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Multi-dimensional Interjurisdictional Competition and Coordination

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Contents

Abstract

The present dissertation aims to extend classical tax competition to a more general framework in which jurisdictions compete in both taxes and non-tax instruments. In this context, issues related to dynamic competition and tax coordination are investigated.

Dynamic aspects of multi-dimensional competition. Under dynamic competition, firms choose their location dynamically in each period to maximize their respective profits. We develop a dynamic relocation rule of firms based on the home attachment principle. Applying this rule, dynamic competition in taxes and public services among unequally sized jurisdictions is investigated. We account for the widely recognized characteristic that small states are more flexible in their decison-making than larger economies. However, small countries may suffer from limited institutional capacity in the provision of public services. Consequently, small and large countries behave asymmetrically when they compete for internationally mobile capital. This heterogeneity is analyzed within a differential game framework. We demonstrate that in case of high capital mobility small economies may collapse economically if public services are inefficiently provided. When capital mobility is very low, a small state's economy always expands despite its limited institutional capacity.

Tax coordination aspects. When jurisdictions compete in taxes and infrastructure, the desirability of tax coordination is analyzed. The timing of the game is considered in two different ways, simultaneous and sequential games. Two tax coordination devices (a common tax rate and a minimum tax rate) are considered. We demonstrate that tax coordination does not necessarily generate the welfare effects often observed in pure tax competition literature. The reason is that the decision to coordinate on tax rate induces a carry-over effect on infrastructure expenditures. Moreover, we highlight that tax coordination is more likely to be detrimental when countries can compete simultaneously in taxes and infrastructure, rather than sequentially.

Then, we investigate whether partial tax coordination benefits the tax union (the insiders) and/or the outsiders since tax coordination can be decided among a subset of countries that forms a tax union. The member states of the union coordinate tax policies but still compete in infrastructure provision. In addition, the union as a whole competes in taxes and infrastructure with the rest of the world. We demonstrate that partial tax coordination can harm both union members and non-union members. This contrasts with the classical view that partial tax coordination is Pareto improving.

Size effect on social welfare. Finally, we analyze how social welfare is impacted by increasing the size asymmetry of countries when they compete in taxes and infrastructure. It appears that increasing size asymmetry does not necessarily exacerbate the inefficiency of tax competition. More precisely, if the degree of international openness is low (high), social welfare decreases (increases) with size asymmetry.

Chapter 1

Interjurisdictional Competition and Coordination

1.1 Introduction

Tax competition is defined as noncooperative tax setting by independent governments, under which each government's policy choices influence the allocation of a mobile tax base among jurisdictions (Wilson and Wildasin, 2004). In general, independent governments are assumed to engage in tax competition to maximize the welfare of their residents.

The present dissertation aims to extend pure tax competition to a more general framework in which jurisdictions compete in both taxes and non-tax instruments (for example, infrastructure provision). In this context, issues related to dynamic competition and tax coordination are investigated.

In the following sections, pure tax competition (and coordination) and multi-dimensional competition (and coordination) are briefly reviewed.

1.1.1 Pure tax competition and coordination

Traditional contributions to the theory of pure tax competition suggest that competition for capital leads to inefficiently low tax rates and the under-provision of public goods. The reason is that competing jurisdictions do not account for the fact that the modifying their respective tax rates impacts the welfare of rival jurisdictions. This fiscal externality leads to inefficiencies, which are analyzed by Oates (1972) and formally modeled by Zodrow and Mieszkowski (1986) and Wilson (1986). Growing economic integration has increased international factor mobility, which puts downward pressure on national tax policies and possibly leads to a 'race to the bottom' in taxes.

Numerous extensions have been made to the early contributions by Zodrow and Mieszkowski (1986) and Wilson (1986) (see comprehensive surveys, Wilson, 1999; Wilson and Wildasin, 2004; Boadway and Tremblay, 2011). Wilson (1995) studies tax competition with mobile production factors, whereas other papers (see Wildasin and Wilson, 1996; Burbidge and Myers, 1994; Wellisch, 1994) consider cases of imperfect mobility of factors. Several authors (Wilson, 1995; Hoyt, 1991; Krelove, 1993; Bucovetsky and Wilson, 1991; Jensen and Toma, 1991) analyze tax competition among jurisdictions assuming that local governments compete with more than two tax instruments.

Asymmetric competition among jurisdictions has also attracted attention in tax competition literature (see for example, Bucovetsky, 1991; Wilson, 1991; Kanbur and Keen, 1993). Bucovetsky (1991) addresses tax competition when competing countries differ in size[1]. Kanbur and Keen (1993) consider asymmetric[2] tax competition and the welfare implications of tax coordination. They show that larger country faces a lower tax elasticity of capital than do smaller rivals, and hence lower marginal cost of public funds. Therefore, they choose higher tax rates than the smaller countries. Moreover, some authors (Kanbur and Keen, 1993) demonstrate that size differences between competing jurisdictions exacerbate the inefficiencies of noncooperative tax behavior. Consequently, reducing the disparities in size should be strictly Pareto-improving.

[1]Wilson (1991) assumes that the endowment of capital is asymmetric among competing regions.

[2]They assume that competing countries are unequally populated.

Models of tax competition usually assume a single-period framework and few papers investigate fiscal competition in a dynamic setting. Coates (1993) considers the issue of property tax competition. His model captures the intertemporal trade-offs between the current and future consumption of both private and public goods. He partially analyzes the open-loop equilibrium of a dynamic game. Cardarelli (2002) focuses on trigger-type strategies in a model of repeated tax competition.

Fiscal competition in both space (i.e., the movement of resources among jurisdictions) and time (i.e., the movement process occurs gradually) is studied by Wildasin (2003) in an explicitly dynamic framework. The model assumes that the degree of factor mobility between jurisdictions is imperfect because it is costly and time-consuming to adjust factor stocks. The paper shows that taxation of mobile factors in the short run redistributes income in favor of the owners of immobile resources, even though this is harmful in the long run. This is because there are short-run rents that can be captured from the non-resident owners of these factors. Wildasin (2011) investigates the comparative dynamics of adjustment to changes in local fiscal policy with two imperfectly mobile productive resources. He suggests that the evaluation of the fiscal treatment of one resource must account for the simultaneous adjustment of both.

Tax coordination has been proposed to correct the inefficiencies resulting from tax competition. Two most commonly advanced coordination devices[3] are tax harmonization and the imposition of a minimum tax rate. For example, Kanbur and Keen (1993) study commodity tax coordination between two unequally sized countries. They show that tax harmonization and setting a minimum tax rate can be Pareto improving. When tax coordination is implemented among a subset of all the considered countries, Konrad and Schjelderup (1999) show that in the standard tax competition framework, partial tax harmonization is Pareto improving if the tax rates are strategic complements.

However, an inconsistency between theoretical and empirical results can arise. For example, empirical evidence of tax competition does not support the 'race to the bottom'

[3]The existing literature also suggests other ways of coordination. Wildasin (1989) suggests that central governments can provide regions with a 'corrective subsidy', whereas Boadway and Flatters (1982) discuss intergovernmental transfers designed to address inefficiencies due to tax competition.

hypothesis highlighted in the tax competition literature. In particular, Bénassy-Quéré et al. (2007) show that high tax rates exist in the majority of EU-15 countries. Baldwin and Krugman (2004) explain that economies of agglomeration support the existence of high tax rates in such industrialized "core" regions. However, other authors (for example, Pieretti and Zanaj, 2011) argue that jurisdictions, in addition to taxes, may compete for mobile factors with non-tax instruments.

The following section reviews the studies in which taxes and infrastructure provision are jointly employed to attract mobile production factors.

1.1.2 Multi-dimensional competition and coordination

In the same way that firms differentiate the quality of their products to relax price competition, regions can avoid head-to-head tax competition by offering infrastructure service that are differentiated by quality (Justman et al., 2002). Tiebout (1956) was the first to suggest that competition between jurisdictions may promote efficiency if citizens are able to sort themselves into jurisdictions composed of those with similar preferences for public good provision. Keen and Marchand (1997) incorporate taxes, public goods, and public inputs into their model. They show that tax competition may lead not only to inefficient levels of aggregate public expenditure but also to systematic inefficiencies in the composition of public expenditures. Epple and Soeg (1999) and Hoyt (2001) analyze interjurisdictional competition in the quality of education services. Justman et al. (2002) demonstrate that regions can benefit by offering infrastructure services that are differentiated by quality, thus segmenting the market for industrial location.

However, in the above mentioned papers, the different strategic variables (taxes and public inputs) are related through a balanced budget. Wildasin (1991) argues that equilibria in fiscal competition games with two instruments related via a budget constraint crucially depend on which instrument is set strategically. Consequently, if countries interact in taxes, infrastructure provision is not a distinct strategic variable.

As a matter of fact, Hauptmeier et al. (2012) analyze how governments set taxes and infrastructure expenditures to affect investors' choices. In this case, if one jurisdiction cuts its tax rates, rival countries try to restore competitiveness by lowering their own rates and increasing public investments. Moreover, if neighbor countries increase their spending on local infrastructure, other governments react by strongly increasing their own spending. The empirics confirm that local governments use both taxes and public investments to compete for mobile capital.

Pieretti and Zanaj (2011) consider asymmetric competition between two unequally sized countries that set taxes and infrastructure provision independently to attract capital. Imperfectly mobile firms are supposed to account for their home attachment. The competing jurisdictions choose public investments in the first stage and set tax rates in the second stage to maximize their respective net tax revenue. As a result, when the mobility costs are low or moderate, each jurisdiction can only be attractive through the supply of higher levels of public goods and not through lower taxes. However, adopting a low-tax regime may only be a winning strategy if the mobility cost is high enough. In contrast to the pure tax competition literature, this paper suggests that if the cost of mobility is intermediate, small jurisdictions may attract international capital without being tax havens by supplying a high level of public goods.

Zissimos and Wooders (2008) analyze how variation of requirements for public goods across firms may bring about differentiation in public goods provision across countries. Then, their model analyzes tax coordination. In their paper, competing governments choose levels of infrastructure expenditures first and then set tax rates after having observed infrastructure expenditures in the previous stage. Their objective is to maximize tax revenue net of infrastructure expenditures. The paper shows that the imposition of minimum tax rates can be Pareto improving in terms of tax income. Setting a minimum tax rate or a common tax rate can enhance efficiency.

In addition to tax coordination, many federal countries have adopted various equalization schemes that allow central governments to address the issue of fiscal imbalances across jurisdictions. Hindriks et al. (2008) investigate a model of federation under fiscal equalization, with two heterogeneous regions competing in capital income taxes and public investments. The federation implements a fiscal equalization scheme in which regions share a proportion of their tax revenue. The paper shows that there is strategic under-investment among regions, even in the absence of equalization, because each region decides to under-invest to soften tax competition.

Zissimos and Wooders (2008) analyze the welfare implications of tax coordination when jurisdictions compete in taxes and infrastructure independently. However, these authors assume that the level of public expenditures remain unchanged after that tax coordination is introduced. This assumption ignores possible reactions in infrastructure expenditures following the decision to coordinate. In Chapters 4 and 5 we show that removing this assumption plays a critical role in analyzing the welfare implications of tax coordination.

1.2 Overview

When jurisdictions are supposed to compete for mobile production factors through tax incentives and non-tax instruments independently[4], many insights based on classical tax competition literature may be altered. This aspect is analyzed extensively in the present dissertation.

The first part of the dissertation consists of two chapters that address the dynamic aspects of multi-dimensional competition. Under dynamic competition, firms choose their location dynamically in each period to maximize their respective profits. Chapter 2 develops a dynamic relocation rule of firms based on the home attachment principle introduced by Mansoorian and Myers (1993). This rule is applied in Chapter 3, which focuses on dynamic competition in taxes and public services among unequally sized jurisdictions. We account for the widely recognized characteristic that small states are more flexible in their decison-making than larger economies. However, small countries may suffer from limited institutional capacity in the provision of public services. Consequently, small and large countries behave asymmetrically when they compete for in-

[4]In this dissertation, non-tax instruments are not linked to taxes by budget constraints.

ternationally mobile capital. This heterogeneity is analyzed within a differential game framework. We demonstrate that in case of high capital mobility small economies may collapse economically if public services are inefficiently provided. When capital mobility is very low, a small state's economy always expands despite its limited institutional capacity.

The second part of the dissertation includes three chapters that focus primarily on the implication of tax coordination when jurisdictions compete in taxes and infrastructure. The desirability of tax coordination is analyzed in Chapter 4. The timing of the game is considered in two different ways. When infrastructure decisions are less flexible than tax policy, jurisdictions compete successively in two strategic variables. In the first stage, governments non-cooperatively select infrastructure levels, and set the tax rates in the second stage. When tax and infrastructure instruments can be viewed as equally flexible, we model the competition using a simultaneous game. Two tax coordination devices (a common tax rate and a minimum tax rate) are considered. We assume that countries still compete in infrastructure after having coordinated their tax policies. We demonstrate that tax coordination does not necessarily generate the welfare effects often observed in pure tax competition literature. The reason is that the decision to coordinate on tax rate induces a carry-over effect on infrastructure expenditures. Moreover, we highlight that tax coordination is more likely to be detrimental when countries can compete simultaneously in taxes and infrastructure, rather than sequentially.

Then, we consider that tax coordination can be decided among a subset of countries that forms a tax union. Chapter 5 investigates whether partial tax coordination benefits the tax union (the insiders) and/or the outsiders. The member states of the union coordinate tax policies but still compete in infrastructure provision. In addition, the union as a whole competes in taxes and infrastructure with the rest of the world. We demonstrate that partial tax coordination can harm both union members and non-union members. This contrasts with the classical view that partial tax coordination is Pareto improving.

The final chapter analyzes how social welfare is impacted by increasing the size asymmetry of countries when they compete in taxes and infrastructure. It appears that increasing size asymmetry does not necessarily exacerbate the inefficiency of tax competition. More precisely, if the degree of international openness is low (high), social welfare decreases (increases) with size asymmetry.

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Part I

Dynamic Multi-dimensional Interjurisdictional Competition

Chapter 2

An Extension of the Home-Attachment Criteria under Dynamic Tax Competition

2.1 Introduction

In[1] their seminal paper dealing with tax and infrastructure competition, Zissimos and Wooders (2008) observe that their static model is silent on how taxes evolve over time. Actually, the lack of a dynamic setting exists for most contributions in the tax competition literature (see, for example, Wilson, 1999; Wilson and Wildasin, 2004; Kanbur and Keen, 1993). Among the few prominent exceptions are the contributions of Wildasin (2003, 2011). These papers analyze the dynamic process of competition for capital under a time-invariant tax rate framework and demonstrate the importance of endogenously determined adjustment costs. However, all firms are identical and don't move with the exception of a subset of inputs which are mobile between jurisdictions. Within such a framework, if one firm, considered as a whole, would like to relocate to another

[1] This chapter is based on, *An extension of the home-attachment criteria under dynamic tax competition*, Y. Han, P. Pieretti and B. Zou. Economics Letters (2013), Vol. 121, 508-510.

jurisdiction, all the other firms would follow. When jurisdictions are symmetric, firms are either spread equally across the different jurisdictions, or they all locate in only one jurisdiction. Therefore, the existence of heterogeneous firms in competing regions is essential to avoid the occurrence of corner situations.

An interesting way to introduce heterogeneity among firms is to assume that entrepreneurs are different in their attachment to home location. This idea was first introduced by Mansoorian and Myers (1993) in fiscal competition and then applied by Ogura (2006). In the same vein, empirical evidence suggests that there is significant home bias in investment decisions (see, for example, Feldstein and Horioka,1980; French and Porteba,1991; Tesar and Werner,1995). However, this bias is not limited to international portfolios. For example, Figueiredo et al. (2002) show that there is a significant advantage of the home region in the location choice of new industrial investments in Portugal.

The home attachment criteria applies easily in a static tax competition model but remains challenging in a dynamic context. The main problem comes from the ranking of firms according to the home preference when there is repeated business relocation. In this chapter we propose a way to update the location preference of firms when they are able to move. Then we show how this extended rule can be applied to the study of dynamic tax competition.

The rest of the chapter is organized as follows. In the next section we present a dynamic relocation rule basing on the home attachment principle. In Section 3 we apply the dynamic ranking rule to a simple dynamic tax competition framework. Section 4 concludes and points to possible extensions of the setting.

2.2 A dynamic relocation rule

Consider two countries, 1 and 2, populated at time t with $S_1(t)$ and $S_2(t)$ firms respectively. The two jurisdictions are represented on a segment $[-S_1(t), S_2(t)]$. The first country extends from $-S_1(t)$ to the origin $O(t),$ and the second, from $O(t)$ to $S_2(t)$. We further assume that, in either country, firms are evenly spread (with unit density) on their respective sub-segment according to their propensity to relocate abroad. As in Ogura (2006), we assume that the population of investors is heterogeneous in the degree of their attachment to home. In our setting, this means that the closer firms are located to the extremes, the more they are attached to their current location. Conversely, the closer firms are to the "border" $O(t)$, the less they are attached to their territory and the easier they are able to relocate abroad. Thus, we can characterize the firms' types in the following way. A firm of type[2] $\alpha_1(t) \in [-S_1(t), O(t)]$ (with $O(t) = 0, \forall t$) located in country 1 at time t, incurs a disutility of relocating abroad equal to the "distance" between $\alpha_1(t)$ and $O(t)$. A firm of type $\alpha_2(t) \in [O(t), S_2(t)]$ located in country 2 at time t, incurs a disutility of moving abroad equal to the "distance" between $O(t)$ and $\alpha_2(t)$.

We now suppose that some firms can relocate abroad. Let us start at $t = 0$ and assume, without loss of generality, that $x(0)$ ($< S_1(0)$) firms of country 1 move to country 2. At period $t = 1$, firms located in country 1 are spread over the new interval $[-S_1(1), O(1)]$, where $S_1(1) = S_1(0) - x(0)$, and firms located in country 2 are spread over $[O(1), S_2(1)]$, where $S_2(1) = S_2(0) + x(0)$.

How do the decisions to relocate modify firms' attachment to their home location? We first consider the firms which don't move. Because country 1 suffers from capital flight, we consider that this loss of attractiveness makes the remaining firms less attached to their current location. For sake of simplification, we assume that the firms located in jurisdiction 1 at time $t = 1$ reduce their home attachment by $x(0)$ uniformly[3]. Put differently, a firm of type $\alpha_1(0)$ at time $t = 0$ which does not relocate will be at time $t = 1$ of type $\alpha_1(1) = \alpha_1(0) + x(0)$, with $\alpha_1(1) \in [-S_1(1), O(1)]$.

We observe the opposite effect in country 2 which, contrary to country 1, improves its attractiveness to foreign firms. We therefore assume that the attachment to home increases uniformly by a constant $x(0)$ in jurisdiction 2. In other words, a firm of type

[2]Note that, by definition, $\alpha_1(t)$ is negatively signed.

[3]We make this choice for sake of simplicity. However, a more complex preference revision could be proposed. We could assume that only a subset of firms revise their preferences, or that, the extent to which firms update their preferences would increase with their past attachment to home.

$\alpha_2(0)$ at time $t = 0$, which does not move its activity abroad, will be at time $t = 1$ of type $\alpha_2(1) = \alpha_2(0) + x(0)$ with $\alpha_2(1) \in [O(1) + x(0), S_2(1)]$.

How do the moving firms modify their preference relative to the new location? A natural attitude to expect is that the more (less) the moving firms are attached to their past location, the less (more) they will be attached to the new location. In other words, for each firm of type $\alpha_2(1) \in [O(1), O(1) + x(0)]$, we write $\alpha_2(1) = \alpha_1(0) + x(0)$ with $\alpha_1(0) \in [O(0) - x(0), O(0)]$.

More generally, we can formulate the following rule. For all $\alpha(t) \in [-S_1(t), S_2(t)]$, we define $\alpha(t) = \alpha(t - \Delta t) + x(t - \Delta t)$, where[4]

$$\alpha(t) = \begin{cases} \alpha_1(t) \in [-S_1(t), O(t)] \\ \alpha_2(t) \in [O(t), S_2(t)] \end{cases},$$

where $x(t) > 0$ if firms move from country 1 to country 2 and $x(t) < 0$ if firms relocate in the opposite direction. Note that $O(t) = 0$ implies $S_1(t) = S_1(t - \Delta t) - x(t - \Delta t)$ and $S_2(t) = S_2(t - \Delta t) + x(t - \Delta t)$.

2.3 Application

In this section we illustrate how the relocation rule that we just highlighted applies to dynamic capital tax competition. To this end, we use the above spatial framework and normalize the total number of firms to one. It follows that $S_1(t) = S(t)$ and $S_2(t) = 1 - S(t)$. At time t, the net profit of a firm located in country $i = 1, 2$ is given by $\pi_i(t) = \Pi_i(t) - \tau_i(t)$, where $\tau_i(t)$ is a unit capital tax paid in country i.

At time t, a firm of type $\alpha_1(t)$ located in country 1 considers staying at home or investing her physical capital abroad. If the entrepreneur decides to stay at home, the profit is given by $\pi_1(t) = \Pi_1(t) - \tau_1(t)$. If she invests abroad, her profit becomes $\pi_2(t) = \Pi_2(t) - \tau_2(t) - k \cdot d(t)$, where k is a unit moving cost, $d(t)$ is the distance between $\alpha_1(t)$ and the origin and $k \cdot d(t)$ is the total relocation cost. The marginal entrepreneur

[4]In discrete time we have $\Delta t = 1$.

$\alpha_1'(t)$ who is indifferent between investing abroad and staying at home verifies the condition $\Pi_1(t) - \tau_1(t) = \Pi_2(t) - \tau_2(t) - k \cdot d'(t)$. Conversely, if firms move from country 2 to country 1, the marginal condition becomes, $\Pi_1(t) - \tau_1(t) - k \cdot d'(t) = \Pi_2(t) - \tau_2(t)$. For sake of simplicity, we set $\Pi_i(t) = a_i$ $(i = 1, 2)$ and $A = a_1 - a_2 < k$. Further, we consider the model in discrete time.

Consequently, we obtain

$$x(t, \tau_1, \tau_2) = \frac{1}{k} (\tau_1(t) - \tau_2(t) - A) \ ,$$

with $x(t) = d'(t) > 0$ if country 2 attracts capital from country 1 and $x(t) = -d'(t) < 0$ if firms move in the opposite direction. The jurisdictions compete in taxes to attract mobile firms. At each period t they set their respective tax rates which maximize their respective tax revenue defined by

$$B_1(t) = [S(t) - x(t)]\, \tau_1(t) \textit{ and } B_2(t) = [1 - S(t) + x(t)]\, \tau_2(t).$$

We now define the motion law for $S_i(t)$ $(i = 1, 2)$, and show how it relates to the ranking rule we defined above. First note that according to this rule the number of firms which move at time $t-1$ are related to the firms' characteristics in the following way

$$x(t-1) = \alpha(t) - \alpha(t-1).$$

Knowing that $S_1(t) = S_1(t-1) - x(t-1)$ and $S_2(t) = S_2(t-1) + x(t-1)$ and substituting $x(t-1)$, we finally get the motion equation for each country $i = 1, 2$,

$$S_i(t) - S_i(t-1) = (-1)^i \left[\alpha(t) - \alpha(t-1)\right].$$

The sequential update of $S_1(t)$ and $S_2(t)$ relative to $x(t-1)$ modifies at each round the jurisdictions' objective functions $B_1(t)$ and $B_2(t)$, which in turn impacts the taxation strategies and the flow of relocations. We now consider tax competition as noncooperative tax setting in an intertemporal environment. The dynamics unfold in the following way. At each period, the jurisdictions set a tax rate which is the best response to the rival's strategic decision. However, this equilibrium is temporary as long as the locational preference changes at each round. Consequently, at each period t, the solution of the game yields the temporary equilibrium tax rates

$$\tau_1(t) = \frac{1}{3}(A+k) + \frac{k}{3}S(t) \;\; and \;\; \tau_2(t) = \frac{1}{3}(2k-A) - \frac{k}{3}S(t).$$

The dynamics of $S(t)$ and $x(t)$ are given by $S(t) = \frac{5}{3}S(t-1) - \frac{A+k}{3k}$ and $x(t) = \frac{1}{3}x(t-1)$. It follows that the game tends monotonically[5] to a rest point, because $x(t) \to 0$ if $t \to \infty$. Consequently, the long run tax rates will be $\tau_1^* = \frac{1}{2}(A+k)$ and $\tau_2^* = \frac{1}{2}(k-A)$ and the size variables, $S_1^* = \frac{1}{2k}(A+k)$ and $S_2^* = \frac{1}{2k}(k-A)$ with $k > A$.

2.4 Conclusion

In this chapter we develop a setting which can be used to study dynamic tax (and/or infrastructure) competition when firms can change their production location over time. To this aim, we adapt the home-attachment criteria of Mansoorian and Myers (1993) and Ogura (2006) to fit into a dynamic framework. Then we illustrate our extended rule within a dynamic tax competition model. Although this model is based on simplifying assumptions, more complex cases can be developed. For example, instead of assuming that all the firms have the same production function, we could consider heterogeneous technologies. Our setting can be used for different purposes. For example, a dynamic game similar to the one of Han et al. (2012), in which jurisdictions compete in taxes and infrastructure, could be developed to answer the question of Zissimos and Wooders (2008) about how tax rates change over time. Another issue would be to explore under which conditions dynamic tax and infrastructure competition would allow convergence across unequally developed countries.

[5] More precisely, this is the case along a saddle-point path.

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Chapter 3

Asymmetric Competition among Nation States: A Differential Game Approach

3.1 Introduction

Small states[1] generally suffer from limited access to capital and labor resources, both in amount and in variety. Foreign production factors can be an important way to fill in this gap. Foreign direct investments (in short, FDI, hereafter) can contribute significantly to the development of small states (Read, 2008). In fact, small economies tend to have high level of access to private foreign capital as a ratio of total capital formation (Streeten, 1993). Indeed, using data from the World Bank, Figure 1 suggests that the ratio of FDI flows to the gross fixed capital formation is higher in small countries (i.e., population less than two million[2]) than in large countries (i.e., population in excess of

[1]This chapter is based on, *Asymmetric competition among nation states: a differential game approach*, Y. Han, P. Pieretti, S. Zanaj and B. Zou. (Revise and Resubmit at Journal of Public Economics)

[2]Our data set contains 51 countries with population less than 2 million. This represents 72% of all the existing "small" countries. An exhaustive description cannot be provided due to a lack of relevant information.

30 million[3]). Moreover, the economic well-being of small countries is positively correlated with the ratio of FDIs. The data in Figure 1 indicate that small countries above the average line, such as Luxembourg, Malta, Cyprus or Estonia, exhibit a high level of per capita GDP, whereas small countries below this threshold have a lower level of per capita GDP. This is confirmed in Figure 2, which suggests that a direct relationship exists between the level of GDP per capita and foreign investments[4] in small economies. In the cluster of larger countries, however, this relationship is hardly apparent. Countries, such as Poland, Italy, Turkey, India and Spain appear above the threshold in Figure 1, whereas the USA, Ukraine, Nepal, Greece among others, are situated below it[5].

Given these facts, this chapter analyzes the impact of foreign investment flows on the economic performance of a small country competing internationally for mobile production factors. In this context, we investigate the conditions by which the economies of such countries can be viable, or even expand, in the long term. To that end, we develop a dynamic framework to study how a small country attracts foreign capital through two policy instruments, namely taxes and public services[6].

[3]Our data set of countries with population in excess of 30 million is exhaustive. It contains 41 countries.

[4]Note that, we have not controlled for other determinants of per capita GDP; for example, the availability of natural resources. Taking into account oil reserves and the recent increase in oil prices would explain the position of Qatar or Brunei in our figures.

[5]The ambiguous role of FDIs on the economic performance of countries is documented in the literature (see, for example Alfaro et al. 2004).

[6]These public services contribute to the domestic attractiveness of private capital, as they are supposed to enhance private productivity. Examples of this are spending for the operation and maintenance of power and transportation infrastructures, operating costs of universities, but also the enforcement of property rights and the provision of capital market, labor and environmental regulations. It follows that countries' attractiveness may also be due to the quality of their institutions. In the Oxford Handbook of Entrepreneurship (2007), it is argued that the abundance of entrepreneurs in a country depends on the existence of regulations, property rights, accounting standards and disclosure requirements, among other factors. Furthermore, in recent years, there has been a surge of national and cross-country studies relating economic development to institutions, especially institutions affecting capital market development and functionality (see, for example, La Porta et al.,1997).

For the sake of simplicity, we focus on two competing countries of uneven size. In this study, size is defined as number of capital-owners in a respective country and these capital owners are simultaneously entrepreneurs and workers. By adopting this approach, our model focuses on the economic size of a country.

The dynamic aspect of international competition is addressed by a differential game framework in which the strategic behavior of the small country differs from that of its larger rival. We account for the widely recognized characteristic that small states are more flexible in their political decision making than much larger countries (see, in particular, Streeten, 1993).

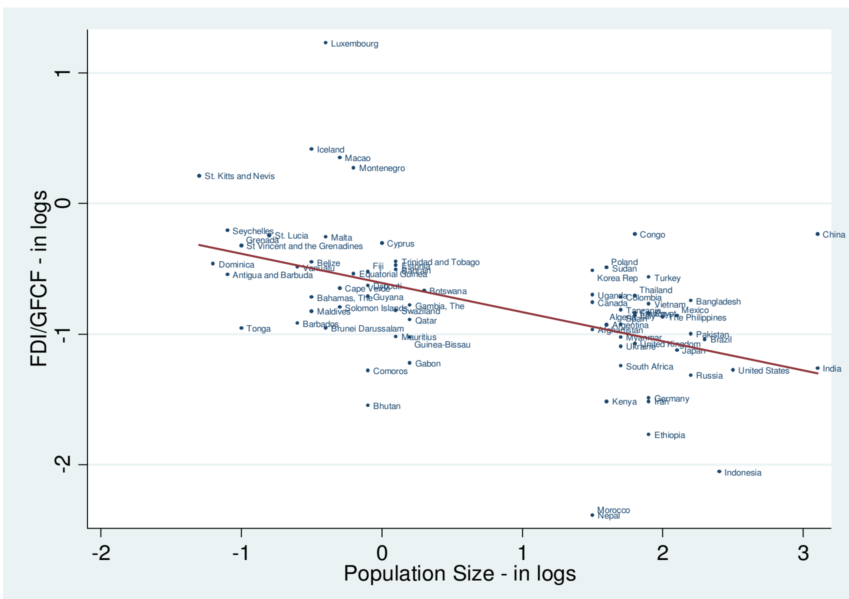

Figure 1: Relationship between the ratio of FDIs to Gross Fixed Capital Formation and population from 2000 to 2010. Source: World Bank

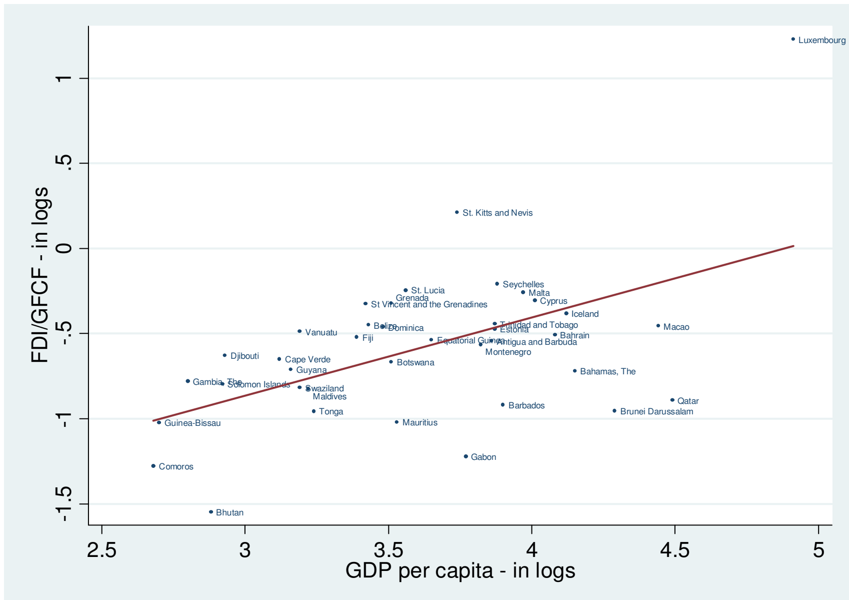

Figure 2 : Relationship between GDP per capita of small countries and the ratio of FDIs to Gross Fixed Capital Formation from 2000 to 2010. Source: World Bank

We thus assume that the small country adopts a Markovian feed-back behavior (i.e., the policy variables are continuously reset in response to the dynamics of the states of the world), whereas the larger country chooses an open-loop rule (i.e., the policy variables are set only once at the initial time). We also acknowledge that small size is associated with handicaps, as, small economies are generally characterized by limited institutional capacity in the provision of public goods (Commonwealth Secretariat, 2000) relative to large countries. Finally, we assume that the capital owners living in both countries have heterogeneous attitudes toward their attachment to home. Thus, they incur costs related to moving abroad. The extend of these costs depends on their attitudes toward their countries. Additionally, their decision to relocate their capital is affected by capital taxation and by productivity-enhancing public services.

The main results of the chapter can be summarized as follows. First, the model shows that GDP, in particular the GDP per capita, of the small country increases with the flow of FDIs, which is consistent with the facts presented above. Moreover, the long-run solutions show that the economy of the small country can expand, shrink or even collapse. In this context, two cases can be distinguished: one exhibits high international openness and another exhibits low international openness. The fundamental difference between these cases is that the small country will only experience economic collapse if capital mobility is high (i.e., high international openness). However, higher efficiency in the provision of public services can partially countervail this effect by decreasing the likelihood of collapse. In the second case, when capital mobility is low, international competition for capital can eventually reduce the size of the small economy without provoking its collapse. If capital mobility is very low, the model shows that international competition tends to expand the economy of the small country. We also assess the extent to which flexibility is beneficial to the small country, given that it suffers from limited institutional capacity. By comparing the Markovian and open-loop outcomes, we find that flexibility mitigates against - but does not eliminate- the likelihood of a small economy collapse. Finally, we show that the benefit of flexibility increases in tandem with the inefficiency of public service provision and with the degree of international openness in the small country.

This chapter contributes to the existing literature in the following ways. First, we provide a dynamic counterpart to previous static papers in which countries compete with two instruments[7]. Following Zodrow-Mieszkowski (1986) model, there has been a growing body of literature on the joint role of taxes and public inputs in attracting mobile production factors. For example, Zissimos and Wooders (2008) analyze how the provision of public goods designed to reduce the production cost of private firms is able to relax international tax competition between governments of equal size. Benassy-Quéré et al. (2007) provide an empirical analysis of the impact of taxes and public goods on the allocation of private capital. They find that both corporate taxes and public capital contribute significantly to inward FDIs. Pieretti and Zanaj (2011) propose a two-stage game in which both a small and large jurisdiction compete for capital using taxes and public goods as policy variables. These contributions are, however, static and thus unable to provide insights into dynamic outcomes. Differential

[7] An exception is Wildasin (2003, 2011) who studies tax competition within an explicitly dynamic framework. In addition to other differences to our paper, he does not consider competition in a non-tax instrument.

games have already been applied to oligopolistic competition (Dockner and Jorgensen, 1984, Karp and Perloff, 1993, Cellini and Lambertini, 2004); however, few studies have applied differential games to tax competition. For example, Coates (1993) deals with the issue of property tax competition and partially analyzes the open-loop equilibrium of a dynamic game.[8] Secondly, by assuming that small countries are more flexible in taking decisions than their larger rivals but at a higher institutional cost as explained above, we account for behavioral and institutional asymmetries which, to the best of our knowledge, are not considered in the traditional tax competition literature.

We assume the economic magnitude expressed in terms of productive resources can vary endogenously as a consequence of public policy and international competition, while the political size is fixed. Similar to our model, the contribution of de la Croix and Dottori (2008) is also concerned with the collapse of a community. To explain the tragedy of Easter Island, these authors show how a closed system can collapse as a result of non-cooperative bargaining between clans. The context and the methodology of their paper is, however, different from ours, given that they use an overlapping generations model in which people live for two periods and compete in fertility rates.

The chapter is organized as follows. The next section models the dynamic competition between two countries of asymmetric size. In Section 3, we derive long-run solutions and Section 4 analyzes the long-run conditions of a small country. The importance of flexibility in small economies is assessed in Section 5 and Section 6 presents the conclusion.

3.2 The model

Suppose that the world is composed of two countries (regions) with unequal populations. Country size may be defined by population, area, or national income (Streeten, 1993). In this study, population, rather than area, is used to define country size. More precisely, size is defined with respect to the number of capital owners who populate

[8] As mentioned by Cardarelli (2002).

the country and these capital owners are simultaneously entrepreneurs and workers. By adopting this approach, our model identifies a country by the size of its economy. Furthermore, capital owners (and their associated activities) are free to relocate to the neighbor country at any point in time. At time $t = 0$, capital flows have not yet taken place, so the population size in each country coincides with its native population.

At $t = 0$, the population of jurisdictions is evenly distributed with unit density on the interval $[-S_1(0), S_2(0)]$. The small country extends from $-S_1(0)$ to the origin 0, and the rest of the world extends from 0 to $S_2(0)$. It follows that the small economy has a size of $S_1(0)$, and the rest of the world has a size of $S_2(0)$, with $S_1(0) < S_2(0)$. We assume that the total number of firms is constant over time and is normalized to one. Thus, for any future time $t \geq 0$, $S_1(t) = S(t)$ and $S_2(t) = 1 - S(t)$.

Entrepreneurs Each citizen is endowed with one unit of capital which is combined with her labor to establish a firm. Therefore, all citizens are self-employed entrepreneurs. Throughout the rest of the paper, we thus use firms and entrepreneurs interchangeably. The firms are distributed at their respective sub-interval according to their disposition to establish a firm outside of their home location. As in Ogura (2006), we assume that this population of entrepreneurs is heterogeneous in the degree of their attachment to the home country.[9] Within the model, we dictate that the closer entrepreneurs are located to extremes of the interval, the more they are attached to their current location. Conversely, the closer that firms are to the border 0, the less they are attached to their territory, and the easier it will be for them to relocate abroad.[10] This means that a firm of type $\alpha_1 \in [-S_1(0), 0]$ located at $t = 0$ in the home country incurs a disutility of relocating abroad equal to kd, where d is the distance [11] between 0 and α_1. The coefficient k represents the unit cost of moving capital abroad and can also be interpreted as the degree of international openness. In the following we argue that firms' location preferences change with t. Consequently we can characterize the firms' types

[9]This characteristic was first considered in the fiscal competition research of Mansoorian and Myers (1993).

[10]For reasons of simplicity, we assume that firms can only relocate to their neighboring jurisdiction.

[11]It follows that $d = -\alpha_1$.

in a more general way. A firm of type $\alpha_1(t) \in [-S_1(t), O(t)]$ (with $O(t) = 0, \forall t$) located in country 1 at time t, incurs a disutility of relocating abroad equal to $d(t) = O(t) - \alpha_1(t)$ and a firm of type $\alpha_2(t) \in [O(t), S_2(t)]$ located in country 2 at time t, incurs a disutility of moving abroad equal to $d'(t) = \alpha_2(t) - O(t)$.

As in Pieretti and Zanaj (2011), we assume that each firm produces $q + a_i$ $(i = 1, 2)$ units of a final good, where q is the private component of (gross) productivity[12]. The fraction a_i of the produced good depends on the public input supplied by the home (foreign) jurisdiction.[13] Note that the product $S_i \cdot (q + a_i)$ represents the total output or GDP produced in country $i = 1, 2$. This implies that $q + a_i$ is the per capita output in a respective country. The total output is sold in a competitive (world) market at a given price normalized to one. Thus, we suppose that both countries have equal access to a common market.[14] This also implies that the smaller jurisdiction does not suffer from a reduced home market. We further consider that the unit production cost is constant and equal to zero without loss of generality. Each entrepreneur pays a tax on capital which is denoted by T_i $(i = 1, 2)$ and levied in the country $i = 1, 2$.[15]

[12]The technology we use can be deduced from a CES production function, $y_i(t) = (q + a_i(t)) [\gamma K^\rho + (1 - \gamma) L^\rho])^{\frac{1}{\rho}}$ with $\gamma \in (0, 1)$, where each person supplies L units of labor and owns K units of capital. If labor and capital are given and uniform across, we can normalize L and K to one. Consequently, the per capita production function reduces to $y_i(t) = q + a_i(t)$.

[13]A public input satisfies the local public good characteristics; that is, it is jointly used without rivalry by firms located within the same jurisdiction. It follows that the benefits and costs of these goods only accrue at the jurisdictional level. As in Zissimoss and Wooders (2008), we abstract congestion costs . Incorporating congestion into the model would complicate our framework without qualitatively improving the results. Moreover, if public input represents immaterial goods as laws and regulations (e.g., protecting intellectual property and, specifying accurate rules for dispute resolution), the lack of congestion in our model is justified by the particular nature of these goods.

[14]Recent empirical work (Guerin, 2006) demonstrates that the distance is economically more significant for FDI than trade, indicating that there are significant information costs to FDI in particular. Consequently, it is likely that trade, being less sensitive to distance, occurs among more countries than FDIs. In our model we account for this fact by assuming that foreign direct investments take place among two jurisdictions but trade occurs among many countries.

[15]Given that each entrepreneur invests exactly one unit of capital in our model, the total tax will be T_i $(i = 1, 2)$.

The temporal perspective of the setting described above is as follows. For each period $t \in [\Delta t, +\infty)$ and for any $\Delta t > 0$, governments update their choices in terms of the public services and taxes offered.

Suppose that an entrepreneur of type $\alpha_1(t)$ is located in country 1 at date t and considers staying at home or investing her physical capital abroad. If she decides not to move [16], her profit is given by[17]

$$\pi_1(t) = q + a_1(t) - T_1(t). \tag{3.1}$$

If she invests abroad, her profit becomes

$$\pi_2(t) = q + a_2(t) - T_2(t) - kd(t).$$

It follows that the marginal entrepreneur of country 1 who is indifferent between investing abroad and staying at home verifies the condition

$$a_1(t) - T_1(t) = a_2(t) - T_2(t) - kd(t).$$

Conversely, if firms move from country 2 to country 1, the marginal condition becomes, $a_1(t) - T_1(t) - kd'(t) = a_2(t) - T_2(t)$.

Consequently, we obtain

$$x(t, a_1, a_2, T_1, T_2) = \frac{a_2(t) - T_2(t)}{k} - \frac{a_1(t) - T_1(t)}{k}. \tag{3.2}$$

[16]At each period t, the firms decide whether it is in their best interest to move their business. More exactly, they choose their best location given that tax rates and infrastructure expenditures are time-variant. We could assume that firms are forward-looking and able to anticipate the future choices of the other agents (firms and governments). However, it is possible to show, already in a three-period version of our model, that multiple solutions are very likely to appear (the details of this model are available on request). If this is the case, firms' decisions will be time inconsistent. This problem is drastically emphasized in continuous time. To be able to solve the model anyhow, we have to impose limiting conditions. Therefore, we assume that firms are myopic in their location choices.

[17]For the sake of simplicity, we consider that q is such that the profit of each firm is positive for all equilibrium levels of public goods and taxes.

In other words, the large country attracts capital ($x(t) = d'(t) > 0$) from the smaller jurisdiction if the net gain of investing abroad, $a_2(t) - T_2(t)$, is higher than the net gain of staying at home, $a_1(t) - T_1(t)$ after taking into account the mobility cost $kx(t)$. If $x(t) = -d'(t) < 0$, capital moves from the large jurisdiction to the smaller one.

The motion equation of the size of the small country's economy $S(t)$ is given by

$$\dot{S}(t) = -x = \frac{a_1(t) - T_1(t)}{k} - \frac{a_2(t) - T_2(t)}{k}. \tag{3.3}$$

The ranking of firms according to their home attachment is fundamental for determining the migration flow $x(t)$ at date t. However, this ranking at date t is altered by the relocations of firms at date $t - \Delta t$. This occurs because of two reasons. First, the entrepreneurs who relocate their activity will have to value their attachment to the new location. Second, the firms which do not move will change their attachment preferences because the relative attractiveness of the competing countries has changed, as demonstrated by the relocations that take place. Accordingly, we need a rule clarifying how the preference ranking changes at each date.

It is legitimate to assume that the firm owners will feel less attached to the new location the more they were attached to the country they come from. On the other hand, firms that remain in a country suffering a loss of activity are likely to be less attached to their current location because of its reduced economic attractiveness. The opposite effect is likely to occur in the country that benefits from new firm locations.

In the following we apply the following rule.

For the firms that do not move, attachment to home will increase in proportion to the level of inward business locations and decrease in proportion to the level of outward relocations. For example, if at date t country 1 suffers from capital flight, the firms still located in jurisdiction 1 reduce their attachment to the current location by $x(t)$ uniformly[18]. More precisely, all the firms of type $\alpha_1(t) \in [-S_1(t), O(t)]$ at date t will be of type $\alpha_1(t + \Delta t) = \alpha_1(t) + x(t)$ at date $t + \Delta t$. For the firms which move from country 1 to country 2, we assume that the more they were attached to their former location

[18]This *linear* form is used for simplicity.

the less they will be attached to the new one. In other words, for each firm of type $\alpha_2(t+\Delta t) \in [O(t+\Delta t), O(t+\Delta t)+x(t)]$ at date $t+\Delta t$, we write $\alpha_2(t+\Delta t) = \alpha_1(t)+x(t)$ with[19] $\alpha_1(t) \in [O(t)-x(t), O(t)]$.

It is important to note that the updated location preferences at date t that result from the relocation flow $x(t-\Delta t)$ of date $t-\Delta t$ determine the outflow $x(t)$, which will induce a further preference update at $t+\Delta t$, and so on... It follows that this updating process is the basic driving force behind the dynamics of the model.

Governments Adopting a public-choice perspective, we posit that the governments maximize tax revenue.[20] To this end, countries compete simultaneously by using taxes and public services to attract entrepreneurs, and firms decide where to locate based on these government policies. We suppose that the effective (net) tax revenue collected by the governments does not coincide with the gross amount of tax revenue collected. Following Vaillancourt (1989) and Blumenthal and Slemrod (1992), tax collection is costly due to the administration, monitoring and enforcing procedures associated with it (Kenny and Winer, 2006). If the marginal cost of collecting taxes rises, then the net tax revenue $R(t)$ at time t is a concave function of the collected taxes. For tractability reasons, the net tax revenue will be given by $R_i = \sqrt{S_i T_i}$.

The instantaneous objective function of government $i (i = 1, 2)$ is thus given by the

[19]More generally, we can formulate the following rule. For all $\alpha(t) \in [-S_1(t), S_2(t)]$, we define $\alpha(t) = \alpha(t-\Delta t) + x(t-\Delta t)$, where

$$\alpha(t) = \begin{cases} \alpha_1(t) \in [-S_1(t), O(t)] \\ \alpha_2(t) \in [O(t), S_2(t)] \end{cases},$$

where $x(t-\Delta t) > 0$ if firms move from country 1 to country 2 and $x(t-\Delta t) < 0$ if firms relocate in the opposite direction.

[20]This assumption should not be interpreted in the classical sense given by Brennan and Buchanan (1980) and applied to Leviathan governments. We do not consider here that regulators are self-interested governments. We simply assume that collected taxes are used to finance productive public services but also public goods that do not directly affect the productivity of firms, such as green spaces, swimming pools, and security bodies.

following:

$$w_i(T_i, a_i) = \sqrt{S_i T_i} - \frac{\beta_i}{2} a_i^2, \tag{3.4}$$

where the second term is the cost of providing public inputs, which is assumed quadratic, whereas β_i is a country specific efficiency parameter. Indeed, the higher the value of β_i, the higher the unit and marginal costs of providing public service.

The key focus of this paper is the long-run behavior of small states. To this end, we highlight two opposing features of small open economies.

First, according to the Commonwealth Secretariat (2000), the public sector of mini-states generally suffers from limited institutional capacity.[21] Moreover, it may be difficult for small states to recruit high-quality civil servants given their limited pool of candidates (Streeten, 1993). These factors can reduce the efficiency and increase the unit costs for the provision of public services (Briguglio,1998). To account for these facts, we assume that $\beta_1 \equiv \beta > \beta_2$. Normalizing β_2 to 1, we impose $\beta > 1$. It follows that β represents the inefficiency of the small country relatively to the large one.[22]

However, small size is a source of more responsive decision-making in a changing economic environment. This can be the case for different reasons. First, small communities are intrinsically more able to reach a consensus on policy issues. This idea has long been put forward by philosophers and political scientists as acknowledged in Alesina (2003). Several economists (for example, Kuznets, 1960; Alesina and Spolaore, 1997; Streeten, 1993) recognize that small-sized communities display a high degree of political homogeneity. In particular, Streeten (1993) suggests that problems related to collective action can be solved more easily in small countries, whereas larger jurisdictions are not able or not willing to attain this degree of flexibility in their decision

[21] In small states, the median wage bill of the public sector as a proportion of GDP is 31 percent, whereas the ratio is 21 percent in large developing countries (Commonwealth Secretariat and World Bank, 2000).

[22] To be consistent, the parameter β should be inversely correlated with the size of the small country. Taking into account this feature would however complicate the analysis without important additional insight. Therefore, we shall assume that the small country is tiny enough to consider β as given. For that reason we assume that the size S_1 is bounded from above by $\overline{S}$ where $\overline{S} < \frac{1}{2}$.

making. It follows that, mobilization around a common effort should be easier. For example, Kuznets (1960) notes that one advantage of small states is to have small and more cohesive populations, which allows them to adapt better to change. In the same vein, Armstrong and Read (1995) recognize that smallness facilitates greater single-mindedness and focus on economic policy-making and a more rapid and effective response to exogenous change. Indeed, reforming existing laws or passing new ones takes much longer in large and diversified economies, where any change in the status quo requires long negotiations involving a large variety of interest groups.

Another reason of higher adaptability in the decision-making is that small countries are specialized in a handful of sectors. Thus the absence of a wide range of lobbyists makes the parliament and the entire administrative body much more responsive.

Finally, small developed economies have to adapt more quickly to a changing environment because they are highly open to the rest of the world and thereby, subject to more volatile business cycles than larger countries. Consequently, responsiveness to external shocks is a question of economic survival. Rodrik (1998) demonstrates that highly open countries and thus small countries have proportionally larger governments in order to mitigate the exposure to the insecurities generated by extreme openness. According to Katzenstein (2003) what really matters politically regarding small economies is their perceived (external) vulnerability. He notes that, "Perceived vulnerability generated an ideology of social partnership that acted like a glue for the corporatist politics of the small European states" (Katzenstein, 2003, p.11). Moreover, because of their high exposure to international shocks, they created relatively robust welfare states in order to reach political bargains. In other words, small economies achieve social cohesion through redistribution policies.

To capture the just highlighted concept of flexibility, we assume that the large jurisdiction commits to a policy path that was adopted at the beginning of the game (i.e., open-loop strategy), whereas policy-makers in the small jurisdiction adopt a Markovian feed-back strategy.

This mixed representation offers a convenient way of modeling differences in flexibility of decision making (Dockner et al., 2000). Although small in a political sense, the mini-state can grow larger as a result of sustained capital inflows. The small country's size could thus exceed a critical threshold that would cause the large country to react more aggressively by also adopting a Markovian strategy. To rule out such a behavioral change, we assume that the size of the small economy will remain tiny enough. In other words, we assume that the size $S(t)$ is bounded from above and impose $S(t) \leq \overline{S} < \frac{1}{2}$, for any $t \geq 0$.

The dynamic objective-functions of the competing jurisdictions are respectively[23]

$$J_1 = \max_{a_1, T_1} \int_0^{+\infty} e^{-rt} w_1(T_1(S,t), a_1(S,t))dt, \tag{3.5}$$

$$J_2 = \max_{a_2, T_2} \int_0^{+\infty} e^{-rt} w_2(T_2(t), a_2(t))dt, \tag{3.6}$$

where r is the discount rate of the public decision-makers, which should reflect the degree of impatience of the population. Given that there is no evidence that this rate is dependent on the size of a population, we accept that r is common to both jurisdictions.

3.3 Steady states and the long-run policy mix

As explained above, we assume that the small jurisdiction adopts a Markovian policy setting, and its larger rival chooses open-loop strategies when designing its optimal decision path. The long run solutions of the above dynamic system are highlighted in the following proposition.

Proposition 1 *For any given parameters k, r, β, there exists a Nash equilibrium characterized*

[23] Similar to Barro (1990), we consider that the government provides flows of public services. It follows that the public service provision will be treated as a control variable.

by the following interior steady state

$$\hat{S} = \frac{(kr)^{-\frac{3}{2}}}{6\sqrt{2}}\left(\frac{\sqrt{2}}{\beta}-1\right)+\frac{2}{3}, \tag{3.7}$$

$$\widehat{a}_1 = \frac{1}{2\beta}\left(\frac{1}{kr}\right)^{\frac{1}{2}},\ \widehat{T}_1 = kr\widehat{S},\ \ \widehat{a}_2 = \frac{1}{2}\left(\frac{1}{2kr}\right)^{\frac{1}{2}}, \widehat{T}_2 = 2kr(1-\widehat{S}), \tag{3.8}$$

with the costate variables $\widehat{\lambda}_1 = \frac{1}{2}\left(\frac{k}{r}\right)^{\frac{1}{2}}, \widehat{\lambda}_2 = -\frac{1}{2}\left(\frac{k}{2r}\right)^{\frac{1}{2}}$. *In the state space of the dynamic system, it is locally asymptotically stable*[24]*. It follows that the long run policy mix of country* $i (i = 1, 2)$ *is given by the pair* $(\widehat{a}_i,\ \widehat{T}_i)$.

We want now that the steady state size of the small country's economy remains smaller than $\frac{1}{2}$. This means that $\hat{S} < \frac{1}{2}$ requires that $k < k^* = \left(\frac{1}{2}\right)^{\frac{1}{3}}\frac{1}{r}$ and $\beta > \underline{\beta} = \frac{\sqrt{2}}{1-\sqrt{2}(kr)^{\frac{3}{2}}}$.

It is convenient to show that the long-run per capita GDP ($\widehat{a}_1 + q$) of the small country increases with $\hat{S}$.[25] Given that $\hat{S}$ is positively related to the FDI inflows, our model is consistent with the stylized fact highlighted in Figure 2, which shows that the per capita output of small economies improves with inward foreign investments. This positive relationship results from infrastructure expenditures that impact the productivity of firms and, thus, improves the attractiveness of the location to foreign investments.

Proposition 2 *The smaller economy always undercuts the rival's tax rate but provides less infrastructure services.*

Indeed, it is readily verified that $\widehat{a}_2 - \widehat{a}_1 = \frac{1}{4\beta}\left(\sqrt{2}\beta - 2\right)\sqrt{\frac{1}{kr}} > 0$ for $\beta > \sqrt{2}$ and $\widehat{T}_2 - \widehat{T}_1 = kr\left(2-3\widehat{S}\right) > 0$, given that $\widehat{S} < \frac{1}{2}$. In other words, the small economy will always be tax competitive but the public services it provides will never be attractive to investors. This result is consistent with the literature on tax competition

[24] We present the convergence path in the Appendix A.2.

[25] The steady-state value $\hat{a}_1$ written as a function of $\hat{S}$ is $\hat{a}_1 = 3kr(\hat{S}-\frac{2}{3}) + \frac{1}{2}(\frac{1}{2kr})^{\frac{1}{2}}$. It follows that $\frac{\partial \hat{a}_1}{\partial \hat{S}} > 0$ is always true.

among economies of uneven size (Bucovetsky, 1991, Wilson, 1991,Kanbur and Keen, 1993, Trandel, 1994), which demonstrates that the benefit of smallness translates into the ability to undercut the tax rates of larger countries. This means that the small country will never be able to tax more than its large rival, which contrasts with some static models on competition in taxes and infrastructure (Hindriks et al., 2008, Pieretti and Zanaj, 2011). The reason is that the small country has a relative disadvantage in providing infrastructure services due to its limited public capacity.

It appears that, the less efficient the small country is in providing public services, the more it will lower its tax rate. Indeed, it is easy to see that $\widehat{a}_2 - \widehat{a}_1$ and $\widehat{T}_2 - \widehat{T}_1$ rise with β. It is interesting to note that increasing international openness (lower k) increases the expenditure gap and the tax gap between the competing countries. Thus, the higher the capital mobility, the more the small country will be inclined to undercut the tax rate of its rival.

Finally, if the long-run solutions have to guarantee non-negative net budget constraints of both economies[26], the following two conditions must hold. Either (a) $k^* > k \geq \overline{k}$ with $\overline{k} = (\frac{1}{32})^{\frac{1}{3}}\frac{1}{r}$, or (b) k verifies $\underline{k} < k \leq \overline{k}$, with $\underline{k} = \left(\frac{1}{50}\right)^{\frac{1}{3}}\frac{1}{r}$ and β satisfies $\underline{\beta} < \beta \leq \overline{\beta}$, with $\overline{\beta} = \frac{1}{2\sqrt{2}-16(kr)^{\frac{3}{2}}}$. The long run budget constraint of the large country will be satisfied if $\widehat{w}_1 \geq 0$, because there are relatively less stringent conditions on the parameters of the large country[27]. It is not excluded that the competing countries may issue temporarily debt to fund their infrastructure expenditures. This raises the question whether the intertemporal budget constraint is satisfied in both countries. In the Appendix we prove that the present value of net revenues in country i is positive if the steady state net revenue in country i is positive($\widehat{w}_i > 0, i = 1, 2$).

[26]The long run net budget of the small and the large countries are $\widehat{w}_1(\widehat{T}_1, \widehat{a}_1) = \frac{16\beta\left((kr)^{\frac{3}{2}} - \frac{1}{8}\sqrt{2}\right)+1}{24kr\beta}$ and $\widehat{w}_2(\widehat{T}_2, \widehat{a}_2) = \frac{5\beta - 8\sqrt{2} + 16\sqrt{2}\beta(kr)^{\frac{3}{2}}}{3\beta}$, respectively.

[27]It also appears that $\widehat{S} \in \left(0, \frac{1}{2}\right)$ in the cases (a) and (b).

3.4 Will small states survive in the long run?

In this section, we focus our attention on the conditions under which the production potential of the small economy will expand ($\frac{1}{2} > \hat{S} > S(0)$), shrink ($\hat{S} < S(0)$) or even collapse ($\hat{S} = 0$).[28]Two cases can be considered according to the degree of capital mobility.

Case 1 *High degree of international openness*: $\underline{k} < k < \overline{k}$.

In this case, the survival of the small economy depends on its relative efficiency in providing public services. Two sub-cases can be distinguished: one in which capital mobility is very high, i.e., $\underline{k} < k < k^s$ with[29]$k^s = \frac{1}{2\left[2+S(0)\right]\right)^{\frac{2}{3}}}\frac{1}{r}$, and a second one in which capital mobility is moderately high, i.e., $k^s < k < \overline{k}$. In the first sub-case, it is readily verified that the small economy expands in the long run, $\widehat{S} > S(0)$, if $\beta < \overline{\beta}$. However, if the relative efficiency of provision of public services in the small economy is too low (i.e., if $\beta > \overline{\beta}$), it will collapse. Furthermore, as the mobility cost approaches its lower bound $\underline{k}$, the small country is more likely to collapse. This occurs because the small economy has to lower its taxes to such an extent that it can no longer sustain its public expenditures ($\widehat{w}_1 < 0$). There are two extreme outcomes in the long-run. Either the small economy expands, or collapses. Therefore, if it shrinks, it must collapse.

This extreme scenario changes in the second sub-case (see Figure 3). According to the values taken by β, the small economy can expand, collapse and shrink without collapsing. If $\beta < \beta^s$ with $\beta^s = \frac{\sqrt{2}}{1-6\sqrt{2}\left[\frac{2}{3}-S(0)\right](kr)^{\frac{3}{2}}}$, it will expand, and if $\beta > \overline{\beta}$, it will collapse. For an intermediate efficiency value, i.e., $\beta^s < \beta < \overline{\beta}$, the small country will shrink but still survive.

The following proposition can then be stated:

[28]We impose (see proof in Appendix A.3) that $S(t) \leq \overline{S} < \frac{1}{2}$. If so, $\underline{\beta}$ would depend on the upper bound of $\overline{S}$. Thus, $\underline{\beta}(\overline{S}) = \frac{\sqrt{2}}{1+6\sqrt{2}(\overline{S}-\frac{2}{3})(kr)^{\frac{3}{2}}}$, in which $\overline{S}$ is decreasing.

[29]It is readily verified that $k^s < \overline{k}$ if $0 < S(0) < \frac{1}{2}$.

Proposition 3 *Assume that international openness is high. The small country's economy can expand if it is relatively efficient in providing public services. Otherwise, its economy will shrink or even collapse in the long run.*

In a world of mobile capital, a small economy may have difficulty surviving even if it is able to adapt to change more quickly than larger countries. This can occur because the efficient provision of public services and capital mobility are crucial to generating the resources necessary to afford further public amenities. In fact, the model shows that below a given threshold, rising capital mobility causes the small economy to cut its taxes to such an extent that its budgetary resources vanish. It follows that small states, but especially micro-states, can secure their status in a global economy if their public sectors provide public services with sufficient efficiency and if their tax rates are more favorable than those of larger countries. At best, this is a necessary condition for attracting foreign capital, or at least, surviving.

Case 2 *Low degree of international openness:* $k^* > k > \overline{k}$.

In this case, the relative inefficiency of the provision of public services can no longer lead to the collapse of an economy because budget resources are not constrained. Formally, the limit value $\overline{\beta}$ tends to ∞ if k approaches $\overline{k}$. This is in marked contrast with the first case, as - in this case- a low degree of financial openness makes capital more captive and provides sufficient tax revenues to cover public expenditures. At worst, the economy of the small country can contract ($0 < \widehat{S} < S(0)$). This occurs if $\widehat{k} > k > \overline{k}$ and $\beta > \beta^s$, with $\widehat{k} = (\frac{1}{8[2-3S(0)])^2})^{\frac{1}{3}}\frac{1}{r}$. However, if mobility is very low, i.e., $k^* > k \ > \widehat{k}$, the small economy will attract foreign capital and thus expand. Surprisingly, this scenario occurs independently of the level of inefficiency.

We conclude with the following proposition:

Proposition 4 *Assume that international openness is low ($k^* > k > \overline{k}$). The small country's economic size never collapses but may shrink if the degree of international openness is not sufficiently low. In this case, the survival of the economy is independent of the efficiency of public service provision (β).*

We provide a summary illustration of the different cases with respect to the parameter values of k and β in Figure 3.

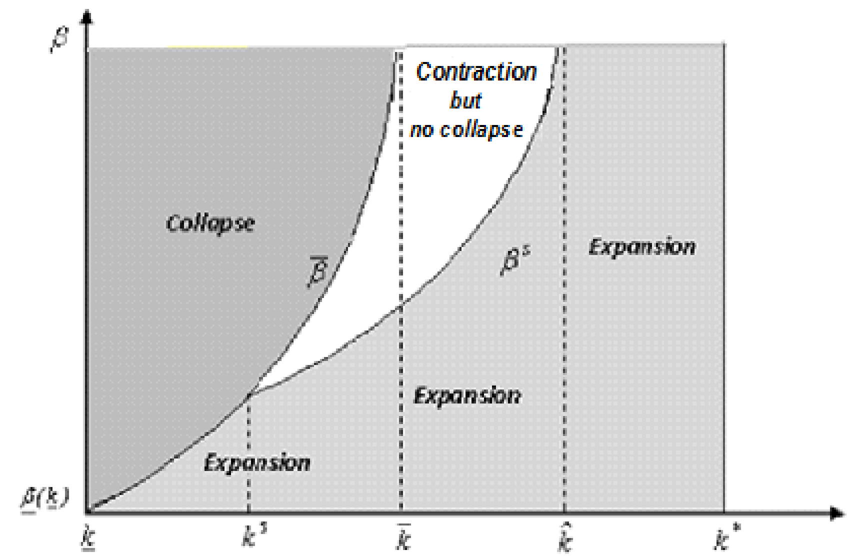

Figure 3 : The evolution of the small country's economic potential according to the mobility cost (k) and the degree of public inefficiency (β).

3.5 How important is flexibility to the small economy?

To assess how beneficial flexibility is to the small country, we first calculate the long-run production potential $\widetilde{S}$ of the small country if it chooses an open-loop behavior identical to its larger rival. We thus obtain

$$\tilde{S} = \frac{(kr)^{-\frac{3}{2}}}{4}(\frac{1}{\beta} - 1) + \frac{1}{2}.$$

The benefit of flexibility can be represented by the difference $\widehat{S} - \widetilde{S}$, which is obtained by comparing the Markovian and open-loop outcomes. It is easy to verify that this difference is always non-negative. Therefore, given the same parameters, the Markovian behavior adopted by the small country is preferable to the open-loop behavior. However, flexibility does not completely eliminate the potential for collapse; it only makes its occurrence less likely.

Given that $\frac{\partial\left(\widehat{S}-\widetilde{S}\right)}{\partial\beta} > 0$, the advantage of the small country's flexibility increases with its inefficiency to provide public services. In other words, the economic size of the small country is more sensitive to an increase in efficiency (β decreases) in the Markovian scenario.[30] Consequently, flexibility counterbalances inefficiency, and the more inefficient a small country is in providing public inputs, the more valuable flexibility is to its long-run survival.

Furthermore, higher capital mobility increases the relative advantage of flexibility, given that $\frac{\partial\left(\widehat{S}-\widetilde{S}\right)}{\partial k} < 0$. Note that increased capital mobility reduces (k increases) the long-term economic potential of the small economy; however, this occurs to a lesser extent in the Markovian scenario. It follows that flexibility countervails the negative effect of high capital mobility, and flexibility brings greater benefits to the small country when capital mobility is low. So, we can conclude by the following proposition.

Proposition 5 *The benefit of flexibility decreases with the small country's efficiency to provide public services and increases with capital mobility.*

We finally observe that similar to the Markovian scenario, the small country never collapses by adopting an open-loop behavior when capital mobility is sufficiently low. However, this condition becomes more restrictive in the open-loop scenario. Indeed, the absence of flexibility in policy making requires now that the mobility cost is higher than $\overline{\overline{k}}$, which exceeds the threshold $\overline{k}$ corresponding to the Markovian case.[31]

[30]In fact, it is convenient to verify that $\left|\frac{\partial\widehat{S}}{\partial\beta}\right| < \left|\frac{\partial\widetilde{S}}{\partial\beta}\right|$.

[31]It is convenient to show that $\overline{\overline{k}} = (\frac{1}{4})^{\frac{1}{3}}\frac{1}{r}$.

3.6 Conclusion

In this chapter, we investigate whether a small open economy can survive in the long-run when facing global competition. To this end, we model the dynamic competition between two unequally sized economies. The policy makers of these two countries compete simultaneously by taxing mobile capital and offering public services. Firms choose to locate their capital in the country where their profits are maximized. We characterize the heterogenous behaviors of the two governments within a differential game framework, in which the small state adopts Markovian (i.e., flexible) behavior, and its larger rival commits to a strategy developed at the initial time point (i.e., open-loop behavior).

The results show that under conditions of high capital mobility, the small economy will risk economic collapse if it provides public services inefficiently. When capital mobility is very low, the economy of the small state always expands despite its limited institutional capacity.

However, further research is needed. In the present study, countries are treated solely as maximizers of tax revenue, and this over-emphasizes the role of tax rates in the long-run outcomes. Therefore, it would be interesting to analyze a scenario in which governments are welfare maximizers and take into account the well-being of their populations. The present paper also models the private sector in an elementary way. Countries are undifferentiated in their ability to produce private goods and the production process is static. Future research should thus consider how international competition is able to impact the growth process of these competing economies when private productivity differs between jurisdictions.

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Appendix A

We define as follows the notion of heterogenous strategic behavior which is used in Dockner et al. (2000, Pages 87–92)[32].

A.1 Definition *A* A 2-tuple (Ψ_1, Ψ_2) of functions $\Psi_1 : [0,1] \times [0, +\infty) \to \mathbb{R}^2_+$ and $\Psi_2 : [0, +\infty) \to \mathbb{R}^2_+$, with $\Psi_1 = (\Psi_{11}(S,t), \Psi_{12}(S,t)), \forall (S,t) \in [0,1] \times [0,+\infty)$ and $\Psi_2 = (\Psi_{21}(t), \Psi_{22}(t))$, constitutes a heterogenous Strategic Nash Equilibrium if an optimal control path exists and is given by the Markovian Strategy

$$(a_1(t), T_1(t)) = (\Psi_{11}(S(t),t), \Psi_{12}(S(t),t)) = \Psi_1(S(t),t)$$

of player 1, and an open-loop strategy

$$(a_2(t), T_2(t)) = (\Psi_{21}(t), \Psi_{22}(t)) = \Psi_2(t)$$

of player 2.

The small open economy (the Markovian strategic player) takes the large country's (open loop) strategy $\Psi_2(t)$ as given, and hence, faces the following optimization problem

$$\begin{cases} \max\limits_{a_1, T_1} \displaystyle\int_0^{\infty} e^{-rt} \left[(S(t)T_1(S,t))^{\frac{1}{2}} - \frac{\beta}{2} a_1^2(S,t) \right], \\ \text{subject to } \dot{S}(t) = \dfrac{a_1(S,t) - T_1(S,t)}{k} - \dfrac{\Psi_{21}(t) - \Psi_{22}(t)}{k}. \end{cases} \tag{3.9}$$

The corresponding current-value Hamiltonian is

$$\mathcal{H}_1(T_1, S, a_1, \lambda_1) = \left[S^{\frac{1}{2}}(t) T_1^{\frac{1}{2}}(S,t) - \frac{\beta}{2} a_1^2(S,t) \right] + \lambda_1 \left(\frac{a_1(S,t) - T_1(S,t)}{k} - \frac{\Psi_{21}(t) - \Psi_{22}(t)}{k} \right)$$

with the costate variable λ_1.

[32] A different but similar idea of guessing symmetric strategies via the Pontryagin maximum principle are also used in Cellini and Lambertini (2004 and the references therein). For a recent and detailed survey see Long (2010).

The large economy faces the following problem

$$\begin{cases} \max_{a_2,T_2} \int_0^\infty e^{-rt} \left[((1-S(t))T_2(t))^{\frac{1}{2}} - \frac{1}{2}a_2^2(t) \right], \\ \text{subject to } \dot{S}(t) = \frac{\Psi_{11}(S,t) - \Psi_{12}(S,t)}{k} - \frac{a_2(t) - T_2(t)}{k}. \end{cases} \tag{3.10}$$

The large country *conjectures* that the small economy's strategies[33] are $\Psi_{11}(S,t) = \frac{1}{\beta k}\lambda_1(t)$ and $\Psi_{12}(S,t) = \left(\frac{k}{2\lambda_1(t)}\right)^2 S$, $\forall S \in [0,1]$ and $t \geq 0$. The current-value Hamiltonian of the large economy is defined by

$$\mathcal{H}_2(T_2, S, a_2, \lambda_2) = \left[(1-S(t))^{\frac{1}{2}} T_2^{\frac{1}{2}}(t) - \frac{1}{2}a_2^2(t) \right] + \lambda_2 \left(\frac{\Psi_{11}(S,t) - \Psi_{12}(S,t)}{k} - \frac{a_2(t) - T_2(t)}{k} \right)$$

with the costate variable λ_2.

The first order conditions yield the small economy's equilibrium choices $T_1(S,t) = \left(\frac{k}{2\lambda_1}\right)^2 S$ and $a_1(S,t) = \frac{\lambda_1}{k\beta}$. The costate variable verifies the equation $\dot{\lambda}_1(t) = r\lambda_1 - \frac{k}{4\lambda_1}$ with the transversality condition $\lim_{t\to\infty} e^{-rt}\lambda_1(t)S(t) = 0$.

The optimal choices of the large economy are $a_2(t) = -\frac{\lambda_2(t)}{k}$ and $T_2(t) = \left(\frac{k}{2\lambda_2(t)}\right)^2 (1 - S(t))$ with the costate equation

$$\dot{\lambda}_2(t) = r\lambda_2 - \frac{k}{4\lambda_2} + \frac{k}{4}\frac{\lambda_2}{\lambda_1^2}. \tag{3.11}$$

The associated transversality condition is $\lim_{t\to\infty} e^{-rt}\lambda_2(t)S(t) = 0$.

We can readily check that the maximized Hamiltonians $H_1^*(S,\lambda_1)$ and $H_2^*(S,\lambda_2)$ are

$$\mathcal{H}_1^*(S,\lambda_1,t) = \left[\frac{k}{2\rho\lambda_1}S - \frac{\beta}{2}\left(\frac{\lambda_1}{k\beta}\right)^2 \right] + \lambda_1 \left(\frac{\frac{\lambda_1}{k\beta} - (\frac{k}{2\lambda_1})^2 S}{k} - \frac{(-\frac{\lambda_2}{k}) - (\frac{k}{2\lambda_2})^2(1-S)}{k} \right)$$

[33]To explain how players in a differential game guess each other's heterogeneous strategy, first consider the case where both players make open-loop decisions. Then, after having solved the game, we would get the following solutions: $\Psi_1(t) = \Psi_1(S(t),\lambda_1(t),t)$ and $\Psi_2(t) = \Psi_1(S(t),\lambda_2(t),t)$, for any t. However, in our model, the small country makes Markovian decisions. Therefore, the large country, which is the open-loop player, conjectures that the small economy is a Markovian player. Consequently, $\Psi_1(t) = \Psi_1(S(t),t)$ has to be replaced by $\Psi_1(S,t)$ with any state variable S. Or, more precisely, the large economy guesses that the small economy's strategy is: $\Psi_1(S,t) = \Psi_1(S,\lambda(t),t)$, for any (S,t).

and

$$\mathcal{H}_2^*(S,\lambda_2,t) = \left[-\frac{k}{2\lambda_2}(1-S) - \frac{1}{2}\left(-\frac{\lambda_2}{k}\right)^2\right] + \lambda_2\left(\frac{\frac{\lambda_1}{k\beta} - (\frac{k}{2\lambda_1})^2 S}{k} - \frac{(-\frac{\lambda_2}{k}) - (\frac{k}{2\lambda_2})^2(1-S)}{k}\right).$$

It is straightforward to see that the equilibrium Hamiltonians are concave with respect to the state variable S. Hence, $a_i(t), T_i(t)$ $(i = 1, 2)$ are optimal paths. It follows that the large country's conjecture about the rival's strategy is optimal. Consequently, the solutions $\Psi_1(S,t) = (a_1(S,t), T_1(S,t))$ and $\Psi_2(t) = (a_1(t), T_2(t))$ for $S \in [0,1]$ and $t \geq 0$ constitute a non-degenerate Markovian Subgame perfect Nash Equilibrium. QED.

A.2 Trajectories

The above analysis shows that there exists a stable trajectory associated to the dynamic system. In this subsection, we explore the convergence path to the steady state. Taking into account the initial and transversality conditions, the FOCs yield the explicit trajectories

$$\lambda_1(t) = \frac{1}{2}\left(\frac{k}{r}\right)^{\frac{1}{2}}, \quad \lambda_2(t) = -\frac{1}{2}\left(\frac{k}{2r}\right)^{\frac{1}{2}}.$$

The trajectory of the state variable is

$$S(t) = (S(0) - \widehat{S})e^{-3rt} + \widehat{S}, \tag{3.12}$$

which is the optimal path converging to the steady state. The convergence speed is $3r$.

A.3 State variable constraint $S(t) \leq \overline{S} < \frac{1}{2}$

Recalling that the size of the small economy is constrained ($S(t) \leq \overline{S} \leq \frac{1}{2}$), we adapt the Lagrangian function as follows

$$\begin{aligned}\mathcal{L}_1(T_1, S, a_1, \lambda_1) &= \left[S^{\frac{1}{2}}(t)T_1^{\frac{1}{2}}(S,t) - \tfrac{\beta}{2}a_1^2(S,t)\right] + \lambda_1\left(\frac{a_1(S,t) - T_1(S,t)}{k} - \frac{a_2(t) - T_2(t)}{k}\right) \\ &+ \mu(S - \overline{S}).\end{aligned}$$

The above first order conditions still hold. The costate variable now verifies the equation $\dot{\lambda}_1(t) = r\lambda_1 - \frac{k}{4\lambda_1} + \mu$. Furthermore, we consider the Kuhn-Tucker condition

$$\mu\left(S - \overline{S}\right) = 0.$$

In other words, we have, either $S < \overline{S}$ with $\mu = 0$ or $S = \overline{S}$ with $\mu \geq 0$. Because the small economy's size is constrained by the upper-bound $\overline{S}$, we impose that $\mu = 0$ whenever $S = \overline{S}$.

Appendix B Budget constraint

In this section, we prove that the present value of net tax revenues (the intertemporal budget constraint) is strictly positive for all $k \in [\underline{k}, k^*]$.

The FOCs relative to the Hamiltonians $\mathcal{H}_1$ and $\mathcal{H}_2$ yield the equilibrium choice variables of jurisdictions 1 and 2: $T_1(S,t) = \left(\frac{k}{2\lambda_1}\right)^2 S(t)$, $a_1(S,t) = \frac{\lambda_1}{k\beta}$, $a_2(t) = -\frac{\lambda_2(t)}{k}$ and $T_2(t) = \left(\frac{k}{2\lambda_2(t)}\right)^2 (1 - S(t))$. The FOCs also yield the motion equation of S : $S(t) = (S(0) - \widehat{S})e^{-3rt} + \widehat{S}$, where $\widehat{S} = \frac{1}{6\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}}(\frac{\sqrt{2}}{\beta} - 1) + \frac{2}{3}$.

Case 1: The small country ($i = 1$)

Consider first the case of the small country. The above results allow us to compute the equilibrium present value of net revenues

$$J_1 = \frac{1}{4}\sqrt{\frac{k}{r}}\left[S(0) + 3\widehat{S}\right] - \frac{1}{8kr^2\beta}.$$

It is easy to check that $J_1 > 0$ if and only if $S(0) + 3\widehat{S} > \frac{1}{2\beta}\left(\frac{1}{kr}\right)^{\frac{3}{2}}$, which is equivalent to $S(0) > \frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}} - 2$. The following conclusions can be derived.

(a) If $k > \overline{k} = \left(\frac{1}{32}\right)^{\frac{1}{3}}\frac{1}{r}$, we have $S(0) > 0 > \frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}} - 2$ and the above inequality is always true, that is, $J_1 > 0$, $\forall S(0)$. Considering that $\widehat{S} > 0$, we claim that $k > \overline{k}$ is a sufficient condition under which the small economy never collapses.

(b) If $k < \overline{k}$, the sign of J_1 depends on the value of $S(0)$.

(b.1) If $\frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}} - 2 > S(0) > 0$, we have $J_1 < 0$. We also impose that $S(0) < \frac{1}{2}$.

Consequently, if $\frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}}-2>\frac{1}{2}$, that is $k<\underline{k}=\left(\frac{1}{50}\right)^{\frac{1}{3}}\frac{1}{r}$, the small economy collapses for sure for any initial value $S(0)$.

(b.2) If $S(0)>\frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}}-2>0$, we have $J_1>0$. Because $S(0)<\frac{1}{2}$, we must require that $\frac{1}{2}>\frac{1}{2\sqrt{2}}\left(\frac{1}{kr}\right)^{\frac{3}{2}}-2$, or $k>\underline{k}=\left(\frac{1}{50}\right)^{\frac{1}{3}}\frac{1}{r}$ for guaranteeing $J_1>0$. However, this condition does not rule out that the small country may collapse in the long run. It may happen that the small economy keeps on shrinking infinitely and converges to 0, such that $\lim_{t\to\infty} S(t)\longrightarrow\widehat{S}\leq 0$. In other words, stating that the small economy is able to payoff its public debt is not enough for eliminating collapse in the long run. Collapse is only excluded if the steady state net revenue is positive ($\widehat{w}_1>0$).

From (a), (b.1.) and (b.2.) we conclude that $J_1>0$ for all $k\in[\underline{k},k^*]$.

Case 2: The large country ($i=2$)

Because $S(t)<\frac{1}{2}$, it is easy to show that $w_2(t)=(1-S(t))\sqrt{2kr}-\frac{1}{16kr}>(1-\frac{1}{2})\sqrt{2kr}-\frac{1}{16kr}>0$ if $k>\underline{k}=\left(\frac{1}{50}\right)^{\frac{1}{3}}\frac{1}{r}$. Consequently, $w_2(t)>0,\ \forall t\in(0,+\infty)$ and $\forall k\in[\underline{k},k^*]$. Under the conditions of our model, the large country will never have to issue debt to fund its expenditures. It follows that the present value of net tax revenues is always positively signed. In other words, $J_2=\int_0^\infty e^{-rt}w_2\left[T_2(t),a_2(t)\right]dt>0,\forall k\in\left[\underline{k},k^*\right]$.

After having analyzed the cases 1 and 2, we finally conclude that $J_i>0,(i=1,2)$ for all $k\in[\underline{k},k^*]$. We also conclude that the present value of net revenues in country i is positive ($J_i>0,i=1,2$) if the steady state net revenue is positive($\widehat{w}_i>0,i=1,2$).

That finishes the proof.

Part II

Multi-dimensional Jurisdictional Competition and Policy Coordination

Chapter 4

On the Desirability of Tax Coordination When Countries Compete in Taxes and Infrastructure

4.1 Introduction

The [1] debate over corporate tax coordination among international jurisdictions remains unresolved. In particular, it has been argued that the member states of the European Union should coordinate tax policies[2] to avoid a "race to the bottom" that would undermine their modern welfare states (Baldwin and Krugman, 2004).[3]

The classical approach on tax coordination (see for example, Kanbur and Keen, 1993;

[1]This chapter is based on, *On the desirability of tax coordination when countries compete in taxes and infrastructure*, Y. Han, P. Pieretti and B. Zou. IMW Discussion paper, 476.

[2]The Ruding Report (1992) made several far-reaching harmonization proposals related to corporate taxation, including the imposition of an EU-wide minimum corporate tax rate (Haufler, 1999).

[3]For this purpose, in the 1990s, the Organization for Economic Cooperation and Development (OECD) launched a "harmful tax competition" initiative. In addition, the United Nations (UN) has called for the creation of an International Tax Organization, which would be specifically charged with curtailing tax competition.

Baldwin and Krugman, 2004) takes it for granted that jurisdictions compete in taxes only and don't consider other non-tax variables as possible additional and independent instruments to attract tax bases. However, several authors argue that jurisdictions not only compete in taxes but also in infrastructure (for example, Hindriks et al., 2008; Zissimos and Wooders, 2008; Justman et al., 2002, and Pieretti and Zanaj, 2011). Moreover, recent empirical research (Hauptmeier et al., 2012) demonstrates that jurisdictions use independent and strategic business tax rates and public inputs to compete for capital.

Therefore, when jurisdictions can compete with tax and non-tax instruments independently, constraining tax rates through tax coordination is likely to create carry-over effects on other strategic instruments thus creating adverse effects not considered in the classical approach. Against this background, it is interesting to reconsider tax coordination.

There are some authors (Keen and Marchand, 1997; Fuest, 1995) who consider the impact of public inputs on the production function of firms and thus account for the effect of infrastructure on internationally mobile capital. However, in these models tax rates and infrastructure expenditures are not independent variables[4]. This results formally from the fact that tax rates and infrastructure expenditures are linked through a balanced budget. According to Wildasin (1991), equilibria in fiscal competition games with two instruments related via a budget constraint crucially depend on which instrument is set strategically. Consequently, if countries interact in taxes, expenditures are not a strategic variable.

The purpose of this chapter is to analyze the desirability of tax coordination when two heterogeneous jurisdictions compete for mobile entrepreneurs using taxes and infrastructure investments that improve firm productivity[5]. These infrastructure investments may represent material or immaterial public goods such as laws and regulations

[4]For example, Fuest (1995) recognizes that his model disregards strategic interactions induced by public infrastructure expenditures.

[5]In another paper, Han (2013) investigates the issue of partial tax coordination and its welfare implications. However, this is not the focus in this paper.

protecting intellectual property and specifying accurate dispute resolution rules.

The literature generally highlights two different ways to coordinate taxation [6] in order to correct the inefficiencies[7] caused by tax competition: tax harmonization and the imposition of a minimum tax rate. Tax harmonization is generally understood as a transition towards a common rate structure (Keen, 1987; Zissomos and Wooders, 2008). More specifically, in the present paper, we define tax harmonization as the equalization of tax rates, which is consistent with the tax competition literature (see, for example, Kanbur and Keen, 1993; Baldwin and Krugman, 2004; Zissimos and Wooders, 2008) and common policy prescriptions[8]. The general conclusion of the classical literature is that appropriately selected uniform tax rates improve efficiency relative to tax competition. The reason is that an upward harmonization of capital tax rates can produce a Pareto improvement (Baldwin and Krugman, 2004). This conclusion also holds when the competing countries are asymmetric in size (Kanbur and Keen, 1993).[9] Another type of coordination is the adoption of a minimum tax rate that allows some room for tax competition. An interesting result highlighted in the literature (see Kanbur and Keen, 1993) is that the imposition of a minimum tax rate can be Pareto-improving.

A related paper to ours is Zissimos and Wooders (2008). However, there is an important difference in the way they treat infrastructure decisions when jurisdictions coordinate their tax rates. For these authors jurisdictions do not adapt their infrastructure

[6] See for example, Kanbur and Keen (1993), Sørensen (2004), Zissimos and Wooders (2008), and Konrad (2009).

[7] These concerns are in keeping with the large tax competition literature (for systematic reviews, see Wilson, 1999; Wilson and Wildasin, 2004; Boadway and Tremblay, 2011). The main point is that independent governments engage in wasteful competition over scarce capital through inefficiently low tax rates and public expenditure levels. Zodrow and Mieszkowski (1986) and Wilson (1986) have formally modeled this process.

[8] In 2003, the EU Council adopted a voluntary Code of Conduct to combat harmful tax competition, and more ambitious proposals for corporate tax harmonization have been advanced, including the introduction of a single EU corporate tax (Conconi et al., 2008).

[9] Kanbur and Keen (1993) show that there exists a critical level above which harmonization results in tax revenue exceeding, for each jurisdiction, that of the non-cooperative equilibrium. However, a uniform level between the Nash equilibrium rates is certain to harm the small country.

decisions to the new environment caused by tax coordination even if these expenditure levels are no longer their best choices. In other words, jurisdictions are supposed to compete in infrastructure when they don't constraint their tax rates, but they cease to compete in public expenditures when taxes are coordinated. In our paper we consider that tax coordination does not constrain infrastructure competition among sovereign jurisdictions[10].

In the following we assume that two jurisdictions of unequal population size[11] compete strategically in taxes and infrastructure expenditures to attract imperfectly mobile firms. Public infrastructure improvements are attractive to firms because they enhance private productivity and firms are not perfectly mobile because they incur relocation costs.

Then, we consider tax harmonization and minimum taxation as alternative coordination devices and compare tax competition with tax coordination from the perspective of net total revenue and global social welfare, respectively.

Because two independent strategic variables are involved, we have to clarify the timing of the game. If we assume that infrastructure spending and tax rates are equally flexible, the jurisdictions will compete simultaneously in these two instruments. This is reminiscent of the Marshallian notion of "long run" when all the decision variables are flexible. However, in a "short term" perspective, tax policy and infrastructure decisions can be unequally flexible. For example, it can take several years to construct a power plant. On the other hand, the capacity of a plant can be augmented by new expenditures but cannot easily be reduced. In other words, infrastructure decisions may involve irreversibility and lack of flexibility. However, we assume that changing tax rates is more flexible in a short term perspective.

In this chapter we address the two aspects we just highlighted by analyzing two alternative scenarios. In a "long term" view we assume that the jurisdictions compete

[10] Fuest (1995) highlights how difficult it is to coordinate in taxes and infrastructure.

[11] Various authors have addressed the importance of size asymmetries in tax competition (Bucovetsky, 1991; Wilson, 1991; Kanbur and Keen, 1993). The general result is that the large jurisdiction issues a higher tax rate and faces a lower elasticity of capital to the tax rate than its small rival.

simultaneously in taxes and infrastructure. By contrast, they are supposed to compete sequentially when the strategic instruments are unequally flexible. In this case, we assume that the governments non-cooperatively select infrastructure levels first and set the tax rates in a second stage. This is the way two instrument competition is generally modeled (see Justman et al., 2002; Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011). In doing so we adopt the rule that the most irreversible decision should be made first.

Generally speaking, the chapter contains two distinct messages. First, when jurisdictions compete in two independent strategic variables, the decision to coordinate on one variable (a tax rate) induces a carry-over effect on the unconstrained instrument (infrastructure expenditures). Consequently, classical results of the tax coordination literature may be qualified. A second message is that the relative flexibility of the strategic instruments, which may depend on the time horizon of the decision-making, does matter. In particular, tax coordination is more likely to be detrimental when countries can compete simultaneously in taxes and infrastructure, rather than sequentially. The reason is that simultaneity eliminates strategic effects between tax and non-tax instruments.

The main results may be summarized as follows. When tax revenue is used to gauge whether tax coordination dominates a non-cooperative equilibrium, the following results are obtained. If the jurisdictions decide to set uniform tax rates, coordination is Pareto-inferior to the non-cooperative equilibrium when countries compete in tax and non-tax instruments. By contrast, if jurisdictions only compete in taxes, our model indicates that tax harmonization can be Pareto improving.

Coordination consisting of the imposition of a lower bound on tax rates hurts the revenue of the low tax country if jurisdictions compete in taxes and infrastructure. However, if inter-jurisdictional tax redistribution is feasible and countries compete sequentially in taxes and infrastructure, it is conceivable that the country incurring a tax loss could be compensated if coordination increases joint revenue. These results are at odds with a classical outcome (see for example, Kanbur and Keen, 1993) that imposing an appropriate minimum rate improves the revenue of each country when jurisdictions compete in taxes alone .

The results differ when we consider the potential welfare gains from tax coordination. When the jurisdictions decide to set uniform tax rates, the profitability of coordination crucially depends on the degree of country-size asymmetry if tax and infrastructure decisions are taken sequentially. If these decisions are taken simultaneously, harmonization is always welfare reducing.

Finally, our model demonstrates that minimum tax coordination always increases social welfare if jurisdictions compete in taxes and infrastructure sequentially. However, if countries compete simultaneously this result is reversed.

The remainder of the chapter is organized as follows. In section 2, we model tax and infrastructure competition between heterogeneous jurisdictions that attempt to attract imperfectly mobile firms. Section 3 analyzes the conditions under which tax harmonization is more desirable than tax and infrastructure competition. Section 4 examines the differences between minimum tax coordination and tax competition. Section 5 concludes.

4.2 The model

Consider two jurisdictions denoted h and f. The countries' populations are evenly distributed with unit density on a segment $(0, 1)$. Country h is assumed to be small in terms of total population, and its size is given by S with $0 < S < \frac{1}{2}$. It follows that the size of country f equals $(1 - S) \in \left(\frac{1}{2}, 1\right)$. Similar to Pieretti and Zanaj (2011), we assume that each individual owns one unit of capital and is simultaneously an entrepreneur and a worker. In other words, each member of the population corresponds to a one-person company[12]. The entrepreneurs can relocate their activity abroad, but

[12]It follows that the world population coincides with the population of firms. We could assume that each firm is run by more than one person, but this would unnecessarily complicate the model without providing further insights.

moving a company to another country is costly[13]. Moreover, we assume that the entrepreneurs are heterogeneous in the ability to cope with the costs associated to business relocation. They will be ranked according to the ease with which they are able to relocate abroad[14]. The closer an individual is to the border separating countries h and f, the easier it is for her to relocate abroad. In other words, an entrepreneur of type $\alpha \in (0, 1)$ who moves abroad incurs a relocation cost of $|\alpha - S|$, which is the "distance" between the border S and an entrepreneur of type α. Note that, because tax competition can induce firms to move, relocation costs can be viewed as a distortion affecting private production.

Firms

Using one unit of capital, each individual living in country j $(j = h, f)$ is able to produce $y_j = q_j + \theta_j$ units of one final good. The parameter q_j $(j = h, f)$ represents firm specific productivity, whereas θ_j is the output fraction, which is country-specific. More precisely, θ_j is the level of infrastructure spending planned by the policy-makers in country j. The focus of the paper is on how size asymmetry and infrastructure expenditures affect the welfare effects of tax competition. Therefore, we assume that firm-specific productivity is uniform across firms, which means that[15] $q_j = q$ $(j = h, f)$. Finally, we assume that the goods are sold in a competitive market with a price normalized to one. The unit cost of production is assumed to be constant and normalized to zero.

A firm of type x located in the home country h is indifferent between producing at

[13]Firms that decide to relocate abroad will have to incur several costs resulting, for example, from losses of real estate sales, moving facilities abroad and from the relocation of workforce. Moreover, firms will have to collect more or less information on laws and regulations that are specific to foreign locations. Possibly, they will have to cope with language barriers and different cultures which can affect the working conditions in the destination country.

[14]For example, the amount of information that is necessary to transferring activities abroad may differ across entrepreneurs. Moreover, the physical relocation costs can be specific to each firm.

[15]In the following, we assume that q is sufficiently large such that the value of the welfare is nonnegative.

home and in the foreign country f if

$$q_h + \theta_h - t_h = q_f + \theta_f - t_f - (S - x)\,, \tag{4.1}$$

where t_h and t_f are source-based tax rates levied on capital in countries h and f, respectively.

Similarly, a firm of type x located in the large country f is indifferent between investing at home and investing abroad if

$$q_f + \theta_f - t_f = q_h + \theta_h - t_h - (x - S). \tag{4.2}$$

The above two conditions yield

$$x = (\theta_h - \theta_f) + (t_f - t_h) + S. \tag{4.3}$$

Note that if $x > S$, firms move from the large to the small country, while if $x < S$, firms move from the small country to its larger rival.

Governments

We now assume that countries attempt to attract companies by competing in taxes and public infrastructure that enhance private productivity. Jurisdictions h and f are thus able to influence the productivity parameter θ_j $(j = h, f)$ of the firms located within their respective boundaries. As in Hindriks et al. (2008) and Pieretti and Zanaj (2011), we assume that one additional unit of the public good produces one additional unit of the private good. It follows that θ_j also represents the amount of the public good supplied by jurisdiction j $(j = h, f)$. The cost of providing this public good in each country j is given by the quadratic cost function $C(\theta_j) = \frac{1}{2}\theta_j^2$. Each jurisdiction j $(j = h, f)$ is assumed to maximize its total tax revenue[16], net of public expenditures, by selecting the appropriate tax rate t_j and infrastructure level θ_j. The governments' objective functions are given by

$$B_h = t_h x - \frac{1}{2}\theta_h^2, \quad B_f = t_f(1 - x) - \frac{1}{2}\theta_f^2. \tag{4.4}$$

[16]For a similar assumption, see Kanbur and Keen (1993), Zissimos and Wooders (2008) or Pieretti and Zanaj (2011).

Two jurisdictions wish to attract productive capital by competing in taxes and infrastructure. In this context it is important to precise in which time sequence the instruments are used. Thus, we consider the timing of the game in two different ways. In a "short term" view when infrastructure decisions are less flexible than tax policy, the jurisdictions compete successively in two strategic variables. In a first stage, governments non-cooperatively select infrastructure levels, and then they set the tax rates [17]. In a "long term" perspective, the tax and infrastructure instruments can be viewed as equally flexible, and a simultaneous game in both instruments is the most suitable.

(a) Simultaneous tax and infrastructure game

The governments set tax rates and infrastructure expenditures simultaneously. The first order conditions[18] yield the following unique equilibrium tax rates

$$\begin{aligned} t_h^* &= S, \;\; t_f^* = 1 - S, \\ \theta_h^* &= S, \;\; \theta_f^* = 1 - S. \end{aligned} \tag{4.5}$$

It follows that the number of companies located in countries h and f are, respectively, x^* and $1 - x^*$, with

$$x^* = S.$$

From the concavity property of the objective function relative to t_j and θ_j, it follows that the strategy-tuple $\left(\theta_h^*, \theta_f^*, t_h^*, \; t_f^*\right)$ is a unique Nash equilibrium. It is straightforward to show that $x^* \in (0,1)$ and $\theta_j^* \geq 0$, $(j = h, f)$ for any $S < \frac{1}{2}$. It also appears that $t_h^* < t_f^*$ and $\theta_h^* < \theta_f^*$. We have here the standard result that the smallest country sets the smallest tax rate. Moreover, the country that taxes less than its rival also provides less public infrastructure. Because the net tax advantage $t_j^* - \theta_j^*$ $(j = h, f)$ of both countries is zero at equilibrium, no firm will move.

The equilibrium tax revenues of both countries are

$$B_h^* = \frac{1}{2} S^2 \text{ and } B_f^* = \frac{1}{2} (1 - S)^2 .$$

[17]This choice of sequentiality follows the rule that the most irreversible decision should be made first.
[18]It can be easily verified that the objective function is jointly concave in the choice variables.

The joint tax revenue is $B^* = B_h^* + B_f^* = \frac{1}{2}\left[(1-S)^2 + S^2\right]$. As in Zissimos and Wooders (2008), we define efficiency as the maximum level of surplus available to all individuals in the two economies

$$W(x) = (\pi_h + \pi_f) + (B_h + B_f) - \int_0^{\left|x^T - S\right|} y dy. \tag{4.6}$$

The two terms in the brackets include, respectively, the total firms' profits[19] and total tax revenues. The last term is the relocation cost faced by relocating companies. Since firms don't move in the equilibrium of the simultaneous game, this last term vanishes. After simplification, the (joint) social welfare W^* resulting from inter-jurisdictional competition equals

$$W^* = q + S^2 - S + \frac{3}{2}.$$

(b) Sequential tax and infrastructure game

We now assume that the non-cooperative governments first select infrastructure levels and then set tax rates. Finally, firms decide where to locate their production processes. We solve the game by backward induction.

Beginning from the second stage, each government maximizes its objective with respect to its tax rate while taking its rival's rate as given. The first order conditions[20] yield the following unique equilibrium tax rates

$$\begin{aligned} t_h &= \frac{(1+S) - \theta_f + \theta_h}{3}, \\ t_f &= \frac{(2-S) + \theta_f - \theta_h}{3}. \end{aligned} \tag{4.7}$$

It follows that the number of companies located in countries h and f are, respectively, x and $1-x$, with

$$x = \frac{(1+S) + \theta_h - \theta_f}{3}.$$

[19]The profit in country j ($j = h, f$) is $\pi_j = (q + \theta_j - t_j)x_j$.

[20]The second order conditions can be easily verified.

After substituting the above tax rates into the jurisdictions' objective functions, we can solve for stage 1 of the game, where the two governments compete in public infrastructure θ_h and θ_f. It is simple to verify that the objective function B_j $(j = h, f)$ is strictly concave in θ_j $(j = h, f)$. The first order conditions thus lead to the unique equilibrium expenditures

$$\theta_h^{**} = \frac{2}{15}(1+3S), \quad \theta_f^{**} = \frac{2}{15}(4-3S). \tag{4.8}$$

Introducing (6.5) into (6.4) yields the equilibrium values

$$t_h^{**} = \frac{3}{2}\theta_h^{**}\ , \quad t_f^{**} = \frac{3}{2}\theta_f^{**}. \tag{4.9}$$

The strategy-tuple $\left(\theta_h^{**}, \theta_f^{**}, t_h^{**},\ t_f^{**}\right)$ is a unique subgame perfect Nash equilibrium (*SPNE*). Equation (4.9) shows that the country that taxes more than its rival also provides more public infrastructure.

The number of firms located in equilibrium in country h is given by

$$x^{**} = \frac{1}{5}\,(1+3S). \tag{4.10}$$

It is straightforward to show that $x^{**} \in (0,1)$ and $\theta_j^{**} \geq 0$, $(i = h, f)$ for any $S < \frac{1}{2}$.

Note that the tax differential between the large and small countries equals

$$t_f^{**} - t_h^{**} = \frac{3}{2}\left(\theta_f^{**} - \theta_h^{**}\right) = \frac{3}{5}\left(1-2S\right). \tag{4.11}$$

It follows that in the sequential version of the game, the small country is able to attract firms from the large country since $t_h^{**} - \theta_h^{**} < t_f^{**} - \theta_f^{*}$ if $0 < S < \frac{1}{2}$. It follows that the firms which move to the small jurisdiction is $x^{**} - S = \frac{1}{5}\,(1-2S) > 0$ $(0 < S < \frac{1}{2})$.

The equilibrium tax revenues of both countries are

$$B_h^{**} = \frac{7}{225}\,(1+3S)^2 \text{ and } B_f^{**} = \frac{7}{225}\,(4-3S)^2\,. \tag{4.12}$$

The joint tax revenue is $B^{**} = B_h^{**} + B_f^{**}$.

Plugging the equilibrium values of $\theta_h^{**}, \theta_f^{**}$, and x^{**} into (4.6) yields

$$W^{**} = q + \frac{1}{450}(108S^2 - 108S + 577). \tag{4.13}$$

4.3 Harmonization versus tax competition

We now assume that the two countries cooperatively select uniform tax rates, for a given level of infrastructure expenditures. Therefore, they only compete in infrastructure. We further assume that the uniform tax rate is designed to maximize either global tax revenue or global social welfare. The two cases will be considered successively. Then, we analyze the conditions under which harmonization is desirable, successively applying the tax revenue and social welfare perspectives. In adopting this approach, we follow Zissimos and Wooders(2008), who compare tax competition between revenue-maximizing jurisdictions with tax coordination, from the perspective of social welfare.

4.3.1 Tax harmonization

We define the uniform tax rate as follows

$$t_h = t_f = t, \; t \geq 0.$$

Therefore, the number of firms that locate in the small country is given by

$$x = (\theta_h - \theta_f) + S.$$

We first solve the infrastructure game. Each jurisdiction selects a level of public infrastructure θ_j by maximizing its revenue for a given tax rate t.

In equilibrium, we obtain

$$\theta_h^u = \theta_f^u = t.$$

It follows that

$$x^u = S.$$

The tax revenues of countries h and f resulting from infrastructure competition for a given uniform tax rate is as follows

$$B_h^u = tS - \frac{1}{2}t^2 \text{ and } B_f^u = t(1-S) - \frac{1}{2}t^2. \tag{4.14}$$

Joint tax revenue becomes

$$B^u(t) = B_h^u + B_f^u = t\,(1-t)\,, \tag{4.15}$$

where $B^u(t)$ is positive if $t \in (0,1)$.

The aggregate social welfare resulting from infrastructure competition with uniform tax rates is

$$W^u = q + (1 + t - t^2). \tag{4.16}$$

We are now able to calculate the harmonized tax rate. First consider the case where the jurisdictions agree on a uniform rate that maximizes joint tax revenue. It is easy to see that $\bar{t} = \arg\max B^u(t) = \frac{1}{2}$. It follows, $\overline{B}^u = B^u(\bar{t}) = \frac{1}{4}$, $B_h^u(\bar{t}) = \frac{1}{8}\,(4S-1)$ and $B_f^u(\bar{t}) = \frac{1}{8}\,(3-4S)$. If tax harmonization is intended to maximize global social welfare we show[21] that $t^s = \arg\max W^u(t) = \frac{1}{2}$. The resulting maximum social welfare equals $W^u(t^s) = q + \frac{5}{4}$.

4.3.2 Comparing net tax revenues

In this section we analyze the desirability of tax harmonization with respect to tax revenues. Comparing tax revenues resulting from tax and infrastructure competition with the maximum revenue resulting from tax harmonization shows that $B_h^* > B_h^u(\bar{t})$ (respectively, $B_h^{**} > B_h^u(\bar{t})$) and $B_f^* > B_f^u$ (respectively, $B_f^{**} > B_f^u$) for all $S \in (0, \frac{1}{2})$.

[21] Assuming that the harmonized tax rate is designed to maximize global welfare is in line with Zissimos and Wooders (2008).

This result appears in the simultaneous tax and infrastructure game, as well as in the sequential game. In other words, if the common rate equals $\bar{t}$, tax harmonization does not make either country better off.

The above finding is at odds with classical results, according to which tax harmonization dominates pure tax competition if the uniform tax rate is *sufficiently high* (see for example, Kanbur and Keen, 1993; Baldwin and Krugman, 2004; and Boadway and Tremblay, 2011). Our model leads to a similar conclusion (see Appendix A) if we restrict ourselves to pure tax competition. Indeed, in that case, tax harmonization generates more revenue than tax competition for both jurisdictions provided that the two countries are not excessively asymmetric with respect to size. However, if revenue transfers are feasible, both countries are always better off under an appropriate common rate.

The idea underlying the above results obtained in case of simultaneous tax and infrastructure game can be explained as follows. First, it should be noted that, in our model, harmonization is equivalent to infrastructure competition with constrained tax rates. It is then obvious that introducing more flexibility in the use of competition instruments does not hurt the payoffs obtained with less flexibility. Specifically, when jurisdictions are also free compete in taxes they have an additional variable to maximize their respective net tax revenue that will be at least as high as in the case of tax harmonization. Formally speaking the net revenue function $B_j^*(S), (j = h, f)$ is the envelope of $B_j^u(S)$ $(j = h, f)$. When the considered jurisdictions are equally sized ($S = \frac{1}{2}$) and when they compete simultaneously in two instruments, it is easy to show that $B_j^*(S) = B_j^u(S)$. This is because the mix of tax and infrastructure decisions is not altered by tax harmonization when $S = \frac{1}{2}$.

When countries compete sequentially, the previous effect remains but is augmented by a strategic effect. As in Hindriks et al. (2008), our model implies that the more jurisdictions improve their attractiveness by investing in infrastructure in the current period, the fiercer tax competition will be in the second stage. The competing jurisdictions anticipate this effect in the first stage and thus underinvest in infrastructure relative to the tax harmonization scenario. To highlight this strategic effect, assume that the jurisdictions are equally sized. It is then easy to show that tax harmonization does not increase taxes but increase infrastructure expenditures in both jurisdictions. Consequently, harmonization decreases net tax revenue in each country.

We can now state the following proposition

Proposition 1 *Moving from tax and infrastructure competition to tax harmonization decreases the tax revenues of all competing countries. This holds true in a simultaneous tax and infrastructure game as well as in a sequential game. However, if the countries compete in taxes only, harmonization can be Pareto-improving in tax revenue.*

4.3.3 Comparing social welfare

Now we use social welfare to gauge the desirability of tax harmonization. To this end, consider the welfare differences, $W^* - W^u(t^s)$ (respectively, $W^{**} - W^u(t^s)$) between the competing jurisdictions. We successively analyze two cases.

(a) Simultaneous tax and infrastructure game

In this case infrastructure investments and tax rates are equally flexible. From the above analysis, it is easy to show that

$$W^* - W^u(t^s) = (\frac{1}{2} - S)^2,$$

which is always positive for all $S < \frac{1}{2}$.

Remember that in case of simultaneous tax and infrastructure competition firms don't move at equilibrium and thus no mobility costs are involved. In addition we see that aggregate firms' profit does not change when we move from tax and infrastructure competition to harmonization. It follows that the welfare change is only affected by the change in net tax revenue and thus, the intuition underlying the above result also proceeds from the fact that harmonization restricts the flexibility in the use of competition instruments. If S is allowed to vary in the interval $\left(0, \frac{1}{2}\right]$, $W^*(S)$ is the envelope of $W^u(S)$.

(b) Sequential tax and infrastructure game

Now, we assume that infrastructure expenditures are not as flexible as tax rates. Then it follows from the above results that $W^{**} - W^u(t^s) = \frac{6}{25}S^2 - \frac{6}{25}S + \frac{29}{900}$. It is straightforward to show that $W^{**} < W^u(t^s)$ if $\frac{1}{2} > S > \overline{S}$, where $\overline{S} = \frac{1}{2} - \frac{5}{36}\sqrt{6}$, and $W^{**} > W^u(t^s)$ if $0 < S < \overline{S}$. It follows that harmonization dominates tax competition as long as the size asymmetry between the two jurisdictions is not sufficiently high. This result does not appear if we restrict ourselves to pure tax competition. Indeed, we demonstrate in Appendix A that moving from tax competition to tax harmonization always improves social welfare. The result is also in contrast to Zissimos and Wooders (2008) who show that efficiency can be achieved by setting a common tax rate.

To explain what happens, we can decompose the welfare difference $W^{**} - W^u(t^s)$ in the following manner

$$W^{**} - W^u(t^s) = \Delta B + \Delta\pi, \tag{4.17}$$

where $\Delta B = (B_h^{**} + B_f^{**}) - [B_h(t^s) + B_f(t^s)]$ and $\Delta\pi = (\pi_h^{**} + \pi_f^{**}) - [\pi_h(t^s) + \pi_f(t^s)]$.

From the previous section, we know that the movement from interjurisdictional competition to harmonization decreases net joint tax revenue ($\Delta B > 0$ for all S). However, it can readily be shown that the same change of regime increases joint profits net of relocation costs ($\Delta\pi < 0$ for all S). The increase of relocation costs can be viewed as a production inefficiency induced by jurisdictional competition. It is reminiscent of the distortional effect on private production of taxation in the classical tax competition models[22]. However, the opposite signs of ΔB and $\Delta\pi$ have a common cause. Indeed, inter-state competition generates more tax revenue than harmonization but less infrastructure expenditures. This benefits the governments and, by the same token, hurts the private economy. Which of the two effects will dominate depends[23] on

[22]In the Zodrow-Mieszkowski (Z-M) type models distortion results from variations in production, whereas in our model distortion results from moving production from one country to another. In the Z-M models, capital moves but without cost, whereas in our model, firms, considered as a whole, move with a cost. In other words, our model does not ignore the harm that taxation can have on private production.

[23]More exactly, we have $\Delta B = \frac{1}{900}\left(504S^2 - 504S + 251\right)$ and $\Delta\pi = -\frac{1}{150}\left(48S^2 - 48S + 37\right)$.

the value of S. Indeed, it is convenient to show that $\Delta B + \Delta\pi < 0$ if $S > \overline{S}$ and $\Delta B + \Delta\pi > 0$ if $S < \overline{S}$.

When $S > \overline{S}$, the degree of size asymmetry between the competing jurisdictions is low and tax competition is fierce. When a common tax rate is agreed, the two countries respond by competing more aggressively in infrastructure provision than without tax harmonization. Consequently, the relative gain in net revenue induced by inter-state competition is not sufficiently high to compensate for the benefit in private productivity that is attainable with tax harmonization ($\Delta B < -\Delta\pi$). As a result, tax harmonization improves social welfare relative to jurisdictional competition. When the degree of size asymmetry between the competing countries is large enough, i.e., $S < \overline{S}$, tax harmonization is no more the most efficient option. The two countries are sufficiently differentiated and tax competition is now less intense. Taxing captive firms becomes relatively more beneficial than providing a high level infrastructure. In other words, the harmonization scenario is no more the most appropriate one ($\Delta B > -\Delta\pi$).

The following proposition concludes

Proposition 2

1) *When unequal jurisdictions compete in taxes and infrastructure simultaneously, tax harmonization is less efficient than two instrument competition.*

2) *When unequal jurisdictions compete in taxes and infrastructure sequentially, tax harmonization is more efficient than two instrument competition. This result is, however, reversed if the countries' sizes are sufficiently asymmetric.*

4.4 Minimum tax versus tax competition

We now assume that the jurisdictions agree on a minimum tax rate τ which is in between the tax rates resulting from tax and infrastructure competition. This option has been analyzed by some authors (see, for example, Kanbur and Keen, 1993). We showed above that $S < \frac{1}{2}$ implies $t_h^* < t_f^*$ (respectively, $t_h^{**} < t_f^{**}$). Thus, the minimum tax rate τ will be $\tau > t_h^* \, (t_h^{**})$. In the following, we investigate firstly the *SPNE* under the constraint of a minimum tax rate; then we analyze the implications of this policy coordination. As a first step we assume that the jurisdictions decide on taxes and infrastructure expenditures simultaneously and then we consider the case where these instruments are used sequentially.

4.4.1 Competition with a minimum tax rate

(a) Simultaneous tax and infrastructure game

First, we consider the case where jurisdictions compete simultaneously in taxes and infrastructure, taking into account a minimum tax rate τ. The low tax country h will set the lower bound as its optimal tax rate[24], which is $t_h^o(\tau) = \tau$. If the common lower bound τ is higher than t_f^*, the high tax country will also set $t_f^o(\tau) = \tau$, and we recover the case of harmonization. Thus, we assume that $t_h^* < \tau < t_f^*$. The high tax country then chooses the tax rate $t_f^o[t_h^o(\tau)]$ that is its best response to $t_h^o(\tau)$. Solving the game yields the *SPNE*

$$\begin{aligned} \theta_h^o &= \tau, \;\; \theta_f^o = 1 - S, \\ t_h^o &= \tau, \;\; t_f^o = 1 - S. \end{aligned} \tag{4.18}$$

The number of firms that locate in the small country is $x^o = S$.

The tax revenue of the small and the large countries are respectively, $B_h^o = S\tau - \frac{1}{2}\tau^2$ and $B_f^o = \frac{1}{2}(1-S)^2$. The joint tax revenue becomes

$$\begin{aligned} B^o &= B_h^o + B_f^o \\ &= \frac{1}{2}[(1-S)^2 + 2S\tau - \tau^2]. \end{aligned} \tag{4.19}$$

Substituting the above equilibrium into (4.6) yields

$$W^o = q + \frac{1}{2}[S^2 - 2S(1-\tau) - \tau^2 + 3]. \tag{4.20}$$

[24] This is because the objective is concave in t_h.

(b) Sequential tax and infrastructure game

We now assume that the jurisdictions first compete in infrastructure expenditures and then in tax rates, which are bounded from below. As we assume that $S < \frac{1}{2}$, in the non-cooperative equilibrium, the small country is the low tax one. Consequently, the small country chooses its best tax rate, which is $t_h^{\otimes}(\tau) = \tau$. Solving the game backwardly, we first analyze tax competition for a given level of infrastructure expenditures and then consider infrastructure competition. The solution of the game yields the following subgame perfect equilibrium values

$$\begin{aligned} \theta_h^{\otimes} &= \frac{\tau}{2},\ \ \theta_f^{\otimes} = 1 - S + \frac{\tau}{2}, \\ t_h^{\otimes} &= \tau,\ \ t_f^{\otimes} = 1 - S + \frac{\tau}{2}. \end{aligned} \tag{4.21}$$

The share of firms that locate in the small country is $x^{\otimes} = S - \frac{1}{2}\tau$. As $x^{\otimes} \in (0,1)$, we impose $\tau < \tau_m = 2S$. Furthermore, to guarantee that $\tau_m > t_h^{**}$, $S > \frac{1}{7}$ is required. Therefore, in the sequel we assume that $\tau \in [t_h^{**}, \min\{t_f^{**}, \tau_m\}]$ and $\frac{1}{2} > S > \frac{1}{7}$.

The tax revenue of the small and the large countries are, successively, $B_h^{\otimes} = S\tau - \frac{5}{8}\tau^2$ and $B_f^{\otimes} = \frac{1}{8}(2 - 2S + \tau)^2$.

The joint tax revenue becomes

$$\begin{aligned} B^{\otimes} &= B_h^{\otimes} + B_f^{\otimes} \\ &= \frac{1}{2}[(1-S)^2 + (1+S)\tau - \tau^2]. \end{aligned} \tag{4.22}$$

The equilibrium social welfare resulting from the above equilibrium is

$$W^{\otimes} = q + \frac{1}{8}[12 - 4(2-S)S + (4 - 3\tau)\tau]. \tag{4.23}$$

4.4.2 Comparing tax revenue

We then analyze whether tax coordination, by imposing a minimum tax rate, increases the tax revenues of the competing countries. To this end, we compare for each country j ($j = h, f$) the difference $B_j^{*} - B_j^{o}$ (respectively, $B_j^{**} - B_j^{\otimes}$).

(a) Simultaneous tax and infrastructure game

When jurisdictions choose taxes and infrastructure simultaneously, we see that for $S < \frac{1}{2}$, we obtain $B_h^* - B_h^o = \frac{1}{2}(S - \tau)^2$ and $B_f^o = B_f^* = \frac{1}{2}(1 - S)^2$. It implies that setting a minimum tax rate has no impact on the high tax country, while it reduces the net tax revenue of the low tax country[25]. The underlying intuition can be explained as follows. Tax coordination forces the low tax country to increase its tax rate and the provision of infrastructure. However, the attractiveness of the low tax jurisdiction does not change. Consequently, the high tax country will not have to react, neither in taxes nor in infrastructure provision.

(b) Sequential tax and infrastructure game

In Appendix B (claims 1 and 2), we show that for $S < \frac{1}{2}$ we obtain $B_h^{**} > B_h^{\otimes}$ and $B_f^{\otimes} > B_f^{**}$. In other words, imposing a lower bound on tax rates does not unanimously improve the revenues of both coordinating countries. Indeed, it appears that the lower tax country loses tax revenue by moving from a non-cooperative equilibrium to minimum tax coordination. Consequently, accounting for the fact that countries can, in addition to tax competition, also compete independently in infrastructure qualifies a classical result (see Kanbur and Keen, 1993) according to which imposing a minimum tax rate Pareto-improves the countries' tax revenues (see Appendix A). Our results also differ from Zissimos and Wooders (2008), where tax coordination can be Pareto-improving in terms of revenue gains.

However, if coordination improves joint revenue, the winner could possibly compensate the loser and each country could thus be made better off. Therefore let us analyze whether a joint revenue improvement ($B^{\otimes} > B^{**}$) is possible. In Appendix B (claim 3), we show that for $\tau \in [t_h^{**}, \min\{t_f^{**}, \tau_m\}]$, we have $B^{**} < B^{\otimes}$ if $S < \frac{4}{3} - \frac{5}{9}\sqrt{3}$. In other words, for certain minimum rate choices, there is no room for compensation if the degree of size asymmetry is not sufficiently high.

The underlying intuition can be explained as follows. When the low tax country de-

[25]From the noncooperative equilibrium, we know that $t_h^* = S$, and the minimum tax rate τ lies between the noncooperative equilibrium rates. Hence, $B_h^* - B_h^o = \frac{1}{2}(S - \tau)^2 > 0$ always holds.

cides on its infrastructure provision at the first stage it knows that it will have to set a minimum tax rate later, which is higher than the current (competitive) rate. In order to avoid fierce tax competition in the future, the low tax country underinvests in infrastructure relative to the coordination scenario when jurisdictions can compete simultaneously in two instruments. As a result the low tax country becomes relatively less attractive to foreign investments. Net tax revenue decreases in the low tax country and it increases in the high tax country.

The following proposition summarizes the above findings

Proposition 3

1) *Assume that jurisdictions compete in taxes and infrastructure simultaneously. Moving from tax and infrastructure competition to minimum tax coordination makes the low tax country worse off. The high tax country is not affected.*

2) *Assume that jurisdictions compete in taxes and infrastructure sequentially. Moving from tax and infrastructure competition to minimum tax coordination has opposite effects on the jurisdictions' tax revenues. The high tax country's revenue is improved, while the low tax country is made worse off. If the degree of size asymmetry is not sufficiently high, there is no scope for compensating the loser, even if a compensation mechanism exists.*

4.4.3 Comparing social welfare

To analyze the impact of the tax bound on social welfare, we compare the welfare with and without a minimum tax rate, $W^o - W^*$ (respectively, $W^{\otimes} - W^{**}$).

(a) Simultaneous tax and infrastructure game

When taxes and expenditures are set simultaneously, we see that $W^o - W^* = \frac{1}{2}(S - \tau)^2$, which is positive. In other words, the imposition of a minimum tax rate reduces social welfare.

(b) Sequential tax and infrastructure game

In Appendix B (claim 4), we show that moving from a non-cooperative equilibrium to minimum tax coordination always increases social welfare.

The following proposition concludes

Proposition 4

1) *Assume that jurisdictions compete in taxes and infrastructure simultaneously. Moving from tax and infrastructure competition to minimum tax coordination* reduces *social welfare.*

2) *Assume that jurisdictions compete in taxes and infrastructure sequentially. Moving from tax and infrastructure competition to minimum tax coordination* improves *social welfare.*

4.5 Conclusion

The purpose of the chapter is to investigate whether tax coordination is desirable when countries compete in taxes and infrastructure. To address this question, we develop a model where governments strategically select tax rates and the level of public expenditures (simultaneously or sequentially) to maximize net tax revenues. In addition we assume that the population size of the competing countries is asymmetric. The desirability of tax coordination is then separately analyzed through its impact on tax revenue and social welfare.

Two things are worth noting. First, when jurisdictions compete in tax and non-tax instruments, tax coordination impacts the non-tax instrument in a way that qualifies classical results derived from pure tax competition. Second, the relative flexibility between tax and non-tax instruments matters when the desirability of tax coordination is assessed.

Our results are in stark contrast to the findings of the pure tax competition literature and generally differ from Zissimos and Wooders (2008). This is particularly relevant for policy issues because the belief that tax competition generally causes the "erosion of national tax bases" may prove erroneous if countries compete in tax and non-tax instruments. Indeed, in our two-country model we show that a uniform tax causes a tax loss to each country and that imposing a minimum tax rate only hurts the low tax jurisdiction. These results are however strongly contrasted if jurisdictions only compete in taxes.

The insights just highlighted don't hinge on simplifying assumptions which made in our model. For example, assuming welfare maximizing jurisdictions rather than tax-revenue maximizers would not change the basic messages of the paper[26].

In a future paper it would be interesting to extend the present analysis to unequally developed countries. This would beg the following question. Can tax and infrastructure competition be a way for lagging countries to catch-up in terms of economic development? Future research could also address the same question by employing a dynamic version of our model. This would allow to investigate under which conditions tax and infrastructure competition could, in the long run, promote convergence across unequally developed countries.

[26]For similar results see Han (2013) who analyzes partial tax coordination in a two-instrument competition model. In this framework the competing jurisdictions are assumed to be welfare maximizers and a more general production function is considered.

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Appendix A

A.1 Pure tax competition

In the case of pure tax competition, we assume $\theta_h = \theta_f = 0$. Solving the tax game yields the equilibrium rates of countries h and f , which are respectively $t_h^T = \frac{1}{3}(1+S)$ and $t_f^T = \frac{1}{3}(2-S)$. The corresponding countries' tax revenues are $B_h^T = \frac{1}{9}(S+1)^2 = \left(x^T\right)^2$ and $B_f^T = \frac{1}{9}(2-S)^2 = \left(1-x^T\right)^2$. The joint tax income is thus $B^T = \frac{1}{9}\left(2S^2 - 2S + 5\right)$.

A.1.1 Tax harmonization

The impact on tax revenues

If both countries opt for tax harmonization, the uniform tax rate can equal any value $t^u \in [0,1]$. As a result, $x^u = S$ companies will be located in the small country and $1-x^u$ in the large economy. The tax revenues of the two countries are then respectively $B_h^u = t^u S$ and $B_f^u = t^u(1-S)$. The joint maximal revenue is $B^u = B_h^u + B_f^u = t^u$. It is now convenient to show that $B^u > B^T$, if $t \in [\frac{5}{9}, 1]$ for all $S \in (0, \frac{1}{2})$. It implies that if the unified tax rate is higher than $\frac{5}{9}$, tax harmonization generates higher total tax revenue than pure tax competition. This is consistent with the tax competition literature (see for example, Kanbur and Keen, 1993; Baldwin and Krugman, 2004 and Boadway and Tremblay, 2011).

We now consider each country individually. For the high tax country we can easily show that $B_f^u > B_f^T$ for $S \in \left(0, \frac{1}{2}\right)$ and $t \in [\frac{(2-S)^2}{9(1-S)}, 1]$. In the same way we can show for the low tax country that $B_h^u > B_h^T$ for all $S \in \left(\frac{7}{2} - \frac{3}{2}\sqrt{5}, \frac{1}{2}\right)$ and $t \in [\frac{(1+S)^2}{9S}, 1]$. In other words, if the competing economies are not too uneven in size, the presence of a uniform tax rate, which is high enough, leads to a Pareto-improvement in tax revenue. Moreover, each country can be made better off for any $S \in \left(0, \frac{1}{2}\right)$, by imposing a uniform tax rate $t \in [\frac{5}{9}, 1]$, if inter-jurisdictional revenue redistribution is feasible.

The impact on social welfare

If tax rates are the same across jurisdictions, the social welfare equals $W^u = q$. The aggregate welfare resulting from pure tax competition is $W^T = q - \frac{1}{18}(2S-1)^2$. Consequently we get $W^T - W^* = -\frac{1}{2}(\ t_f^T - t_h^T)^2 < 0$. Moving from tax competition to tax harmonization is thus welfare improving.

A.1.2 Minimum tax

The impact on tax revenues

We assume that the tax rates set by the jurisdictions are now bounded from below by τ such that $\tau \in \left(t_h^T, t_f^T\right)$. In that we follow Kanbur and Keen (1993). The small country will set $\widetilde{t}_h = \tau$ since it is its best choice. The high tax country chooses its best reply $\widetilde{t}_f = \frac{\tau}{2} + \frac{1-S}{2}$. It follows $\widetilde{x} = \frac{1}{2}(1 + S - \tau)$. The tax income for each country is respectively $\widetilde{B}_h = \frac{1}{2}\tau(1 + S - \tau)$ and $\widetilde{B}_f = \frac{1}{4}(\tau - S + 1)^2$. The aggregate tax income is then $\widetilde{B} = \frac{1}{4}\left(S^2 - 2S + 4\tau - \tau^2 + 1\right)$.

It is then easy to check that for $\tau > t_h^T$ we have $\widetilde{B}_h > B_h^T$ and $\widetilde{B}_f > B_f^T$. It follows that imposing a minimum tax rate to the competing jurisdictions is a Pareto-improvement in tax revenue. This result is reminiscent of Kanbur and Keen (1993).

The impact on social welfare

The social welfare resulting from a minimum tax bound $\tau \in \left(t_h^T, t_f^T\right)$ equals $\widetilde{W} = q - \frac{1}{2}(\frac{1}{2} - \frac{1}{2}\tau - \frac{1}{2}S)^2$. Hence, $\widetilde{W} - W^T = \frac{1}{72}(S - 3\tau + 1)(7S + 3\tau - 5)$. Since $\tau \in \left(t_h^T, t_f^T\right)$ it is straightforward to show that $W(\tau) > W^T$. Consequently, a minimum tax lying between the non-cooperative equilibrium tax rates is welfare improving. This result is in line with Kanbur and Keen (1993).

A.2 Claims and their proofs

Claim 1. *With $\tau \in [t_h^{**}, t_f^{**}]$, we always have $B_h^{**} > B_h^{\otimes}$.*

Proof. Recall that the tax revenue of country h resulting from sequential tax and infrastructure competition is $B_h^{**} = \frac{7}{225}(1 + 3S)^2$. The non-cooperative equilibrium tax rates are $t_h^{**} = \frac{1+3S}{5}$ and $t_f^{**} = \frac{4-3S}{5}$. In addition, $B_h^{\otimes} = S\tau - \frac{5}{8}\tau^2$ is positive only if $0 < \tau < \frac{8S}{5}$. It is easy to check that $B_h^{\otimes}$ reaches its maximum at $\widehat{\tau} = \frac{4S}{5}$. Furthermore,

$B_h^{\otimes}$ is decreasing in τ for $\tau \in [\widehat{\tau}, t_f^{**}]$. Since $\widehat{\tau} - t_h^{**} = -\frac{1-S}{5} < 0$, it follows that $B_h^{\otimes}$ decreases in τ for $\tau \in [t_h^{**}, t_f^{**}]$ and reaches its maximum at t_h^{**}. Therefore, to prove the claim, we only need to show that $B_h^{**} > B_h^{\otimes}(t_h^{**})$. It is straightforward to show that $B_h^{**} - B_h^{\otimes}(t_h^{**}) = \frac{t_h^{**}}{360}(101 - 57S) > 0$. That finishes the proof.

Claim 2. *There is $B_f^{**} < B_f^{\otimes}$ for $\tau \in [t_h^{**}, t_f^{**}]$.*

Proof. We know that $B_f^{\otimes} = \frac{1}{8}(2 - 2S + \tau)^2$ and $B_f^{**} = \frac{7}{225}\left(3S - 4\right)^2$. Given that $B_f^{\otimes}$ is increasing in τ for $\tau \in [t_h^{**}, t_f^{**}]$, the claim is proved if the inequality $B_f^{\otimes} > B_f^{**}$ holds for the minimum value of $B_f^{\otimes}$ which equals to $B_f^{\otimes}(t_h^{**}) = \frac{1}{8}\left(\frac{11-7S}{5}\right)^2$. After straightforward calculations, we get $B_f^{\otimes}(t_h^{**}) - B_f^{**} = \frac{1}{8}\left(\frac{11-7S}{5}\right)^2 - \frac{7}{225}(4 - 3S)^2 > 0$ for any $0 < S < \frac{1}{2}$.

Claim 3. *For $\frac{4}{3} - \frac{5\sqrt{3}}{9} < S < \frac{1}{2}$, there exists interval of τ, such that, for $\tau \in (t_h^{**}, \underline{\tau})$, we have $B^{**} > B^{\otimes}$.*

Proof. Set $x = 1 - S$ and let $\underline{\tau} = 1 - \frac{1}{2}x - \sqrt{\frac{13x^2}{100} + \frac{3x}{25} - \frac{13}{225}}$ and $\overline{\tau} = 1 - \frac{1}{2}x + \sqrt{\frac{13x^2}{100} + \frac{3x}{25} - \frac{13}{225}}$ be the solutions of $\Psi(\tau) = B^{**} - B^{\otimes} = 0$. The function $\Psi(\tau)$ is negative for $\tau \in (\underline{\tau}, \overline{\tau})$, since it is convex in τ and reaches its negative minimum at $\widehat{\tau} \in (\underline{\tau}, \overline{\tau})$. It can further be checked that $\underline{\tau} > t_h^{**}$ if $\frac{1}{2} < x < \frac{5\sqrt{3}-3}{9}\left(< \frac{6}{7}\right)$ and that $t_f^{**} < \overline{\tau}$ if $\frac{1}{2} < x < \frac{6}{7}$. It follows that $\Psi(\tau) > 0$ for $\tau \in (t_h^{**}, \underline{\tau})$ which is only possible for $x \in \left(\frac{1}{2}, \frac{5\sqrt{3}-3}{9}\right)$, or equivalently for $\frac{1}{2} > S > \frac{4}{3} - \frac{5\sqrt{3}}{9}$.

Claim 4. *$W^{\otimes} > W^{**}$ for $\tau \in [t_h^{**}, \min\{\tau_m, t_f^{**}\}]$ with $\tau_m = 2S$.*

Proof. It is convenient to show that, function

$$H(S) = W^{\otimes} - W^{**} = \left(\frac{7}{15}\right)^2 + \frac{37}{50}S(S-1) + \frac{\tau}{8}(4 - 3\tau)$$

is strictly convex and reaches its minimum at $S = \frac{1}{2}$. Moreover, at this minimum,

$$H\left(S = \frac{1}{2}\right) = \frac{59}{25 \cdot 72} + \frac{\tau}{8}(4 - 3\tau) > 0,$$

where the last inequality comes from the fact that $\tau \in (0, 1)$ which was implied by $\tau \in [t_h^{**}, \min\{\tau_m, t_f^{**}\}]$.

Thus, for any $0 < S < \frac{1}{2}$, we have $H(S) > H\left(S = \frac{1}{2}\right) > 0$. We finish the proof.

Chapter 5

Who Benefits From Partial Tax Coordination?

5.1 Introduction

The[1] issue of corporate tax harmonization has been debated in the European Union (EU) since the European Economic Community was established. Specifically, in 2003 the EU Council adopted a voluntary Code of Conduct against harmful tax competition, and more ambitious proposals for corporate tax harmonization have been proposed, including the introduction of a single EU corporate tax (see Conconi et al., 2008). The primary motivation for this is that the growing economic integration has increased international mobility of capital and labor, which increasingly places downward pressure on national tax policies. Consequently, many authors have noted that independent governments engage in wasteful competition over scarce capital through inefficiently low tax rates and public expenditure levels (Zodrow and Mieszkowski, 1986; Wilson, 1986). Accordingly, tax coordination is proposed to correct the alleged inefficiencies caused by tax competition, as is highlighted in the tax literature (for sys-

[1]This chapter is based on, *Who benefits from partial tax coordination?* Y. Han, CREA Discussion paper, 2013-24.

tematic reviews, see Wilson, 1999; Wilson and Wildasin, 2004; Boadway and Tremblay, 2011).

However, neither a common corporate tax rate nor a minimum tax rate[2] has been successfully implemented in the EU[3]. Konrad and Schjelderup (1999) argue that some countries may prefer a low tax status[4]. This is exemplified by tax havens, which have a commercial interest in not harmonizing their taxation levels. Moreover, for political reasons, it is also not always possible to agree on full tax coordination (Marchand et al., 2003). Thus, as an alternative, partial tax coordination seems to be a more realistic policy option. Partial coordination generally describes a situation in which each individual agent cooperates with a subset of others but not with everyone in the economy or the society (Beaudry et al., 2000). The Enhanced Cooperation Agreements (ECAs)[5] among EU member states can be regarded as an example of partial coordination[6].

The issue of partial coordination has been addressed in the tax competition literature. Konrad and Schjelderup (1999) demonstrated that in the standard tax competition framework, tax harmonization among a subset of countries is Pareto improving if tax rates in the initial fully noncooperative Nash equilibrium are strategic complements. In addition, Conconi et al. (2008)[7] suggest that, if capital is sufficiently mobile,

[2]The Ruding Committee (1992) proposed a common minimum corporate tax rate for the EU .

[3]Keen and Konrad (2012) argue that regional blocs other than the EU (Central America, East and South Africa and elsewhere) have also sought to reach agreements limiting corporate tax competition among themselves, but as in EU, with limited success.

[4]Burbidge et al. (1997) theoretically demonstrated that with more than two states, incomplete federation can be the unique equilibrium by assuming endogenous coalition formation.

[5]EU member states are divided about whether or not to pursue corporate tax harmonization. For this reason, a subset of European countries has recently been institutionalized in the form of Enhanced Cooperation Agreements (ECAs) under the treaties of Amsterdam (1997) and Nice (2003). An ECAs occurs if not all 27 Member States agree upon cooperation, but only a subgroup (or coalition) among them (with a minimum of eight).

[6]Policy coordination among EU member states, rather than coordination with all of the countries in Europe, can be regarded as another example of partial coordination.

[7]The paper analyzes partial tax coordination in a context with downward pressure on tax rates due to tax competition on the one hand and upward pressure on tax rates due to time-consistent confiscatory taxation on the other.

partial tax harmonization benefits all countries involved relative to both global and no harmonization.

Many authors argue that jurisdictions compete not only in taxes but also in the provision of infrastructure (see Justman et al., 2002; Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011). However, the existing literature on the desirability of partial tax coordination is primarily based on the assumption that countries solely compete in tax rates. In the present study, we investigate whether partial tax coordination[8] can benefit the countries within and outside the tax union when countries use taxes and infrastructure strategically[9]. One closely related contribution to our work is Sørensen[10] (2004), who shows that, when countries are symmetric, the outsider enjoys a larger welfare gain from a binding minimum tax than countries in the union. Given cross-country asymmetries[11], the welfare gains from regional tax coordination mainly accrue to countries with high initial tax rates.

However, our setting differs from that in Sørensen (2004). First of all, taxes and infrastructure expenditure are related via a budget constraint in Sørensen (2004), hence the equilibrium taxes and public expenditures crucially depend, as Wildasin (1991) noted, on which instrument is strategically selected[12]. However, recent empirical research (Hauptmeier et al., 2012) demonstrates that jurisdictions use strategic tax rates and public inputs independently to compete for capital. Our model does not have this budget constraint[13], and hence taxes and expenditures are two independent strategic

[8]In another paper of mine (Han et al., 2013), we investigate welfare implications of full tax coordination. There we consider a two-country model and tax coordination are implemented in the two countries. However, in the present paper, we consider a three-country model and only a subset of all countries coordinate tax policies, which essentially differs from the setting of Han et al. (2013).

[9]In our paper, we do not focus on the stability of the tax union. We simply assume that the union is formed by other factors outside the context of the tax competition problem.

[10]The model in the paper incorporates various forms of taxations, a public consumption good, infrastructure provision, and a redistributive lump sum transfer.

[11]Sørensen (2004) assumes that countries differ in pure profit shares, foreign ownership shares, initial endowments, and social preferences regarding redistribution.

[12]Koethenbuerger (2011) also argues that models of local public finance predominantly assume that local governments set taxes while expenditures are residually determined via the budget constraint.

[13]This is in the same vein as Hindriks et al. (2008), Zissimos and Wooders (2008), Pieretti and Zanaj

variables[14]. In addition, he considers an egalitarian social welfare function[15]. In our paper, we do not consider the redistributional aspects of tax policies, and thus we assume that the governments maximize social welfare without concern for inequality. Therefore, we can exclusively focus on the impact of policy coordination on social welfare.

In the present chapter, we investigate the welfare implications of partial tax coordination when countries compete in taxes and infrastructure[16]. To this end, we assume that only a subgroup of all countries considered forms a union. Moreover, the union's member states only coordinate their tax policies while still compete in the infrastructure provision. This implies that the union countries, while coordinating their tax rates, are able to adjust their infrastructure policies to attract foreign capital[17]. In addition, the union competes in taxes and infrastructure with the rest of the world.

Two partial coordination devices are considered successively. We first discuss the welfare implications of tax harmonization (a common tax rate) within the union. Because a common tax rate may prove difficult to implement, we consider the case in which a minimum tax rate is imposed within the union. We then analyze the related welfare effects.

Our results show that a subgroup of countries agreeing to a common tax rate can have adverse consequences for both union and nonunion countries. This is in stark contrast with Konrad and Schjelderup's (1999) finding that partial tax harmonization is Pareto improving when jurisdictions solely compete in taxes. Our result also differs from that

(2011), and Hauptmeier et al. (2012).

[14]The only condition we require is that the budget is non-negative, which is the case because the jurisdictions are assumed to impose a lump sum tax to finance public expenditures if necessary, as assumed in Hindriks et al. (2008).

[15]The government in each country is concerned with the average individual welfare level and the dispersion of individual utilities around this mean.

[16]These infrastructure investments may represent material or immaterial public goods such as laws and regulations protecting intellectual property and specifying accurate dispute resolution rules.

[17]One may argue that jurisdictions would also coordinate infrastructure expenditures, however, as Han et al. (2013) suggest that it is not realistic. This is because expenditure coordination would drastically limit sovereign policy making, as many infrastructure expenditures primarily satisfy internal policy goals and are incidentally attractive to foreign investments.

in Sørensen (2004), in which partial coordination leaves all countries better off, assuming countries compete in both[18] taxes and infrastructure. In addition, we demonstrate that both high tax and low tax countries can be worse off when a lower tax bound is applied within the tax union. This result is at odds with Sørensen (2001, 2004), who concludes that the imposition of a minimum tax rate benefits the high tax country and harms the low tax country.

The chapter is organized as follows. In the next section, we study the welfare implications of partial coordination when countries only compete in taxes. In section 3, we derive optimal strategies from tax and infrastructure competition for each government. Section 4 then compares social welfare with and without partial tax harmonization. The welfare implications of a minimum tax rate are considered in section 5. Section 6 concludes.

5.2 The benchmark

As a benchmark, we first study the welfare implications of partial tax coordination assuming countries compete only by taxes. As in Sørensen (2004), two cases are considered. We assume that a tax union implements a common tax rate with symmetric competing countries. When the countries are asymmetric, we assume that a minimum tax rate is imposed[19] in the union.

5.2.1 Partial coordination with symmetric countries

Consider three identical countries $i = 1, 2, 3$. They compete in taxes to attract perfectly mobile capital from the rest of the world. There is no domestic ownership of capital[20].

[18] As we argued above, in his paper, taxes and infrastructure are not independent variables.

[19] To the best of our knowledge, the welfare implications of imposing of a minimum tax rate among a subset of countries has not been studied when they solely compete in taxes.

[20] This assumption is made in several contributions (see, for example, Hindriks et al., 2008; Kempf and Rota-Graziosi, 2010).

We assume that the jurisdictions tax capital to extract rents from the capital owners. The total stock of capital is fixed and normalized to 1. In each country, there is a representative firm and the number of residents is normalized to one. The government in country i selects a unit tax rate t_i , which is source-based. Capital locates in the country where profits are highest.

The production of the representative firm in each country is given by the function $F_i(k_i)$, which is increasing, twice continuously differentiable and concave in the level of capital k_i ($i = 1, 2, 3$). Under perfect mobility, the allocation of capital will equate its net return ρ across all jurisdictions. This net return is assumed to be positive. We thus obtain the following equality

$$\rho = f_1(k_1) - t_1 = f_2(k_2) - t_2 = f_3(k_3) - t_3, \tag{5.1}$$

where f_i is the marginal product of capital in country i. The above arbitrage condition determines the amount of capital in each country k_i ($i = 1, 2, 3$). By setting an appropriate tax rate t_i, each government maximizes the welfare W_i of its residents, the sum of the return to the immobile factor and the tax revenue,

$$W_i = F_i(k_i) - f_i(k_i)k_i + t_ik_i, \tag{5.2}$$

which is rebated to the residents. For reasons of tractability, we assume that the production function takes the form[21]

$$F_i(k_i) = ak_i - \frac{b}{2}k_i^2,$$

where $a > 0$ is a shift parameter of the production function and $b > 0$ is the rate of decline of the marginal product of capital relative to k_i.

The parameter b plays a critical role in our model. The higher the value of b, the lower the productivity of capital for a given amount of invested capital. As Machlup (1991) pointed out, the scarcity degree of complementary factors influences the declining rate in marginal productivity. In other words, the scarcer these factors are the higher the value of b should be.

[21]Note that a linear quadratic production function is assumed by several authors, such as Bucovetsky (1991, 2009), Peralta and Ypersele (2006), and Itaya (2008).

Because the net return of capital must be nonnegative, we impose the condition[22] $\frac{a}{b} > k_i$. The welfare function of country i becomes

$$W_i = \frac{b}{2}k_i^2 + t_i k_i.$$

From (5.1), the capital invested in each jurisdiction is

$$k_1^* = k_2^* = k_3^* = \frac{1}{3}.$$

Maximizing the welfare of each country yields the following optimal tax rates

$$t_1^* = t_2^* = t_3^* = \frac{b}{6}.$$

The corresponding payoffs are

$$W_1^* = W_2^* = W_3^* = \frac{b}{9}. \tag{5.3}$$

In what follows, we assume that countries 1 and 2 form a tax union and set a common tax rate t^c that maximizes the total welfare of the union. Country 3 remains outside and observes the coordination inside the union. Therefore, the tax union and country 3 compete for mobile capital by selecting taxes t and t_3 noncooperatively. The amount of capital located in each economy is then $k_1 = k_2 = \frac{1}{4}$ and $k_3 = \frac{1}{2}$. Solving the game, the equilibrium tax rates are

$$t^c = \frac{b}{2},\ t_3^c = \frac{b}{4}.$$

The union as a whole faces a lower elasticity of capital supply than the individual member states. Thus, the uniform tax rate is higher than the noncooperative equilibrium rates, $t^c > t_i^*$ ($i = 1, 2$). Because tax rates are strategic complements, country 3 sets a higher tax rate than in the noncooperative case, $t_3^c > t_3^*$. The resulting payoffs are

$$W_1^c = W_2^c = \frac{5b}{32},\ W_3^c = \frac{b}{4}. \tag{5.4}$$

Comparing welfare levels with and without coordination, it is easy to see that

$$\begin{aligned} W_i^c - W_i^* &= \frac{13}{288}b > 0, i = 1, 2, \\ W_3^c - W_3^* &= \frac{5}{36}b > 0. \end{aligned}$$

[22] In what follows, we assume that a is sufficiently large.

That is, partial tax harmonization improves the welfare of all of the countries if we only consider pure tax competition. This result is consistent with classical results (see Konrad and Schjelderup, 1999).

5.2.2 Partial coordination with asymmetric countries

Countries can be asymmetric in many respects (see Bucovetsky, 1991; Wilson, 1991; Keen and Kanbur, 1993), such as size, initial resource endowments, and productivity. In our paper, we assume that countries are heterogeneous in their degree of development, which is reflected by a country specific productivity parameter. For simplicity[23], we assume[24] that countries 2 and 3 are identical but characterized by a higher level of development than country 1. This is assumed without loss of generality. We thus assume that $F_1(k_1) < F_2(k_2) = F_3(k_3)$. The different production functions take the following form

$$\begin{aligned} F_1(k_1) &= ak_1 - \frac{b}{2}k_1^2, \\ F_i(k_i) &= (a+\varepsilon)\,k_i - \frac{b}{2}k_i^2,\ i = 2,3, \end{aligned} \tag{5.5}$$

where the shift parameter ε is positively signed. We first solve the noncooperative game among the three jurisdictions. We then analyze the welfare effects of the lower bound on taxes.

When all countries compete, solving[25] for the first order conditions (FOCs) leads to the following equilibrium taxes

$$t_1^n = \frac{b}{6} - \frac{2\varepsilon}{9},\ t_2^n = t_3^n = \frac{b}{6} + \frac{\varepsilon}{9}.$$

It follows that $k_1^n = \frac{1}{3} - \frac{4\varepsilon}{9b}$ and $k_2^n = k_3^n = \frac{1}{3} + \frac{2\varepsilon}{9b}$. The less developed country attracts less capital relative to the advanced one, $k_1^n < k_2^n = k_3^n$. The tax rate in country 1 is also

[23] More generally, we could consider that all the countries differ in terms of their level of development. However, this would unnecessarily complicate the calculations without providing further insight.

[24] For a similar assumption, see Bucovetsky and Smart (2006), Burbidge and Cuff (2005), and Peralta and van Ypersele (2005).

[25] It is easy to check that W_i ($i = 1,2,3$) is concave in t_i.

lower due to its low productivity, $t_1^n < t_2^n = t_3^n$. The social welfare levels of the three countries are

$$W_1^n = \frac{(3b-4\varepsilon)^2}{81b},\ W_2^n = W_3^n = \frac{(3b+2\varepsilon)^2}{81b}. \quad (5.6)$$

Now we assume that countries 1 and 2 agree on a minimum tax rate t^l that lies between the noncooperative equilibrium tax rates. Because country 1 is the low tax jurisdiction ($t_1^n < t_2^n$), it chooses the lower bound t^l as its best strategy[26]. Countries 2 and 3 anticipate the tax policy of country 1 and respond strategically. The resulting equilibrium tax rates are

$$t_1^l = t^l,\ t_2^l = t_3^l = \frac{1}{7}(t^l + b + \varepsilon).$$

The capital invested in the different countries is $k_1^l = \frac{3b-4t^l-4\varepsilon}{7b}$ and $k_2^l = k_3^l = \frac{2(b+t^l+\varepsilon)}{7b}$. As $k_i^l \geq 0$, we impose $b \geq \frac{4\varepsilon+4t^l}{3}$. The corresponding welfare levels for each country are

$$\begin{aligned} W_1^l &= \frac{1}{98b}(3b-4t^l-4\varepsilon)(10t^l+3b-4\varepsilon) \\ W_2^l &= W_3^l = \frac{4}{49b}(t^l+b+\varepsilon)^2. \end{aligned}$$

Comparing cooperation with tax competition from the perspective of social welfare (comparing W_i^l with W_i^n), we demonstrate that every country will be better off under cooperation if $t_1^n < t^l < \min\{\frac{17}{180}(3b-4\varepsilon), t_2^n\}$.

That is, the minimum tax rate must be higher than the lowest rate in the non-cooperative case, but sufficiently low for all of the countries to benefit from cooperation.

5.3 Competition in taxes and infrastructure

In this section, we assume that the governments provide local firms with public goods intended to enhance the productivity of private capital. Countries thus compete both in taxes and the provision of infrastructure. The level of infrastructure provided by country i ($i = 1, 2, 3$) is denoted g_i. The results of the noncooperative competition will

[26]This is because the social welfare function is concave in tax rates.

serve as a baseline to gauge the desirability of tax harmonization. In the spirit of Hindriks et al. (2008), the production function, which is specific to country i ($i = 1, 2, 3$) exhibits constant returns in infrastructure and takes the form

$$F_i(k_i, g_i) = (a + g_i)\, k_i - \frac{b}{2} k_i^2.$$

The cost function of the public input is given by $c_i(g_i) = \frac{g_i^2}{2}$, $i = 1, 2, 3$. The convexity reflects that the provision of public infrastructure is increasingly difficult. The equilibrium share of capital located in each country is determined by the arbitrage condition

$$\rho = f_1(k_1, g_1) - t_1 = f_2(k_2, g_2) - t_2 = f_3(k_3, g_3) - t_3, \tag{5.7}$$

where $f_i(k_i, g_i) = (a + g_i) - bk_i$ is the marginal product of capital in country i and ρ is the world interest rate. It follows that the amount of capital invested in country i is

$$k_i = \frac{1}{3} - \frac{(g_h + g_j - 2g_i) - (t_h + t_j - 2t_i)}{3b}, \; h, j \neq i.$$

The subscripts h and j ($h, j = 1, 2, 3$) refer to the other two countries.

Each government selects the tax rate and level of infrastructure that maximize its welfare function

$$\begin{aligned} W_i &= F_i(k_i, g_i) - f_i(k_i, g_i)k_i + t_i k_i - \frac{g_i^2}{2} \\ &= \frac{b}{2} k_i^2 + t_i k_i - \frac{g_i^2}{2}. \end{aligned} \tag{5.8}$$

In the following, we solve a two-stage game. In the first stage, countries select the public expenditure levels. Tax rates are set in the second stage for given infrastructure levels that are selected in the first stage[27]. We solve the game by backward induction.

[27]The choice of sequentiality follows the rule that the most irreversible decision must be made first (see Justman et al., 2002; Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011).

5.3.1 Tax game

First, we focus on the tax game. It is easy to verify that the welfare function W_i is concave in t_i. The best tax response of country i is

$$t_i = \frac{1}{8}\left[(g_h + g_j - 2g_i) + (t_h + t_j) + b\right], \; h, j \neq i. \tag{5.9}$$

Because the reply functions are upward sloping, taxes are strategic complements. Note also that the slope is less than one, which ensures the stability of the equilibrium. By solving the system of equations (5.9), we derive the Nash equilibrium in taxes

$$t_i = \frac{1}{18}\left[4g_i - 2(g_h + g_j) + 3b\right]. \tag{5.10}$$

5.3.2 Infrastructure game

At the first stage, each jurisdiction maximizes its payoff with respect to its infrastructure provision g_i. The FOCs yield

$$g_i = \frac{8(2g_h + 2g_f - 3b)}{81b - 32}, \; h, j \neq i.$$

We require that $b > \frac{32}{81}$ to ensure that the objective functions in g_i are concave. The equilibrium public expenditure of country i is

$$g_i^{**} = \frac{8}{27}. \tag{5.11}$$

Introducing (5.11) into the equations (5.10) yields the equilibrium tax rate of country i

$$t_i^{**} = \frac{b}{6}.$$

The amount of capital invested in country i is $k_i^{**} = \frac{1}{3}$. The welfare of country i is then

$$W_i^{**} = \frac{1}{729}\left(81b - 32\right), \; i = 1, 2, 3, \tag{5.12}$$

which is positive because $b > \frac{32}{81}$.

5.4 Partial tax harmonization

In this section, we analyze whether partial tax harmonization is desirable. To that end, we assume that countries 1 and 2 form a tax union and set a common tax rate t that maximizes their joint welfare. However, the member states of the union are assumed to select their infrastructure levels noncooperatively. This is because many infrastructure expenditures primarily satisfy internal policy goals and are incidentally attractive to foreign investments. Therefore, it is difficult to coordinate these types of sovereign decisions. Country 3 stays outside the union and observes the coalition of countries 1 and 2. The outsider competes with the union as a whole by providing infrastructure in the first stage and competes over tax rates in the second stage. We first solve the game, and then compare social welfare with and without tax policy coordination.

5.4.1 Competition with partial tax harmonization

Beginning from the second stage, the FOCs in tax rates[28] yield

$$\begin{aligned} t &= \frac{1}{6}(g_1 + g_2 - 2g_3 + 3b), \\ t_3 &= \frac{1}{12}(-g_1 - g_2 + 2g_3 + 3b). \end{aligned} \tag{5.13}$$

We observe that the larger the rate of decline of marginal productivity b, the higher the tax rate will be for a given level of public infrastructure provision. The reason is that the marginal productivity of capital is lower for a higher value of b, which results in a lower demand for capital. The competition for capital is relaxed, and tax rates increase.

In the first stage, the three countries compete in public infrastructure. Solving the FOCs with respect to g_i, we obtain the equilibrium levels of infrastructure provision

$$\begin{aligned} g_1^u &= g_2^u = \frac{23\,(9b-4)}{18\,(24b-13)}, \\ g_3^u &= \frac{2\,(36b-23)}{9\,(24b-13)}. \end{aligned} \tag{5.14}$$

[28] It is easy to verify that $W_1 + W_2$ is concave in t and W_3 is concave in t_3.

To guarantee the concavity of W_i in g_i, we impose $b > \frac{77}{144}$. This condition is fulfilled if we require that the level of infrastructure g_i is nonnegative, which requires that $b > \frac{23}{36}$. Substituting (5.14) into (5.13), we obtain the equilibrium tax rates

$$\begin{aligned} t^u &= \frac{4b\,(9b-4)}{3\,(24b-13)}, \\ t_3^u &= \frac{b\,(36b-23)}{6\,(24b-13)}. \end{aligned}$$

It is easy to verify that the uniform tax rate within the union is higher than that of the outsider, $t^u > t_3^u$, as the union as a whole faces a lower tax elasticity of capital. However, to remain attractive, the tax union must provide more public infrastructure than the outsider. Indeed, we obtain $g_1^u = g_2^u > g_3^u$. The amount of capital located in each country is

$$\begin{aligned} k_1^u &= k_2^u = \frac{2\,(9b-4)}{3\,(24b-13)}, \\ k_3^u &= \frac{36b-23}{3\,(24b-13)}. \end{aligned} \tag{5.15}$$

The resulting welfare levels are given as follows

$$\begin{aligned} W_1^u &= W_2^u = \frac{(9b-4)^2(720b-529)}{648(24b-13)^2}, \\ W_3^u &= \frac{(36b-23)^2(9b-2)}{81(24b-13)^2}, \end{aligned} \tag{5.16}$$

which are positive when $b > \underline{b} = \frac{529}{720}$. In the following, we assume that condition $b > \underline{b}$ always holds.

5.4.2 Comparing social welfare

Because the member states of the union are identical, we can write

$$\begin{aligned} W_1^u - W_1^{**} &= W_2^u - W_2^{**} \\ &= \frac{32}{729} - \frac{b}{9} + \frac{(9b-4)^2(720b-529)}{648(24b-13)^2}, \end{aligned} \tag{5.17}$$

which is a cubic polynomial of parameter b. It is easy to check that $W_i^u - W_i^{**} > 0$ ($i = 1, 2$), if $b > \bar{b}$ where[29] $\bar{b} = 1.09$. Consequently, partial tax harmonization improves the welfare of countries 1 and 2 if the value of b is sufficiently high. However, setting a uniform tax rate makes the union members worse off if $\underline{b} < b < \bar{b}$.

To understand the intuition underlying this result, first note that a "low" value of b ($b < \bar{b}$) implies that the demand for capital and hence competition for capital is "high". However, when the value of b is relatively "high" ($b > \bar{b}$), competition for capital is "low". Furthermore, when the union is constrained by a uniform tax rate, infrastructure competition becomes more pronounced[30] than in the noncooperative case ($g_i^u > g_i^{**}$). Thus the intuition is straightforward. When international competition for capital is intense ($b < \bar{b}$), partial tax harmonization results in the over-use of costly infrastructure spending. The additional net output[31] induced by an increased amount of infrastructure spending in the case of partial tax harmonization is overcompensated by the additional cost of providing infrastructure. Thus, agreeing on a common tax rate reduces the welfare of the union countries relative to the noncooperative scenario ($W_i^{**} > W_i^u$). However, when competition for capital is less intense ($b > \bar{b}$), partial tax harmonization improves the social welfare of the tax union ($W_i^u - W_i^{**} > 0$, $i = 1, 2$), as the net output increase it induces exceeds the additional cost of providing infrastructure.

The following result can be stated

[29]We solve the cubic equation $W_i^u - W_i^{**} = 0$ ($i = 1, 2$) for b and obtain that one root is $\bar{b} = 1.09$ and the other two are complex, which is not our interest.

[30]Note that here we do not explain the results by mentioning the strategic effect between infrastructure expenditures and taxes, which is the case in a two-stage game. Generally, governments underinvest in the second stage to reduce the intensity of tax competition in the first stage. However, the main point here is that tax coordination results in over-provision of infrastructure by the union. This predicts that even we consider a simultaneous game in the paper, the results obtained from the two-stage game remain. Without the strategic effect emerging in the two-stage game, a simultaneous game will lead the union to respond more aggressively by investing in infrastructure than in the two-stage game.

[31]Indeed, it is convenient to write $W_i^u - W_i^{**} = \Delta I_i - \Delta C_i$ ($i = 1, 2$), which means that the welfare change induced by the transition from noncooperative tax competition to partial harmonization results from a net output gain ($\Delta I_i = (F_i(k_i^u, g_i^u) - \rho^u k_i^u) - (F_i(k_i^{**}, g_i^{**}) - \rho^{**} k_i^{**})$ and a change in the cost of providing public inputs ($\Delta C_i = \frac{(g_i^u)^2}{2} - \frac{(g_i^{**})^2}{2}$), where ρ^u and ρ^{**} are interest rates with and without partial tax harmonization, respectively.

Proposition 1 *If a subgroup of countries commits to a common tax rate but competes in infrastructure, social welfare in the tax union falls when $\underline{b} < b < \bar{b}$ and rises when $b > \bar{b}$ relative to noncooperative competition in taxes and infrastructure.*

Now consider the impact of partial tax harmonization on the outsider's welfare. The welfare change in the nonmember state resulting from partial harmonization is

$$W_3^u - W_3^{**} = \frac{32}{729} - \frac{b}{9} + \frac{(36b-23)^2(9b-2)}{81(24b-13)^2}. \tag{5.18}$$

Solving $W_3^u - W_3^{**} = 0$ yields the unique[32] root $\underline{b} < b^m = 0.76$. Consequently, tax harmonization in the union increases the welfare of the nonmember state when $b > b^m$ but decreases its welfare when $\underline{b} < b < b^m$.

The underlying intuition can be explained as follows. When the value of b is sufficiently low, $b < b^m$, the member states compete aggressively in infrastructure as we highlighted above. This results in an over-provision of infrastructure by the union. Moreover, the infrastructure expenditures of the competing entities (union versus the outsider) are strategic substitutes[33]. Consequently, the outsider country will under-provide infrastructure and compete with low taxes. Eventually, the union attracts more capital than in the noncooperative case, and hence less capital flows to the nonunion country. As a result, the outsider's gain from lower investment costs[34] does not compensate for the loss it incurs in net output. Accordingly, its social welfare decreases when countries 1 and 2 coordinate tax policy. When the value of b is sufficiently high, $b > b^m$, the member states provide a relatively moderate level of infrastructure. Because infrastructure expenditures are strategic substitutes, the outsider will not substantially reduce its provision of public inputs, and tax competition will not be excessively intense. As a result, the outsider will attract sufficient capital[35], and hence its

[32]We solve the cubic equation $W_3^u - W_3^{**} = 0$ for b and obtain that one root is $b^m = 0.76$ and the other two are smaller than $\underline{b}$, which violates our assumption that $b > \underline{b}$.

[33]The FOCs of the infrastructure game in the tax harmonization case yield the best response functions $g_1^u = g_2^u = \frac{-46g_3+69b}{144b-46}$ for countries 1 and 2 and $g_3^u = \frac{-2g_1^u+3b}{9b-2}$ for country 3.

[34]Similarly, we consider the decomposition $W_3^u - W_3^{**} = \Delta I_3 - \Delta C_3$, where ΔI_3 and ΔC_3 are the variations in the net output and the cost of infrastructure provision, respectively.

[35]Note that the world interest rate under partial tax coordination is lower than in the noncooperative

social welfare will be higher than in the noncooperative case.

The following proposition concludes

Proposition 2 *If a subgroup of countries commits to a common tax rate while competing in infrastructure, the social welfare of the nonmember state declines if* $\underline{b} < b < b^m$ *and increases when* $b > b^m$ *relative to noncooperative competition in taxes and infrastructure.*

From Propositions 1 and 2, we can conclude the following. When $\underline{b} < b < b^m$, both the tax union and the outsider are worse off. When $b^m < b < \bar{b}$, the tax union is worse off while the nonmember state is better off. If $b > \bar{b}$, all of the countries benefit from the partial tax harmonization.

These results are at odds with the findings in pure tax competition (Konrad and Schjelderup, 1999)[36], where partial tax harmonization is Pareto improving if the tax rates in the initial fully noncooperative equilibrium are strategic complements. They are also in contrast to the result obtained by Sørensen (2004) that all countries are better off with partial tax harmonization, although the union countries gain less than the outside country.

5.5 A minimum tax rate

In the previous section, we demonstrated that partial tax harmonization does not necessarily improve welfare in the tax union when countries compete in both taxes and infrastructure. Does the imposition of a minimum tax rate improve the member states' welfare? To answer this question, we assume that in a first stage, each country noncooperatively selects its level of public investment. In a second stage, each country sets its tax rate subject to a lower bound, which is imposed on the union countries. Country 3 is not subject to this tax constraint.

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game.

[36]Our result also contradicts the finding in Conconi et al. (2008) that partial tax harmonization benefits all of the countries relative to the noncooperative case.

5.5.1 Competition with a minimum tax rate

As in the benchmark model (pure tax competition with asymmetric countries), we assume that $F_1(k_1, g_1) < F_2(k_2, g_2) = F_3(k_3, g_3)$ without loss of generality. The production function takes the form[37]

$$\begin{aligned} F_1(k_1, g_1) &= (a + g_1)\, k_1 - \frac{b}{2} k_1^2, \\ F_i(k_i, g_i) &= (a + g_i + \varepsilon)\, k_i - \frac{b}{2} k_i^2,\ i = 2, 3, \end{aligned} \tag{5.19}$$

where ε is positive.

By analogy[38] to section 3, we are able to demonstrate that country 1 is the low tax country if all countries choose the levels of their tax rates and infrastructure noncooperatively. Indeed, in equilibrium we obtain

$$\begin{aligned} t_1^{non} &= b(\frac{1}{6} - \frac{6\varepsilon}{27b - 16}), \\ t_2^{non} &= t_3^{non} = b(\frac{1}{6} + \frac{3\varepsilon}{27b - 16}), \end{aligned}$$

and[39]

$$\begin{aligned} g_1^{non} &= \frac{8}{27} - \frac{32\varepsilon}{81b - 48}, \\ g_2^{non} &= g_3^{non} = \frac{8}{27} + \frac{16\varepsilon}{81b - 48}. \end{aligned}$$

Therefore, if a minimum tax rate τ is agreed between countries 1 and 2, it only[40] binds country 1 and induces it to choose this lower bound τ. Solving the game by starting from the second stage, countries 2 and 3 set taxes noncooperatively. We obtain the

[37]The production function is similar to that in Hindriks et al. (2008).

[38]We solve a two-stage game. In the first stage, countries select the public expenditure levels. Tax rates are set in the second stage.

[39]The superscript $''non''$ denotes value in the noncooperative equilibrium.

[40]We only consider the case in which the minimum tax rate lies between the noncooperative equilibrium rates, as in Keen and Kanbur (1993).

equilibrium tax rates

$$\begin{aligned} t_1^{\min} &= \tau, \\ t_2^{\min} &= t_3^{\min} = \frac{3(\tau+b)(7b-4)+21b\varepsilon}{147b-88}. \end{aligned}$$

In the first stage, infrastructure expenditures are chosen noncooperatively by all the countries. Solving the subgame yields infrastructure equilibium

$$\begin{aligned} g_1^{\min} &= \frac{4(\tau+b)(63b-40)-336b\varepsilon}{7b(147b-88)}, \\ g_2^{\min} &= g_3^{\min} = \frac{40\left[(\tau+b)(7b-4)+7b\varepsilon\right]}{7b(147b-88)}. \end{aligned}$$

Concavity is guaranteed if $b > \frac{200}{441}$.

5.5.2 Comparing social welfare

Let $W_i^{\min}$ and W_i^{non} denote the welfare of country i with and without minimum tax coordination, respectively. The welfare difference of the low tax country (country 1) is

$$\begin{aligned} \Delta W_1 &= W_1^{\min} - W_1^{non} \\ &= A_1(b)\tau^2 + B_1(b,\varepsilon)\tau + C_1(b,\varepsilon), \end{aligned}$$

where, $A_1(b) = -\frac{4[21b(49b-16)(105b-82)+3200]}{49(147b-88)^2b^2} < 0$, $B_1(b,\varepsilon)$ and $C_1(b,\varepsilon)$ are functions of the parameters b and ε. It can be verified that $W_1^{\min} - W_1^{non}$ can be positively or negatively signed for different parameters (b,ε).

The welfare difference of the high tax country i ($i = 2, 3$) are

$$\begin{aligned} \Delta W_i &= W_i^{\min} - W_i^{non} \\ &= \frac{4[(b+\tau)(7b-4)+7b\varepsilon]^2(441b-200)}{49(147b-88)^2b^2} - \frac{(81b-32)(27b+18\varepsilon-16)^2}{729(27b-16)^2}, \end{aligned}$$

It can be shown that the sign of $W_i^{\min} - W_i^{non}$ can be positive or negative depending on the values of the parameters.

From the above welfare analysis for the insiders and the outsider, we see that the imposition of a minimum tax can be welfare improving or welfare worsening both for the union members and the nonunion member.

To illustrate the impact of a lower tax bound on welfare, we provide simulations with different values for the parameter[41] pair (b, ε). The horizontal axis represents τ, and the vertical axis denotes the change in welfare ΔW_i, where $\Delta W_2 = \Delta W_3$.

First, we set $b = 1$ and consider different values of ε. When $\varepsilon = 0.1$, we show in Figure 1(a) that the low tax country always loses, while the high tax country (Figure 1 (b)) always gains. However, in Figure 2 when $\varepsilon = 0.3$, the low tax country can gain if the lower tax bound is not excessively high, and countries 2 and 3 lose if the bound τ is excessively low.

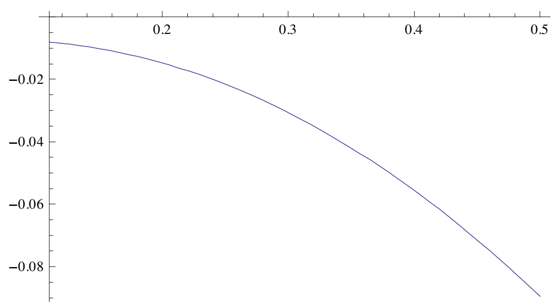
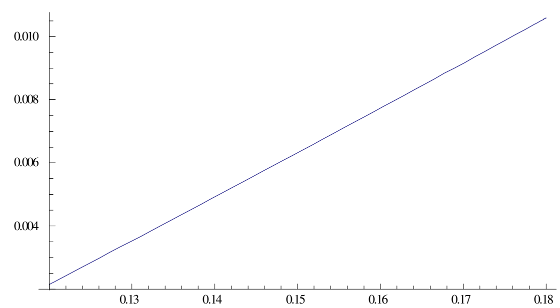


Figure 1(a) social welfare change for country 1, $\varepsilon = 0.1$



(b) social welfare changes for countries 2 and 3, $\varepsilon = 0.1$

[41]For each figure, τ begins at its minimum value, i.e., the noncooperative equilibrium tax rate of country 1, as we assume that the lower bound lies between the two noncooperative equilibra.

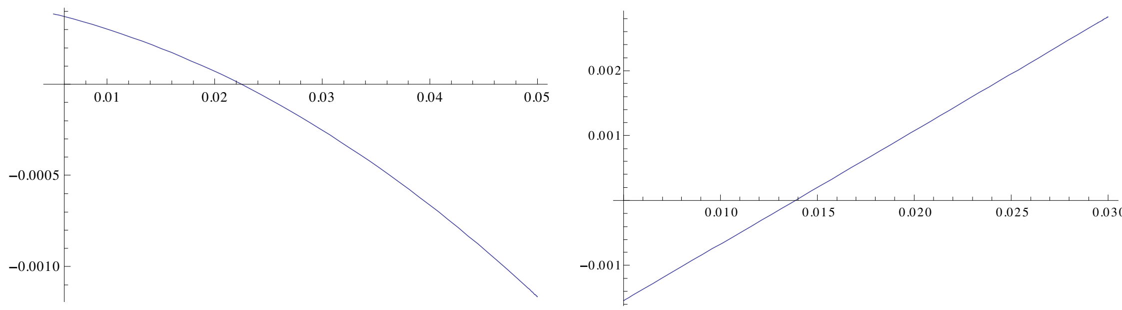


Figure 2(a) social welfare change for country 1, $\varepsilon = 0.3$

(b) social welfare changes for countries 2 and 3, $\varepsilon = 0.3$

We then set $\varepsilon = 0.2$ and consider different values of b. Figure 3 demonstrates that when $b = 0.8$, the low tax country loses if the minimum tax rate is excessively high, while countries 2 and 3 always gain. However, Figure 4 (a) illustrates that country 1 is always worse off if $b = 1.0$, while the high tax countries (Figure 4 (b)) can be harmed if the lower tax bound is not sufficiently high.

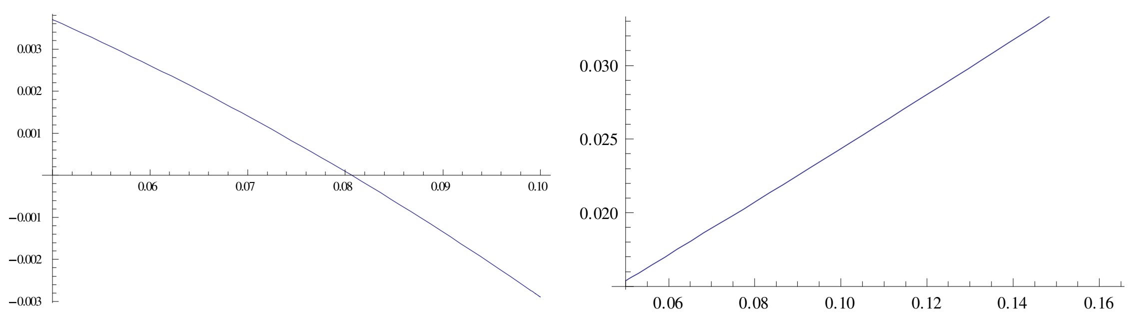


Figure 3(a) social welfare change for country 1, $b = 0.8$

(b) social welfare changes for countries 2 and 3, $b = 0.8$

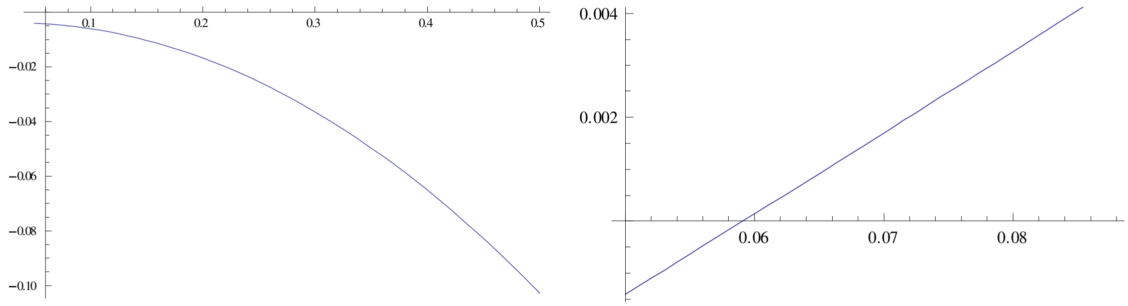


Figure 4(a) social welfare change for country 1, $b = 1.0$

(b) social welfare changes for countries 2 and 3, $b = 1.0$

The results highlighted by the above simulations are in contrast to those resulting from pure tax competition when a minimum tax rate is imposed. When countries only compete in taxes, we have shown that all of the countries can be better off as long as the minimum tax is not excessively high. However, our simulations reveal cases where the imposition of a lower tax bound does not necessarily improve the social welfare of the member sates[42] when the minimum tax rate is sufficiently low. It can even harm the high tax countries[43], which differs from the findings of Sørensen (2001, 2004), who shows that establishing a minimum tax rate only harms the low tax country. When the tax bound is sufficiently high, the welfare effects depend crucially on the values of parameters b and ε.

We state the results in the following proposition

Proposition 3 *When countries compete in taxes and infrastructure, the imposition of a sufficiently low tax bound within a subgroup of countries does not necessarily improve the social welfare of the tax union. It can even harm both the high and low tax countries.*

[42] This result still holds when country 1 is the more advanced country. We can demonstrate this in a similar way and the proof is available upon request.

[43] Note that the high tax countries could be member or nonmember states.

5.6 Conclusion

In this chapter, we investigate the welfare implications of partial tax coordination when countries compete strategically in taxes and infrastructure. In a three-country model, we assume that two countries form a union and only coordinate their tax policy, while they compete in the provision of infrastructure. Moreover, the tax union competes with the nonunion country both in taxes and infrastructure. After assuming that all of the countries are identical, we first analyze the welfare effects of the establishment of a uniform tax rate within the union. We then explore the welfare effects of a lower bound on taxes when the member states are asymmetric in their levels of development.

We demonstrate first that partial tax coordination can harm both the member and non-member states. Essentially, partial tax coordination allows the member states to freely compete in infrastructure for foreign direct investment while, to some extent, preventing them from defending their competitive situation in a globalized economy. Second, we demonstrate that the high tax country can also be made worse off under partial coordination, which contrasts with the general belief that only the low tax country loses. This could be a caveat for high tax countries such as France and Germany, which are pushing the European Union to speed up tax coordination efforts[44]. Finally, our results suggest that low productivity countries should opt for tax harmonization. Indeed, our results show that tax harmonization among these countries leaves them better off.

Future research is needed. When the taxation polices of states are subject to policy coordination, their expenditure decisions are unfettered. To be in a favorable position regarding the constraints of tax coordination, the competing jurisdictions may choose to be a leader or a follower in infrastructure competition. Future research should address the desirability of tax coordination by endogenizing the timing of infrastructure decisions. It would be also interesting to investigate how partial tax coordination im-

[44]As first stated in the Financial Times (May 2, 2003, p2), which was then followed by a report in the Irish Examiner (an Irish national daily newspaper) on January 18, 2012, indicating that Germany and France are pushing the EU to speed up tax coordination efforts, despite Irish and British opposition, and will soon make proposals to harmonize corporate tax rates. The call is contained in a document to be discussed at the EU summits on January 30 and in March of 2012.

pacts economic growth both in member and nonmember states, given their incentives to invest in public infrastructure differ as explained in this paper.

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Chapter 6

Does Size Asymmetry Exacerbate the Inefficiency of Tax Competition?

6.1 Introduction

Important[1] contributions that address capital tax competition between asymmetric jurisdictions, such as those of Bucovetsky (1991) or Wilson (1991), demonstrate that larger countries choose higher tax rates than smaller countries because they face a relatively lower tax elasticity of capital and, hence, a lower marginal cost of public funds. As a result, under their assumptions, equilibrium tax rates differ across states and lead to an inefficient allocation of capital (Wilson and Wildasin, 2004; Burbidge and Cuff, 2005; Boadway and Tremblay, 2011). Particularly, Kanbur and Keen (1993) analyze commodity tax competition when countries differ in population size. While reasserting the result that smaller countries charge lower tax rates than larger countries, these authors demonstrate that, under given assumptions, increasing size asymmetry exacerbates the inefficiency of tax competition. In other words, increasing size inequality between jurisdictions makes tax competition more harmful.

[1]This chapter is based on, *Does size asymmetry exacerbate the inefficiency of tax competition?* Y. Han, P. Pieretti and B. Zou. Economics Letters (2014), Vol. 122, 16-18.

However, many authors argue that jurisdictions compete strategically and independently with respect to taxes and infrastructure expenditures (for example Hindriks et al., 2008; Zissimos and Wooders, 2008; Hauptmeier et al, 2012). The aim of this chapter is to show that inter-jurisdictional competition with tax and non-tax instruments may change the classical view regarding the detrimental effect of increasing country size disparities. In particular, we demonstrate that this view has no general validity and depends crucially on the degree of international capital mobility.

6.2 The model

Consider two jurisdictions symbolized by S and L that compete for foreign direct capital. Population is evenly distributed, with a unit density, over the interval $[0, 1]$. Country S is assumed to be small in terms of total population. Its size is given by s, and $0 < s < 1/2$. The size of the large country, L, equals $\frac{1}{2} < 1 - s < 1$. Similar to Pieretti and Zanaj (2011), we assume that each individual owns one unit of capital and is, at the same time, an entrepreneur and a worker. In other words, a one-person company is associated with each member of the population[2]. While the entrepreneurs can move their activity abroad, we assume, similar to Ogura (2006), that they are heterogeneous in the preferences and can be ranked according to their willingness to relocate abroad. The closer an individual is to the border separating countries S and L, the easier it is for the individual to relocate abroad. Specifically, an entrepreneur of type $x \in [0, 1]$ who moves abroad incurs a disutility $k|x - s|$. Here, $k > 0$ is the unit cost of capital relocation, which will also be interpreted as the degree of international openness and $|x - s|$ is the "distance" between the border s and the entrepreneur of type x.

Firms

As in Pieretti and Zanaj (2011), we introduce a linear technology in the following way.

[2]It follows that the world population coincides with the population of firms. We could complicate the model by assuming that each firm is run by more than one person, but this would unnecessarily complicate the model without further insights.

Each individual in country j $(j = S, L)$ is able to produce, with one unit of capital, $y_j = q + \theta_j$ units of one final good, where q is the output share determined by the private sector[3] and θ_j is the fraction depending on a public investment in country j. We assume that the final good is sold in a competitive market at a given price normalized to one. Because firms are free to move, location choices must be considered. The capital owners will set up their activity where profit, net of taxes and moving cost, is the highest.

Assume without loss of generality that the capital owner $x \in [0, s]$ living in country S is indifferent toward producing at home or producing in the foreign country L if

$$q + \theta_S - t_S = q + \theta_L - t_L - k(s - x), \tag{6.1}$$

where t_S and t_L are source-based tax rates levied on capital in countries S and L, respectively.

It follows that

$$x = \frac{1}{k}((\theta_S - \theta_L) + (t_L - t_S)) + s. \tag{6.2}$$

If $x > s$, firms move from the larger country to the smaller one, while firms move from the smaller country to its larger rival if $x < s$.

Governments

We now assume that the jurisdictions of S and L are able to increase, by appropriate public infrastructure expenditures, the productivity of all the firms located within their respective territories. As in Hindriks et al. (2008) and Pieretti and Zanaj (2011), we assume that one additional unit of public good produces one additional unit of private good. Consequently, the amount of public good supplied by jurisdiction j $(j = S, L)$ equals θ_j. The cost of providing this public good in country j is given by the quadratic cost function $C(\theta_j) = \frac{1}{2}\theta_j^2$. Each jurisdiction j $(j = S, L)$ is supposed to maximize its total tax revenue[4], net of public expenditures, by choosing the appropriate tax rate t_j

[3] We assume that q is large enough such that the net income of firms and the social welfare are always positive.

[4] For a similar assumption, see Kanbur and Keen (1993), Zissimos and Wooders (2008), and Pieretti

and infrastructure levels θ_j . The government's objective functions are thus given by

$$B_S = t_S x - \frac{1}{2}\theta_S^2, \quad B_L = t_L(1-x) - \frac{1}{2}\theta_L^2. \tag{6.3}$$

6.2.1 Competition in taxes and infrastructure

We now consider a situation where the jurisdictions compete in taxes and infrastructure expenditures. To that end, we analyze a two-stage game[5]. First, the governments choose the level of infrastructure non-cooperatively and then set the tax rates. Finally, firms decide where to locate their businesses. We solve the game backwards.

Starting from the second stage, each government chooses the tax rate that maximizes its objective assuming that the rival's rate is given. The first order conditions yield the following unique equilibrium in tax rates:

$$t_S = \frac{1}{3}\left[k(1+s) + \theta_S - \theta_L\right], \quad t_L = \frac{1}{3}\left[k(2-s) + \theta_L - \theta_S\right]. \tag{6.4}$$

After having substituted the above tax rates into the jurisdictions' objective functions, we can solve for stage 1 when governments compete for infrastructure expenditures θ_S and θ_L. Solving the first order conditions leads to the unique equilibrium infrastructure expenditures

$$\theta_S = \frac{6k(1+s) - 4}{3(9k-4)}, \quad \theta_L = \frac{6k(2-s) - 4}{3(9k-4)}. \tag{6.5}$$

Introducing (6.5) into (6.4) yields the equilibrium tax rates

$$t_S = \frac{k[3k(1+s) - 2]}{9k-4}, \quad t_L = \frac{k[3k(2-s) - 2]}{9k-4}. \tag{6.6}$$

Imposing $\theta_j > 0$, $t_j > 0$ and $x \in (0,1)$ requires that $k > \underline{k} = \frac{2}{3}$. It is straightforward to see that, at equilibrium, the productivity of firms will be the highest in the larger

and Zanaj (2011).

[5]The choice of sequentiality follows from the rule that the most irreversible decision must be made first.

country and the tax rate will be the lowest in the smaller country. Indeed, we have $\theta_L - \theta_S = 2k\frac{1-2s}{9k-4} > 0$ and $t_L - t_S = 3k^2\frac{1-2s}{9k-4} > 0$ because $0 < s < 1/2$. At equilibrium, we also show that $x - s > 0$ where $x = \frac{3k(1+s)-2}{9k-4}$. In other words, the smaller country attracts a fraction of entrepreneurs coming from the larger jurisdiction by undercutting the rival's tax rate even if it can provide attractive infrastructure. The larger country tries to resist the capital outflow by providing more infrastructure than its small rival.

6.3 Size effect on social welfare

As in Zissimos and Wooders (2008), we define efficiency as the maximum level of surplus available to all individuals in the two economies:

$$W = (\pi_S + \pi_L) + (B_S + B_L) - k\int_0^{|x-s|} ydy. \tag{6.7}$$

The two terms in the brackets include, respectively, the joint firms' profits[6] and joint tax revenues. The last term is the companies' relocation costs.

We can write more explicitly that

$$W = q + \theta_S x + \theta_f(1-x) - \frac{1}{2}\theta_S^2 - \frac{1}{2}\theta_L^2 - k\int_0^{|x-s|} ydy. \tag{6.8}$$

For analytical convenience, we decompose social welfare in net global production ($\Psi_1 = q + \theta_S x + \theta_L(1-x) - \frac{1}{2}\theta_S^2 - \frac{1}{2}\theta_L^2$) and total mobility cost ($\Psi_2 = k\int_0^{|x-s|} ydy$). Substituting the above equilibrium tax rates (6.6) and equilibrium public inputs (6.5) into (6.8), we obtain

$$\begin{aligned} W &= \Psi_1 - \Psi_2 \\ \textit{with}\ \Psi_1 &= q + 4\frac{\left(2s^2 - 2s + 5\right)k^2 - 36k + 8}{\left(9k-4\right)^2} \\ \textit{and}\ \ \Psi_2 &= \frac{1}{2}k\left(1-2s\right)^2\frac{\left(3k-2\right)^2}{\left(9k-4\right)^2} \end{aligned} \tag{6.9}$$

[6]The profit in country j is $\pi_j = (q + \theta - t_j)x_j$, where $x_S = x$ and $x_L = 1 - x$.

It is interesting to see how the jurisdictions' size asymmetry can affect social welfare. First note that increased size asymmetry induces the smaller country to use tax-dumping in a more aggressive way. Indeed, the tax differential $t_L - t_S$ increases when s decreases. Accordingly, how do the competing jurisdictions change their attitudes toward infrastructure expenditures? Above we show that the large country reacts by augmenting its infrastructure supply in addition to lowering its tax rate, while the small country reduces its infrastructure expenditures. However, in the aggregate, infrastructure expenditures increase and as a result net global production ($\frac{\partial \Psi_1}{\partial s} < 0$) also increases. On the other hand, increasing size asymmetry exacerbates inter-jurisdictional competition and induces more capital to move. As a result, the welfare is negatively impacted ($\frac{\partial \Psi_2}{\partial s} > 0$). However, the sum of the two just highlighted effects is uncertain and depends eventually on capital mobility.

When capital mobility is high ($\underline{k} < k < \widehat{k}$, with $\widehat{k} = \frac{1}{9}(2\sqrt{7} + 8)$), the positive impact of higher size asymmetry on global net production exceeds the negative effect of higher capital mobility. Consequently, the social welfare increases ($\frac{\partial W}{\partial s} < 0$).

If capital mobility is low ($k > \widehat{k}$), the opposite effect occurs ($\frac{\partial W}{\partial s} > 0$). In this case, capital is relatively captive and inter-jurisdictional competition is weak. It follows that the incentive to invest in infrastructure is low, and the effect on net world productivity is moderate. Because the unit cost of moving capital is high, the cost effect dominates the productivity effect and social welfare decreases. This result is consistent with the standard tax competition literature (see, for example, Kanbur and Keen, 1993), but it has no general validity[7].

The following proposition concludes

Proposition 1 *Inter-jurisdictional competition in taxes and infrastructure yields the following results:*

(a) *if the degree of international openness is low, $k > \widehat{k}$, social welfare decreases with size*

[7]Our model reproduces the classical result if the jurisdictions are only uneven in size and only compete in taxes. The reason is that size asymmetry exacerbates capital mobility without overall output creation.

asymmetry;

(b) *if the degree of international openness is high,* $\frac{2}{3} < k < \widehat{k}$, *social welfare increases with size asymmetry.*

6.4 Conclusion

This chapter shows that size disparity among competing economies has an ambiguous effect on overall social welfare when countries not only compete in taxes, but also in infrastructures. The reason is that increasing size disparity impacts the intensity of inter-jurisdictional competition and thus influences the mix of policy instruments that are used to attract mobile capital. Basically, increased size asymmetry makes the smaller country more aggressive in undercutting its rival, and consequently, more firms will relocate their businesses. In standard tax competition models, relocation is uniquely wasteful as long as it does not induce (or is accompanied by) additional output creation.

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