than the government, and therefore private borrowing cannot completely compensate for the public borrowing restriction.

Finally, we have assumed that the interest rate is exogenous. Alternatively, one could allow for a positive, possibly convex relation between the interest rate and the level of public borrowing in the current or the previous period. The case of a contemporaneous relationship turns out to be a simple extension to our model in which the marginal increase in the initial public debt burden is reinforced by its effect on the interest paid.[28] The case with a lagged relationship introduces a cost on the inter-temporal redistribution via public borrowing. If the relation between past borrowing and the current interest rate is non-linear (e.g. convex), this precludes the friction-less reallocation of resources between periods through additional borrowing. As a consequence, more borrowing is not necessarily the best option for inter-temporal redistribution since the corresponding costs must be compared to the cost of redistribution between periods via an adjustment in long-run public infrastructure investment. Our results thus rely on the assumption that public borrowing is generally used as the best option for inter-temporal utility-smoothing in the sense of Barro (1979).

6 Empirical Insights from Local Tax Competition

The results we derive from the fiscal competition model are consistent with descriptive evidence on key fiscal policy indicators for a large set of developed economies (see Section 2). While tax competition between these countries appears to be a relevant phenomenon (Slemrod, 2004; Devereux *et al.*, 2008), it is difficult to determine whether a tax rate change of one jurisdiction is a reaction to another jurisdiction's policy with relatively few jurisdictions

[27]In this regard, the simplifying assumption of a representative citizen in our model constitutes an exemption which would need to be relaxed to determine the optimal way of public goods provision.

[28]Formally, $\frac{\partial^2 U^i}{\partial m_i \partial b_{i0}} = h''_{i1}\gamma^2 \left(1 + r + \frac{\partial r}{\partial b_{i0}} b_{i0}\right) c' < h''_{i1}\gamma^2 (1+r) c' < 0$.

and a limited time frame. For this purpose, we note that our theoretical results also apply to local tax policy and, following previous studies (Brülhart & Jametti, 2006; Buettner, 2006; Egger *et al.*, 2010; Chirinko & Wilson, 2017), complement our analysis with descriptive evidence from fiscal competition among sub-national governments.[29] Using administrative data on tax rates, public infrastructure investment and debt repayments, we analyze the impact of legacy debt shocks on tax competition between 11,064 German municipalities. The case of Germany is a good testing ground as the constitution provides municipalities with substantial discretion in fiscal policy. Each municipality approves its own budget, which includes decisions on public borrowing and public investment expenditure. Furthermore, several tax rates are set at the municipal level including the taxation of business profits ("Gewerbesteuer") which affects firms location decision (Becker *et al.*, 2012). Most importantly, fiscal policy in German municipalities varies substantially both with respect to the tax rates applied and in terms of the debt ratio.

We examine how fiscal policy variables of municipalities and their competing neighbors (defined as distance-weighted averages of neighboring municipalities within a radius of 10 km) evolve around substantial increases in debt repayments of these municipalities. For this purpose, we employ an event-study design which closely follows the setup in Fuest *et al.* (2018). In this specification, the fiscal policy variable of interest (tax rates and public infrastructure investment of a municipality or its neighbors) is regressed on a set of dummies indicating individual periods before and after the debt repayment shock. Such a shock is defined as a year in which the share of net redemption payments (i.e. the difference between the total debt redemption payment and the revenue from additional borrowing)[30] in the net expenditure of a municipality exceeds three times its within-municipality average. It thus corresponds to an increase in the initial debt repayment burden, b_{i0}, in our theoretical model, which in turn results in a net repayment burden in period 1 of $b_{i1} - (1 + r)b_{i0}$.

Empirically, the debt repayment shock may be subject to endogeneity. We are thus cautious with regard to causality in our empirical observations. However, we note that German municipalities often issue debt which matures several election cycles later, making it difficult for local governments to effectively time bond maturities. This mitigates endogeneity concerns. The research design is further validated because the event-study design does not detect any difference in pre-trends for tax rates, which are the focus of this analysis.

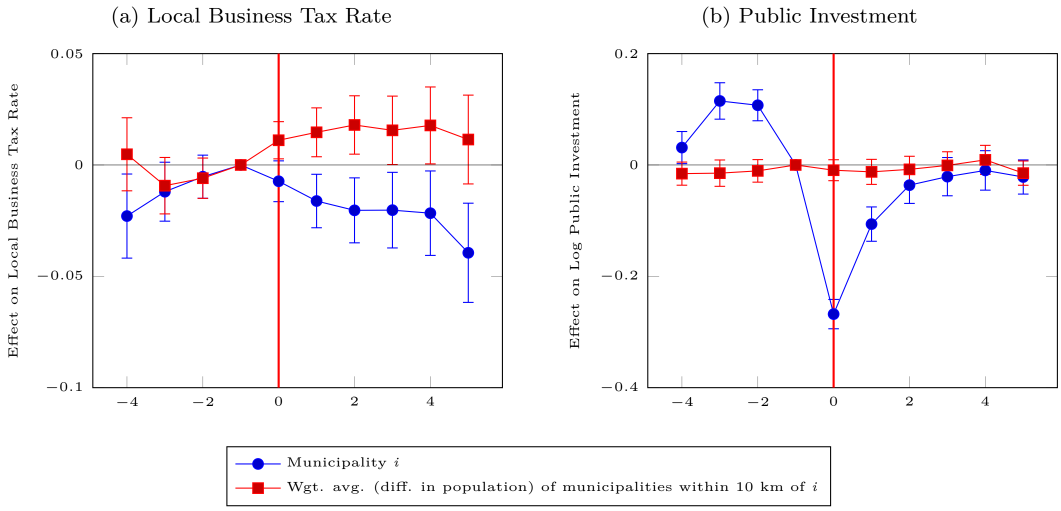
Here, we graphically present the results of the event-study analysis. A more detailed description of the methodological approach and the data used in this exercise can be found

[29] The extent to which local governments engage in tax competition remains subject to debate. Empirical studies using spatial lag models have pointed towards the existence of local tax competition with tax rates being strategic complements (e.g. Buettner, 2001; Hauptmeier *et al.*, 2012). In an additional regression presented in the Online Appendix, we are able to confirm this result for our sample. However, spatial lag models are problematic if tax rates of competing jurisdictions are not endogenous. Recent studies using different identification strategies offer ambiguous results. While Baskaran (2014) finds no strategic interaction of local tax rates, Eugster & Parchet (forthcoming) provide evidence for local tax competition.

[30] Net redemption payments are set to zero whenever newly issued credit exceeds redemption payments. This avoids classifying temporary reductions of municipal borrowing with a continuing increase in public debt as debt repayment shocks.

in the Online Appendix. Figure 2 displays graphs for the response of the local business tax

Figure 2: Event Study



This figures plots the estimated coefficients and standard errors for the following event-study design: $y_{i,t} = \sum_{n=-4}^{5} \alpha_n s_{i,t-n} + \boldsymbol{\beta_2 x_{i,t}} + \boldsymbol{\psi} + \epsilon_{i,t}$. $y_{i,t}$ is the fiscal policy variable of interest in municipality i (blue dots) or the weighted averages of its neighbors (red squares) at year t, $s_{i,t}$ is a dummy that indicates whether in year t municipality i experienced a debt repayment shock. End points of the event window are adjusted to indicate whether a debt repayment shock has occurred 4 or more years before (upper window limit) and 5 or more years after a given year (lower window limit) (Kline, 2012; Fuest *et al.*, 2018). The regressor in the year before the repayment shock is dropped and normalized to zero. $\boldsymbol{x_{i,t}}$ is a vector of control variables including the logarithm of total population and the logarithm of district GDP per capita of the municipality i (blue dots) or the weighted averages of its neighbors (red squares). $\boldsymbol{\psi}$ is a vector of fixed effects including year-fixed effects, municipality-fixed effects and state-year-fixed effects. Standard errors are clustered on firm level. 95% confidence intervals are reported. Estimations include municipality-fixed, year-fixed and state-year-fixed effects.

rate (panel a) as well as public infrastructure investment (panel b) of both the municipality itself (blue dots) and the neighboring municipalities (red squares).

First, we explore the local business tax response (panel a). From year 2 after the debt shock onward, the tax rate is about 0.02 percentage points lower in each year. This delayed response mirrors the dynamics in the theoretical analysis. The tax rate cut - that is aimed at restoring the jurisdiction's attractiveness - only occurs in later periods when a lower level of past investment and thus less public infrastructure becomes effective.[31] How do competing municipalities react to debt repayment shocks affecting their neighbors? We approach this issue in an additional estimation involving the weighted average of the business tax rate of a municipality's neighbors as dependent variable. Our results suggest that neighboring governments increase their tax rates for local business profits. This finding is consistent with our theoretical model and is an indicator of tax competition. Thus, we observe a significant divergence in the local business income tax rate of indebted municipalities and their neighbors.

Turning to infrastructure expenditure, we note in Panel (b) of Figure 2 that the jurisdictions which experience a debt repayment shock substantially reduce their investment

[31] The estimated tax cut is significant but in absolute size relatively small. We attribute this finding to a generally low level of tax competition among German municipalities. The lack of fiscal competition among German municipalities has mainly been explained by the existence of equalization grants for municipalities in many German states (Baretti *et al.*, 2002; Buettner, 2006; Egger *et al.*, 2010). Furthermore, previous studies have found only small cross-border effects of local tax rates in Germany (e.g. Buettner, 2003).

expenditure in the year of the shock and also in the years immediately after the shock. The main effect occurs instantly, with a decrease of public investment expenditure of 26.8% in the year of the shock. The negative effect is smaller in later years and diminishes to an insignificant decrease of 0.1% five years after the shock. This dynamic pattern is consistent with our theoretical analysis. Turning to the pattern prior to the shock, the level of public investment is higher in the treated localities prior to the shock. Quantitatively, however, the positive effect does not match the negative effect after the repayment shock so that on net, infrastructure spending decreases in that jurisdiction. Building on our theoretical model in Section 5.1, the positive pre-trend in public investment spending could mean that at least part of the debt repayment shock (i.e. the initial debt burden in the theoretical model) is related to an earlier increase in public infrastructure investment. We expect past infrastructure spending of a jurisdiction to make it more appealing to investors in the long run. This at least partly compensates for the negative impact of subsequent infrastructure spending cuts on the jurisdiction's attractiveness, and therefore reduces current strategic infrastructure spending in competing jurisdictions. In fact, we find no significant effect of a debt repayment increase on infrastructure investments of competing neighbors. The estimated coefficients are displayed as red squares in Panel (b) of Figure 2. Strategic interaction of infrastructure spending in the sample may be further weakened by positive spillover-effects of infrastructure due to close proximity of competing municipalities. In that case jurisdictions benefit from what happens in neighboring regions and partially free ride. Moreover, an upward adjustment in infrastructure spending, as predicted by our theory, is sometimes not easily achieved in practice as new investment opportunities have to be developed first.[32]

7 Conclusion

In this paper, we have used a two-jurisdiction, two-period model to analyze the role of initial public debt levels on fiscal competition. We first show that in the absence of government borrowing constraints 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 consider a situation in which one government is constrained in its borrowing, either due to endogenous default or constraints from fiscal rules. This restricts inter-temporal redistribution by governments and provides an important theoretical link between legacy debt and fiscal competition.

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

[32] In contrast, municipalities can easily reduce current investment expenditure by postponing or canceling planned investment projects.

tax rates in the second period. In our two-jurisdiction model, the jurisdiction experiencing an increase in legacy debt therefore invests less and sets a lower tax on capital, while the opposite occurs in the other (unconstrained) jurisdiction. 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, but tends to reinforce the effect of initial debt.

Our model is inspired by the effects of the economic and financial crisis in 2008-2010, which indeed led to strong reductions in public investment spending and delayed reductions in corporate tax rates in countries that experienced a major downgrade in the debt rating. In addition, we show that the fiscal behavior of municipalities in Germany is broadly in line with the theoretical model predictions. Tax rates diverge when a municipality experiences a debt repayment shock. While the response is statistically significant, it is relatively small in value, which may be explained by the strong fiscal equalization scheme and the large number of interacting municipalities. We also find a strong negative public investment response by the municipality experiencing the shock. Neighboring regions, however, do not adjust in a significant way their public investment, as our benchmark result predicts, perhaps because increases in investment take more time compared to cuts.

Our results provide insights into current policy debates. For example, in Germany the federal states (Länder) have little tax autonomy. Some policy makers and many academics support more tax autonomy for states such as a state income and 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 government borrowing constraints play a crucial role and would disadvantage highly indebted regions. Our model also sheds light on the efforts to harmonize corporate taxes in the European Union. Attempts to harmonize tax rates may have become more difficult after the economic and financial crisis because countries with a high debt repayment burden may have very different fiscal policy strategies than governments with a low level of consolidation requirement.

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Appendix

A.1 Second-Order Conditions for Case I

The Hessian for the system of first-order conditions (10) to (12) for jurisdiction i is given by

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

In the second term, we insert the first-order condition for taxes (10) 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 (10) to (12) to yield a maximum, $\boldsymbol{H}$ must be negative definite which is the case if and only if

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

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

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

Condition (A.1) is fulfilled for any sufficiently convex public investment cost function $c(m_i)$. In particular, noting from (12) that $h'_{i2} = h'_{i1}$, we know that $c''(m_i) > \frac{\beta\gamma\rho^2}{9\nu}$ is a sufficient condition for (A.1) to be satisfied. This relation holds for a wide range of parameters and functional forms. 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 $\frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} = -\gamma^2 h''_{i1} c' - \gamma h''_{i2} \left(\frac{\partial \tilde{N}_{i2}(1+\gamma\tilde{\tau}_{i2})}{\partial m_i} \right) > 0$ such that for (A.3) to hold, we must have $\frac{\partial^2 U^i}{\partial m_i^2} \frac{\partial^2 U^i}{\partial b_{i1}^2} > \left(\frac{\partial^2 U^i}{\partial b_{i1} \partial m_i} \right)^2$. Inserting the first-order conditions (11) and (12), it is straightforward to show that this condition is satisfied if $c''(m_i) > \frac{\beta\gamma\rho^2}{9\nu}$.

A.2 Comparative Statics for Case II

If Condition 1 is binding in jurisdiction 1, the system of first-order conditions is given by

$$\frac{\partial U^i}{\partial \tau_{i1}} = h'_{i1}\frac{\partial\left(N_{i1}\left(1+\gamma\tau_{i1}\right)\right)}{\partial \tau_{i1}} = 0,\ i=1,2, \tag{A.4}$$

$$\frac{\partial U^1}{\partial m_1} = -h'_{11}\gamma c' + \beta h'_{12}\frac{\partial\left(\tilde{N}_{12}\left(1+\gamma\tilde{\tau}_{12}\right)\right)}{\partial m_1} = 0, \tag{A.5}$$

$$\frac{\partial U^2}{\partial m_2} = -\gamma c' + \beta\frac{\partial\left(\tilde{N}_{22}\left(1+\gamma\tilde{\tau}_{22}\right)\right)}{\partial m_2} = 0. \tag{A.6}$$

Condition (A.6) is obtained by inserting the first-order condition for b_{21}, (12), into the first order condition for m_2, (11), as in Case I. The Hessian for the system of first-order conditions for jurisdiction 1 (A.4), and (A.5) given by

$$\boldsymbol{H} = \begin{pmatrix} \frac{\partial^2 U^1}{\partial m_1^2} & \frac{\partial^2 U^1}{\partial \tau_{11}\partial m_1} \\ \frac{\partial^2 U^1}{\partial m_1 \partial \tau_{11}} & \frac{\partial^2 U^1}{\partial \tau_{11}^2} \end{pmatrix} = \begin{pmatrix} \frac{\partial^2 U^1}{\partial m_1^2} & 0 \\ 0 & \frac{\partial^2 U^1}{\partial \tau_{11}^2} \end{pmatrix}$$

In the second term, we insert the first-order condition for taxes (A.4) to verify that $\frac{\partial^2 U^1}{\partial m_1 \partial \tau_{11}} = 0$. For (A.4) and (A.5) to yield a maximum, $\boldsymbol{H}$ must be negative definite which is the case if and only if

$$\frac{\partial^2 U^1}{\partial m_1^2} = h''_{11}\left(\gamma c'\right)^2 - h'_{11}\gamma c'' + \beta h''_{12}\left(\frac{\partial \tilde{N}_{12}\left(1+\gamma\tilde{\tau}_{12}\right)}{\partial m_1}\right)^2 + \beta h'_{12}\frac{\gamma\rho^2}{9\nu} < 0, \tag{A.7}$$

$$\frac{\partial^2 U^1}{\partial m_1^2}\frac{\partial^2 U^1}{\partial \tau_{11}^2} > 0. \tag{A.8}$$

Condition (A.7) holds if $-\frac{\partial\left(\tilde{N}_{12}(1+\gamma\tilde{\tau}_{12})\right)}{\partial m_1}\frac{c''}{c'} < \frac{\gamma\rho^2}{9\nu}$ which is true for any convex function c. Since $\frac{\partial^2 U^1}{\partial \tau_{11}^2} < 0$, (A.8) must hold whenever (A.7) holds. The first-order conditions for taxes (A.4) yield again (13). The Dixit (1986) stability conditions are

$$\frac{\partial^2 U^i}{\partial m_i^2} < 0,\ \frac{\partial^2 U^{-i}}{\partial m_{-i}^2} < 0,\ \frac{\partial^2 U^i}{\partial m_i^2}\frac{\partial^2 U^{-i}}{\partial m_{-i}^2} > \frac{\partial^2 U^{-i}}{\partial m_{-i}\partial m_i}\frac{\partial^2 U^i}{\partial m_i \partial m_{-i}}. \tag{A.9}$$

Taking the total differential of the first-order conditions with respect to b_{10}, we arrive at the following system of equations

$$\begin{pmatrix} \frac{\partial^2 U^1}{\partial m_1^2} & \frac{\partial^2 U^1}{\partial m_1 \partial m_2} \\ \frac{\partial^2 U^2}{\partial m_2 \partial m_1} & \frac{\partial^2 U^2}{\partial m_2^2} \end{pmatrix}\begin{pmatrix} \mathrm{d}m_1 \\ \mathrm{d}m_2 \end{pmatrix} + \begin{pmatrix} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} \\ 0 \end{pmatrix}\mathrm{d}b_{10} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \tag{A.10}$$

which can be rearranged to yield

$$\frac{\mathrm{d}m_1}{\mathrm{d}b_{10}} = -\frac{1}{\phi}\frac{\partial^2 U^2}{\partial m_2^2}\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} < 0,\ \frac{\mathrm{d}m_2}{\mathrm{d}b_{10}} = \frac{1}{\phi}\frac{\partial^2 U^2}{\partial m_2 \partial m_1}\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} > 0, \tag{A.11}$$

with $\phi = \frac{\partial^2 U^1}{\partial m_1^2}\frac{\partial^2 U^2}{\partial m_2^2} - \frac{\partial^2 U^2}{\partial m_2 \partial m_1}\frac{\partial^2 U^1}{\partial m_1 \partial m_2} > 0$. The first effect is obtained because of the Dixit (1986) stability conditions and since $\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} < 0$. The second effect results from $\frac{\partial^2 U^2}{\partial m_2 \partial m_1} = -\frac{\gamma\rho^2}{9\nu} < 0$. From Proposition 1, we know that the effect of a change in b_{i0} on τ_{i2}^* and N_{i2}^* is given by

$$\frac{d\tau_{i2}^*}{db_{i0}} = \frac{\rho}{3}\frac{d\Delta q_{i2}}{db_{i0}} = \frac{\rho}{3}\left(\frac{dm_i}{db_{i0}} - \frac{dm_{-i}}{db_{i0}}\right), \; \frac{dN_{i2}^*}{db_{i0}} = \frac{\rho}{6\nu}\frac{d\Delta q_{i2}}{db_{i0}} = \frac{\rho}{6\nu}\left(\frac{dm_i}{db_{i0}} - \frac{dm_{-i}}{db_{i0}}\right) \tag{A.12}$$

where $\Delta q_{i2} = m_i - m_{-i}$ (assuming that $\bar{q}_1 = \bar{q}_2$). It follows from (A.11) that $\frac{d\tau_{12}^*}{db_{10}} < 0$, $\frac{dN_{12}^*}{db_{10}} < 0$, $\frac{d\tau_{22}^*}{db_{20}} > 0$ and $\frac{dN_{22}^*}{db_{20}} > 0$.

Adjustment in period 1 borrowing only occurs in jurisdiction 2 as jurisdiction 1 is constrained. We derive jurisdiction 2's borrowing response by totally differentiating the corresponding first order condition for b_{12} (12) with respect to m_1, m_2 and b_{12} which yields

$$\frac{\partial^2 U^2}{\partial b_{21}^2}db_{21} + \frac{\partial U^2}{\partial b_{21}\partial m_2}dm_2 + \frac{\partial U^2}{\partial b_{21}\partial m_1}dm_1 = 0. \tag{A.13}$$

Substituting (15) and (16) for dm_1 and dm_2 we solve for

$$\frac{db_{21}}{\mathrm{d}b_{10}} = \frac{1}{\phi}\left(\frac{\partial U^2}{\partial b_{21}\partial m_1}\frac{\partial^2 U^2}{\partial m_2^2} - \frac{\partial U^2}{\partial b_{21}\partial m_2}\frac{\partial^2 U^2}{\partial m_2 \partial m_1}\right)\frac{\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}}}{\frac{\partial^2 U^2}{\partial b_{21}^2}} > 0 \tag{A.14}$$

where the inequality follows because $\frac{\partial U^2}{\partial b_{21}\partial m_2} > 0$, $\frac{\partial^2 U^2}{\partial m_2 \partial m_1} < 0$, $\frac{\partial^2 U^2}{\partial m_2^2} < 0$, $\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} < 0$, $\frac{\partial^2 U^2}{\partial b_{21}^2} < 0$ (see Section A.1) and $\frac{\partial U^2}{\partial b_{21}\partial m_1} = -\gamma h_{i2}''\left(\frac{\partial \tilde{N}_{22}(1+\gamma\tilde{\tau}_{22})}{\partial m_1}\right) < 0$.

A.3 Comparative Statics for Constrained Borrowing in Both Jurisdictions

Taking the total differential of the first-order conditions we arrive at the same system of equations as in (A.10) which can be rearranged to yield expressions for $\frac{\mathrm{d}m_2}{\mathrm{d}b_{10}}$ and $\frac{\mathrm{d}m_1}{\mathrm{d}b_{10}}$ as in (A.11). Since $\frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} < 0$, the Dixit (1986) stability conditions (A.9) again imply $\frac{\mathrm{d}m_1}{\mathrm{d}b_{10}} < 0$. However, since the first-order condition for b_{20} does not necessarily hold, it cannot be substituted to yield $\frac{\partial^2 U^2}{\partial m_2 \partial m_1} < 0$ which leads to the unambiguous result obtained for jurisdiction 2 in (A.11). If $h_{i2}'' = 0$ such that U^2 is quasi-linear, we can show that $\frac{\mathrm{d}m_2}{\mathrm{d}b_{20}} < 0$ by verifying that in this case

$$\frac{\partial^2 U^2}{\partial m_2 \partial m_1} = -\beta h_{22}''\left(\frac{\rho}{6\nu} + \frac{\gamma\rho}{3}\left(\frac{1}{2\nu}\tau_{12} + N_{12}\right)\right)^2 - \frac{\gamma\rho^2}{9\nu}\beta h_{22}' = -\frac{\gamma\rho^2}{9\nu}\beta h_{22}' < 0.$$

The effect of a marginal increase in b_{10} on tax rates and the number of firms is again given by (A.12). Substituting from (15) and (16) and noting that

$$\frac{\partial^2 U^2}{\partial m_2 \partial m_1} = -\beta h'_{22} \frac{\gamma \rho^2}{9\nu} - \beta h''_{22} \left(\frac{\rho}{6\nu} (1 + \gamma \tau_{22}) + \frac{\rho}{3} N_{22} \right)^2 ,$$
$$\frac{\partial^2 U^2}{\partial m_2^2} = h''_{21} (\gamma c')^2 - h'_{21} \gamma c'' - \frac{\partial^2 U^2}{\partial m_2 \partial m_1}$$

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

$$\frac{d\tau_{12}^*}{db_{10}} = -\frac{1}{\phi} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} \frac{\rho}{3} \left(h''_{21} (\gamma c')^2 - h'_{21} \gamma c'' \right) < 0,$$
$$\frac{dN_{12}^*}{db_{10}} = -\frac{1}{\phi} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} \frac{\rho}{6\nu} \left(h''_{21} (\gamma c')^2 - h'_{21} \gamma c'' \right) < 0,$$
$$\frac{d\tau_{22}^*}{db_{10}} = \frac{1}{\phi} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} \frac{\rho}{3} \left(h''_{21} (\gamma c')^2 - h'_{21} \gamma c'' \right) > 0,$$
$$\frac{dN_{22}^*}{db_{10}} = \frac{1}{\phi} \frac{\partial^2 U^1}{\partial m_1 \partial b_{10}} \frac{\rho}{6\nu} \left(h''_{21} (\gamma c')^2 - h'_{21} \gamma c'' \right) > 0.$$

The inequality is a result of the convexity of c and the strict concavity of h_{i1}. Note that in the derivation above, the indices for jurisdiction 1 and 2 are interchangeable because, with both jurisdictions constrained in their borrowing, it is irrelevant where the marginal increase in initial public debt that we investigate in the comparative static analysis occurs.

A.4 The Economic and Financial Crisis 2008: Additional Tables

Table A.1: S&P Country Ratings, 2008-2017

Country	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Constrained in 2010-2012
AUS	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
AUT	AAA	AAA	AAA	AAA	AA+	AA+	AA+	AA+	AA+	AA+	No
BEL	AA+	AA+	AA+	AA	AA	AA	AA	AA	AA	AA	No
BGR	BBB	BBB	BBB	BBB	BBB	BBB	BB+	BB+	BB+	BBB-	No
CAN	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
CHE	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
CYP	A+	A+	A	BBB	CCC+	B-	B+	BB-	BB	BB+	Yes
CZE	A	A	A	AA-	AA-	AA-	AA-	AA-	AA-	AA-	No
DEU	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
DNK	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
ESP	AAA	AA+	AA	AA-	BBB-	BBB-	BBB	BBB+	BBB+	BBB+	Yes
EST	A	A-	A	AA-	AA-	AA-	AA-	AA-	AA-	AA-	No
FIN	AAA	AAA	AAA	AAA	AAA	AAA	AA+	AA+	AA+	AA+	No
FRA	AAA	AAA	AAA	AAA	AA+	AA	AA	AA	AA	AA	No
GBR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AA	AA	No
GRC	A	BBB+	BB+	CC	B-	B-	B	CCC+	B-	B-	Yes
HRV	BBB	BBB	BBB-	BBB-	BB+	BB+	BB	BB	BB	BB	No
HUN	BBB	BBB-	BBB-	BB+	BB	BB	BB	BB+	BBB-	BBB-	No
IRL	AAA	AA	A	BBB+	BBB+	BBB+	A	A+	A+	A+	Yes
ISL	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-	BBB	BBB+	A	No
ITA	A+	A+	A+	A	BBB+	BBB	BBB-	BBB-	BBB-	BBB	Yes
JPN	AA	AA	AA	AA-	AA-	AA-	AA-	A+	A+	A+	No
KOR	A	A	A	A	A+	A+	A+	AA-	AA	AA	No
LTU	BBB+	BBB	BBB	BBB	BBB	BBB	A-	A-	A-	A-	No
LUX	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
LVA	BBB	BB	BB+	BB+	BBB	BBB+	A-	A-	A-	A-	No
MLT	A	A	A	A	A-	BBB+	BBB+	BBB+	A-	A-	No
NLD	AAA	AAA	AAA	AAA	AAA	AA+	AA+	AAA	AAA	AAA	No
NOR	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
NZL	AA+	AA+	AA+	AA	AA	AA	AA	AA	AA	AA	No
POL	A-	A-	A-	A-	A-	A-	A-	A-	BBB+	BBB+	No
PRT	AA-	A+	A-	BBB-	BB	BB	BB	BB+	BB+	BBB-	Yes
ROM	BB+	BB+	BB+	BB+	BB+	BB+	BBB-	BBB-	BBB-	BBB-	No
SVK	A+	A+	A+	A+	A	A	A	A+	A+	A+	No
SVN	AA	AA	AA	AA-	A	A-	A-	A-	A	A+	No
SWE	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	AAA	No
USA				AA+	AA+	AA+	AA+	AA+	AA+	AA+	No