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FISCAL HARMONIZATION IN THE CONTEXT OF GLOBALIZATION AND GROWING DEMAND OF MORE REGIONAL AUTONOMY

Patricia Sanz Córdoba

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PATRICIA SANZ-CÓRDOBA

Ph.D. DISSERTATION
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Submitted to the Department of Economics of Universitat Rovira i Virgili in the fulfillment of the requirements for the degrees of Doctor of Philosophy in Economics

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We STATE that the present study, entitled *Fiscal Harmonization in the Context of Globalization and Growing Demand of more Regional Autonomy*, presented by Patricia Sanz-Córdoba for the degree of Doctor of Philosophy in Economics, has been carried out under my supervision at the Department of Economics of this university, and that it fulfills all the requirements to receive the International Doctorate Distinction.

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The doctoral thesis supervisor

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September, 2017 Patricia S. C.

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FOREWORD

Within the international tax competition background, capital taxation has received much attention in the last decades. From an economic perspective, investment should be located in the most productive jurisdiction; however, it is located where tax rates are lower. Corporations locate in the lowest tax jurisdiction forcing governments to cut taxes to compete for mobile capital and, hence, inducing to a decrease in tax revenues. In the new era of economic integration and increasing capital mobility – that is, the economic globalization – tax competition is more evident than before, leading what is called the *race to the bottom*, reducing the welfare state and providing inefficiently low tax rates and public goods. Consequently, the tax burden has been transferred from the mobile capital taxation to the more immobile factors such as taxes on labor, exacerbating labor market rigidities and unemployment. Furthermore, the existence of fiscal strategic interactions among countries and their implications on the race to the bottom phenomenon is another interesting issue discussed within the international tax competition context. Each government mimics the fiscal policy applied by its neighboring countries, either because the tax competition, spillovers, or the yardstick competition.

As a response of the increasing fiscal competition among governments, both politicians and economists have advocated for the coordination of capital tax rates to reduce the associated inefficiencies and welfare costs. It is generally recognized that global tax harmonization is difficult to achieve since global negotiations toward coordinating international capital taxation has not took effect. For example, the European Union (EU) member states have made a lot of proposals for coordination, however, some countries would prefer the tax competition outcome rather than the global coordination if compensatory transfers are not allowed in the agreement.[1] Conse-

[1]Asymmetries between jurisdictions exacerbate the difficulty for achieving harmonization since the low-productive jurisdiction is better off under the fiscal competition than with the harmonized tax rate.

quently, the debate has been focused on the desirability of tax coordination among a coalition of countries, i.e., on *partial tax harmonization*.

The literature on tax harmonization has devoted surprisingly little attention to defining this phenomenon although there have been lot of proposals for corporate tax harmonization among EU members. Definitions of tax harmonization eliminate coordination of decentralized economies, where different levels of governments (e.g. federal, state, and local) impose taxes on the same tax base. Rather, it encompasses the large class of models of (horizontal) tax coordination, under which governments at the same level are coordinating their taxes. *Partial tax harmonization* is described in this thesis as a cooperative tax setting among a coalition of jurisdictions where commitment are credible. Such agreement consist in deciding a common capital tax rate that maximizes the joint welfare of the tax coalition and it is formed when it is beneficial for each of its members. Consequently, jurisdictions give up parts of their autonomy in tax matters. Therefore, this definition is broader and includes the coordination of decentralized economies.

Most of the literature on partial tax harmonization has assumed that jurisdictions only compete in taxes, but there are some authors who have analyzed general tax competition in which jurisdictions compete in tax and nontax instruments (e.g., infrastructure investments). This assumption is particularly relevant because, in fact, EU countries are discussing the coordination of capital taxation and, simultaneously, are involved in the coordination of other nontax instruments that affect the allocation of capital goods.

The first chapter analyzes how partial tax harmonization within a coalition of asymmetric jurisdictions is influenced by a simultaneous coordination of infrastructure investments. For this purpose, we use the tax competition model, conceding a subset of jurisdictions to form a tax coalition. Moreover, asymmetries in productivity levels between jurisdictions are allowed. Two kinds of infrastructure coordination are considered: infrastructure coordination with jurisdiction-specific investments and through the choice of a common investment level. The main results of the chapter can be summarized as follows. First, partial tax harmonization can be welfare enhancing for tax coalition members whenever they are not too different in their productivity levels. Second, tax harmonization becomes feasible when tax coalition members dispose of additional instruments for the coordination of tax and nontax policies even if productivity asymmetries between them are substantial. Therefore, productivity asymmetries represent a serious handicap for partial tax harmonization that can be remedied by coordinating nontax instruments

when they allow reducing these asymmetries. Finally, infrastructure coordination through the choice of a common investment level is particularly indicated when asymmetries between potential members of a tax coalition are large. However, infrastructure coordination does not always facilitate partial tax harmonization. The current usage of structural funds orientated to reduce regional infrastructure deficits is therefore suitable to facilitate tax harmonization within the EU.

The second chapter considers partial tax harmonization as a strategic response to international tax competition in a more general setting where a country can also be a fiscally decentralized economy. We analyze a country's optimal fiscal strategy in the context of international (and national) tax competition. For this purpose, we build on the tax competition models, allowing a subset of centralized jurisdictions to form a tax coalition. Countries are also asymmetric in productivity levels but characterized by multilevel government such that there is both horizontal and vertical tax competition. Three strategies are considered: i) fiscal centralization under which the central government decides all tax rates in the country; ii) fiscal decentralization under which central and local governments choose independently their capital tax rates; and iii) partial tax harmonization under which two countries form a tax union that commonly determines a unique tax rate for all jurisdictions. The main result from the analysis is that fiscal decentralization is a handicap in achieving partial tax harmonization. Thus, it is shown that tax harmonization is more difficult to achieve in fiscally decentralized economies with high levels of productivity. This result is confirmed by recent data and explains the observed difficulties in achieving capital tax harmonization in the EU.

The last chapter investigates the existence of international tax competition among OECD countries, considering the importance of combating the "harmful" tax practices. We address the question whether or not fiscal interactions between governments exist and whether governments with similar public infrastructure investment levels increase the fiscal interdependence among them. For this purpose, we use a spatial panel data model. Results reveal the existence of tax interdependence in the closest neighboring OECD countries where international tax competition still occurs. The tax interdependence is higher for countries with similar public infrastructure investment levels. Therefore, the hypothesis that countries with similar public infrastructure investment levels incur in higher fiscal interactions is accepted.

Each chapter is independent of the rest but all together are connected by the same tax competition literature. For this reason, each begins with an introduction and ends with the

main conclusions that are reached on the basis of its content. The references, appendices, figures and tables, if any, are added at the end of each chapter.

CHAPTER 1

PARTIAL TAX HARMONIZATION THROUGH INFRASTRUCTURE COORDINATION

Overview. This chapter analyzes the role of infrastructure coordination in facilitating partial tax harmonization within a coalition of asymmetric jurisdictions. Two main results are obtained. First, productivity asymmetries represent a serious handicap for partial tax harmonization that can be remedied by coordinating nontax instruments when they allow reducing these asymmetries. Second, infrastructure coordination through the choice of a common investment level is particularly indicated when asymmetries between potential members of a tax coalition are large. The current usage of structural funds orientated to reduce regional infrastructure deficits is therefore suitable to facilitate tax harmonization within the European Union.

Keywords: Partial Tax Harmonization; Infrastructure Coordination; EU Structural Funds Policy

1.1 Introduction

Since the 1980s processes of economic integration have increased the international mobility of capital to an extent never observed before. This has led to a *race to the bottom* in capital taxation among developed countries as can be observed in Fig. 1.1 for European Union (EU) member countries. The result of this tendency are inefficiently low tax rates (Zodrow and Mieszkowski, 1986; Wilson, 1986; Bucovetsky and Wilson, 1991).[1] As a consequence, and to maintain the existing welfare standards, the tax burden has been shifted from capital towards labor which has raised growing concern in many countries.[2] Both politicians and economists have therefore advocated for the coordination of capital taxation to reduce the associated efficiency and welfare costs (Keen, 1987; Bucovetsky, 1991; Kanbur and Keen, 1993; Fuest and Huber, 2001; Baldwin and Krugman, 2004; Sørensen, 2004; Konrad, 2009; Devereux and Fuest, 2010; Keen and Konrad, 2013).[3] Since global tax harmonization, however, is difficult to achieve the recent debate has focused on the desirability of tax coordination among a coalition of countries, i.e., on partial tax harmonization (Burbidge et al., 1997; Konrad and Schjelderup, 1999; Beaudry et al., 2000; Brøchner et al., 2007; Conconi et al., 2008; Bucovetsky, 2009; Bettendorf et al., 2010; Vrijburg and de Mooij, 2010; Eichner and Pething, 2013).[4]

While most of the literature on partial tax harmonization has assumed that jurisdictions only compete in taxes, in this chapter, we consider competition in further nontax instruments (e.g., infrastructure investments).[5] Thereby we allow jurisdictions not only to coordinate their tax rates but also their nontax instruments. This is particularly relevant because we observe that countries that are discussing the coordination of capital taxation, simultaneously, are involved in the coordination of other nontax instruments that affect the allocation of capital goods.[6] Thus,

[1] See Wilson (1999), Wilson and Wildasin (2004), and Boadway and Tremblay (2011) for a review of the tax competition literature.

[2] For example, in EU member countries, the implicit average tax on capital has decreased from 44% in 1980 to 35% in 1994 while the implicit tax on labor has increased from 34% to 40.5% during the same period (European Commission, 1996).

[3] See Dankó (2012) regarding the proposals for corporate tax harmonization in the EU.

[4] Keuschnigg et al. (2014) define tax coordination and harmonization in the EU as follows: *"tax coordination refers to a cooperative tax setting, where countries or a group of them build on domestic tax systems to render them compatible with the aims of the Union as formulated the Treaty on the European Union. Consequently, countries deliberately give up parts of their autonomy in tax matters"*. Moreover, *"harmonization is viewed as tighter coordination, leading to almost identical or at least similar tax systems, tax bases and tax rates within a Union"*.

[5] Notice, however, that some authors have analyzed general tax competition in which jurisdictions compete in tax and nontax instruments. See, for example, Hindriks et al. (2008), Zissimos and Wooders (2008) or Pieretti and Zanaj (2011).

[6] For example, it has been shown that infrastructure investments rise international capital mobility by attract-

Combined corporate income tax rate of EU countries (period 1995-2011)

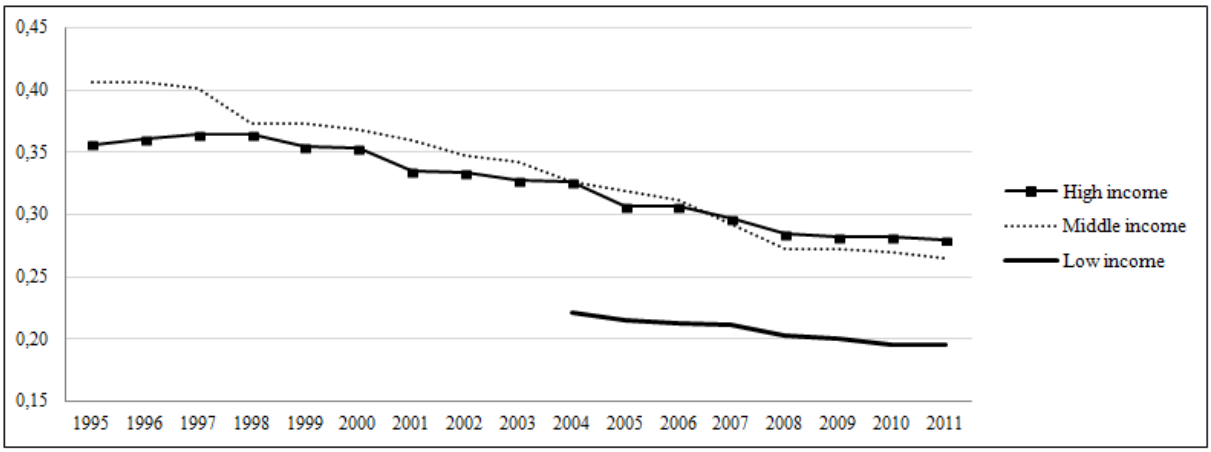

Figure 1.1: Countries are classified into high, middle and low income countries. High income countries comprise Austria, Belgium, Denmark, Finland, France, Germany, Netherlands, Sweden, and United Kingdom. Middle income countries include Greece, Italy, Spain, and Portugal. Low income countries encompass Czech Republic, Estonia, Hungary, Slovak Republic, Slovenia, and Poland. Source: Own calculation based on OECD (2015).

in the EU for instance, a major part of public infrastructure investments is financed via structural funds. Similarly, while state governments in the United States (US) have discretionary power on setting capital taxes, at the same time, the federal government partly decides over their infrastructure investments. Against this background, the aim of this chapter is to assess the impact of nontax instruments in achieving a partial harmonization of capital tax rates.

For this purpose, we use the tax competition model developed by Zodrow and Mieszkowski (1986) and Wilson (1986) in which we allow a subset of jurisdictions to form a tax coalition, as in Konrad and Schjelderup (1999). The framework of Konrad and Schjelderup (1999) is modified by allowing for asymmetries in productivity levels between jurisdictions and by assuming that governments make infrastructure investments that enhance the productivity of private firms. For the sake of simplicity, the focus is on three jurisdictions that differ in their productivity levels. The timing of the game is as follows. In stage 1, jurisdictions 1 and 2 decide whether to coordinate tax rates and infrastructure investments, where commitments are assumed to be credible. In stage 2, jurisdictions simultaneously decide their infrastructure investments. Finally, in stage 3, after observing the different investment levels, each jurisdiction simultaneously chooses its capital tax rate.[7]

ing foreign capital (Bjorvatn and Schjelderup, 2002; Justman et al., 2002; Benassy-Quéré et al., 2007; Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011).

[7]The assumption that jurisdictions first choose infrastructure investments and then tax rates is common in

Regarding the scope of the cooperation agreements between jurisdictions 1 and 2 we study three cases. First, the two jurisdictions coordinate their tax rates while setting infrastructure investment levels separately. We follow part of the literature in assuming that such a partial tax harmonization agreement consists in deciding a common capital tax rate that maximizes the joint welfare (Burbidge et al., 1997; Konrad and Schjelderup, 1999; Fuest and Huber, 2001; Conconi et al., 2008; Bucovetsky, 2009; Kammas and Philippopouslos, 2010; Eggert and Itaya, 2014; Han et al., 2017).[8] A tax coalition is formed when it is beneficial for each of its members.[9] Second, jurisdictions 1 and 2 choose a common capital tax rate and furthermore coordinate their infrastructure investments. The investment levels are allowed to be different and are chosen to maximize the joint welfare. This case mimics the situation of decentralized economies such as the US, for example. Third, both jurisdictions agree on a common tax rate and a common level of infrastructure investments. This case is particularly relevant as it resembles the infrastructure policy followed in the EU where structural funds are used to reduce asymmetries in infrastructure investments among EU members. To see this, take a look at the per capita infrastructure investment in EU member countries displayed in Fig. 1.2. We find that per capita infrastructure investment among high, middle and low income countries has nearly converged in 2008.[10] This tendency is not accidental but is due to EU structural funds that amounted to a total of 100.5 billion euro during the period 2000-06. Thus, in Fig. 1.3 we observe that a substantial number of total infrastructure investments in middle and low income countries were financed by the EU which in Greece, for example, amounted to more than 70%. [11]

From the analysis two central messages emerge. First, productivity asymmetries represent a serious handicap for partial tax harmonization that can be remedied by coordinating nontax instruments when they allow to reduce these asymmetries. The results indicate that both kinds of infrastructure coordination, jurisdiction-specific and with a common investment level, are suitable for this purpose. A necessary condition for the effectiveness of such an infrastructure

the literature (Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011; Han et al., 2017) and motivated by the irreversibility of the former decision.

[8]Notice, in some studies partial tax harmonization consists in agreeing upon a minimum tax rate (Kanbur and Keen, 1993; Peralta and Ypersele, 2006; Konrad, 2009; Osterloh, 2013; Keen and Konrad, 2013).

[9]We thereby assume that side-payments between coalition partners are not feasible. See Keen and Konrad (2013) Section 3.3, for a discussion of the literature on coordination among a subset of countries.

[10]After the financial crisis in that year, however, we witness a divergence of per capita investments as low and middle income countries have reduced investments while high income countries have maintained the tendency of a slight increase in yearly investments.

[11]Interestingly, though the objective of EU structural funds policy is manyfold, a widespread view is that this policy leads to more intensive tax competition and that it therefore is detrimental to the achievement of a partial tax harmonization in the EU (Becker and Fuest, 2010).

Transport infrastructure investment per capita of EU countries (period 1995-2011)

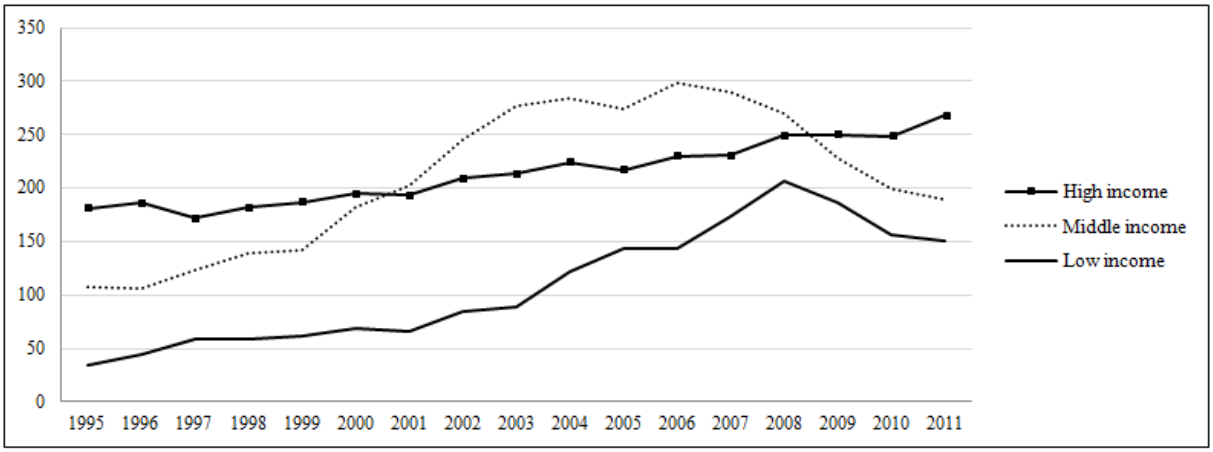

Figure 1.2: For country classification see Figure 1.1. Measurement: Infrastructure investment per capita in Euros. Source: Own calculation based on OECD (2015).

Share of EU financed infrastructure investment over total infrastructure investment (period 2000-06, period 2003-06 for low income countries)

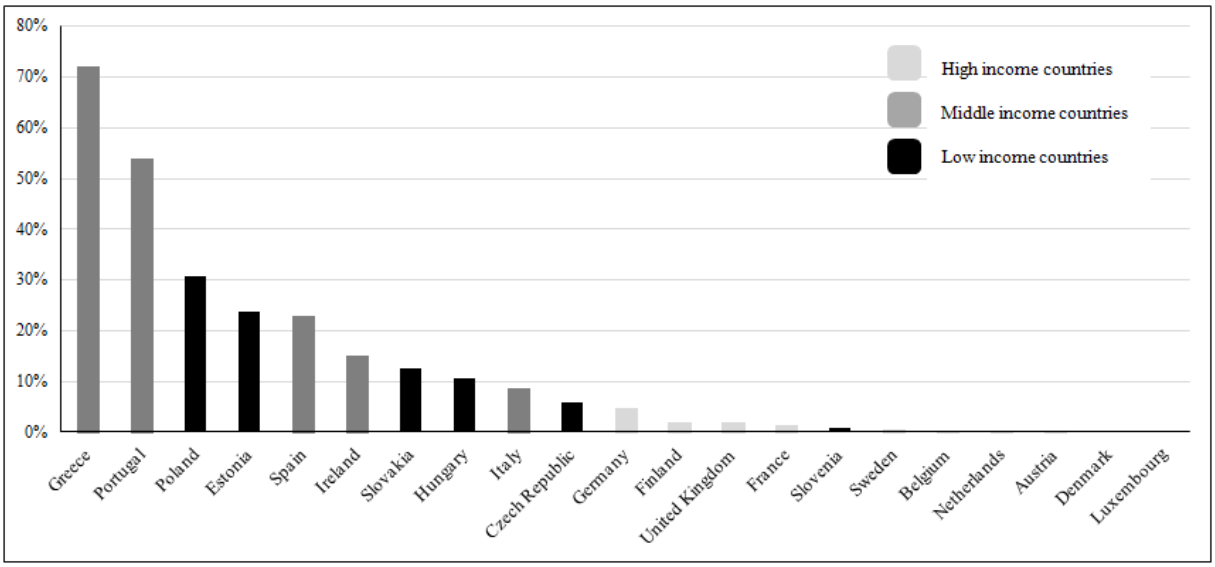

Figure 1.3: For country classification see Figure 1.1. Measurement: Infrastructure investment per capita financed by EU divided by total per capita infrastructure investment. Source: Own calculation based on OECD (2015) and Sweco (2008).

coordination between asymmetric jurisdictions is that the jurisdiction outside the tax coalition is not too productive. The second message that comes up from the analysis is that infrastructure

coordination through the choice of a common investment level is particularly indicated when asymmetries between potential members of a (partial) tax coalition are large. Thus, we find that such a coordination agreement sustains partial tax harmonization in situations in which this is not possible with the choice of jurisdiction-specific investments. As a consequence, we judge the current usage of EU structural funds orientated to reduce regional infrastructure deficits as suitable to facilitate tax harmonization within the EU.

The main results of the chapter can be summarized as follows. First, partial tax harmonization can be welfare enhancing for the jurisdictions of the partial tax coalition whenever they are not too different in their productivity levels. This result extents the analysis of the case of symmetric jurisdictions by Burbidge et al. (1997) and Konrad and Schjelderup (1999). They have shown that an increase in capital tax rates by the (partial) tax coalition partners can increase their welfare even if it implies a capital transfer to third jurisdictions. The intuition behind our result is that a common capital tax rate in the tax coalition means that with increasing asymmetries capital transfers in the less productive jurisdiction become too large to compensate the advantage of a reduction in the intensity of international tax competition.

Second, tax harmonization becomes feasible when the members of the partial tax coalition dispose of additional instruments for the coordination of tax and nontax policies even if productivity asymmetries between the members of the tax union are substantial. The effect of such an enhanced coordination is a reduction infrastructure investments differences between tax coalition members. Infrastructure coordination allows to internalize the negative externality of overinvestment due to infrastructure competition. As a consequence, the joint coordination of tax rates and infrastructure investments avoids the aggressive competition in infrastructure investments and allows to obtain additional gains for both coalition members. In general terms we can summarize this result as follows. Whenever two asymmetric parties are engaged in a non-cooperative relationship that involves sequential strategic choices, and side-payments are not available, achieving an agreement on a full package that involves coordination of actions at all stages is easier than achieving an agreement on a partial package that excludes some stages from the arrangement.

Third, infrastructure coordination does not always facilitate partial tax harmonization. This is the case in which asymmetries both inside and outside the tax coalition are substantial. Thus, a high productivity jurisdiction outside the tax coalition reacts more aggressively and responds with a reduction of its capital tax rate to the tax increase of the tax coalition. The

corresponding welfare cost in terms of capital outflows imposed either on the less productive coalition member (under infrastructure coordination with jurisdiction-specific investments) or on the more productive coalition member (under infrastructure coordination through the choice of a common investment level) renders the mere tax harmonization preferable for them.

The analysis is related to several studies. Firstly, neglecting infrastructure investments, our model is a simplified version of the general model of tax competition developed by Zodrow and Mieszkowski (1986) and Wilson (1986). As formulated by Keen and Konrad (2013), in the case of symmetric countries, "the decentralized tax-setting means that countries fail to properly exploit what is, from the collective perspective, ..., the first best feasible". For the more interesting case of asymmetric countries (or jurisdictions), general results are hard to find. Therefore, further restrictions on the functional forms of the production function and the utility function of public goods are necessary (see e.g., Wildasin, 1991; Bucovetsky, 2009; Hindriks et al., 2008; Kempf and Rota-Graziosi, 2010). With these simplifications the resulting best-response functions become linear and the Nash-equilibrium can be easily derived (see Keen and Konrad (2013, 270-4). Several insights from this model are already well-understood. Thus, capital-rich countries, more productive countries and countries with a stronger taste for public goods will choose higher tax rates. Furthermore, as shown by Bucovetsky (2009), under asymmetries in population size it is the smaller country that sets lower tax rates in equilibrium. We take this model as a reference point and analyze how endogenously chosen infrastructure investments affect partial tax coordination within the model.

Secondly, as simultaneous tax coordination by all countries is unlikely to be established, the literature has focused on tax coordination by a subset of countries that might be able to create mechanisms or institutions that allow a credible commitment to maintaining jointly agreed tax rates. Konrad and Schjelderup (1999) have shown that such a partial tax harmonization can increase the welfare of the participating jurisdictions. This depends on the response of jurisdictions from outside the tax coalition, and the relative size of the tax union. Thus, a necessary condition for a welfare enhancing effect is that tax rates are strategic complements and that jurisdictions are not too different. Brøchner et al. (2007) study partial tax coordination in the EU, using a general equilibrium model. They conclude that corporate tax coordination would generate a moderate overall welfare growth. However, while such a coordination would leave some EU member states as winners, others would lose from it. As a consequence, yielding an agreement on tax cooperation requires compensation mechanisms. Conconi et al. (2008), apart

from tax competition between governments, consider the commitment problem of governments not to increase capital taxes once capital has been installed. Their analysis shows that with such a commitment problem, compared to both no tax coordination and global tax harmonization, partial tax harmonization can be welfare enhancing for all members of the tax coalition if capital is sufficiently mobile.

Thirdly, some authors have introduced productive public goods into the general model of tax competition. Keen and Marchand (1997) extent the standard model of fiscal competition by assuming that governments, apart from taxes, also choose public inputs to maximize social welfare.[12] They find that simultaneous capital and infrastructure competition not only yields inefficiently low tax rates but also inefficiently high infrastructure investments. Zissimos and Wooders (2008) show that the intensity of tax competition can be mitigated when firms production costs are reduced by public infrastructure investments. Becker and Fuest (2010) analyze the effects of infrastructure coordination using a model in which countries compete for the location of profitable firms. They find that the coordination of infrastructure investments between two countries can mitigate tax competition between these countries. The main differences between their and our model is that we focus on partial tax harmonization, allow for asymmetries among countries and, most importantly, consider policy responses of third countries.[13] Moreover, our model is framed in the capital tax competition literature while their model belongs to the literature on interjurisdictional competition for profitable firms.

Finally, recent studies have analyzed tax harmonization when countries also compete in nontax instruments such as infrastructure investments. Han et al. (2017) analyze the desirability of global tax coordination when countries compete in taxes and infrastructures. They find that tax coordination with an additional nontax instrument is more likely to be detrimental when countries compete simultaneously rather than sequentially since simultaneity eliminates strategic effects between tax and nontax instruments. The main difference to this chapter is that infrastructure investments in their analysis are not subject to coordination between jurisdictions and that they focus on global tax harmonization instead of partial tax harmonization. Han (2013) analyzes how infrastructure investments affect partial tax harmonization between symmetric jurisdictions. He finds that it can harm tax coalition members as well as nonmembers which is in contrast to the classical result that partial tax harmonization is Pareto improving in such

[12]Fuest (1995) finds that with a publicly provided factor of production the welfare effect of co-ordinated tax increases becomes ambiguous.

[13]This last aspect is especially relevant to derive policy implications for tax harmonization in the EU which under increasingly international capital mobility depends on global tax competition.

a case. Here the main difference is that he also does not consider the coordination of nontax instruments and that his analysis is limited to the case of symmetric countries.

The rest of the chapter is organized as follows. Section 1.2 sets up the model and derives the benchmarks of non-cooperation and partial tax harmonization. The main results on the impact of infrastructure coordination in achieving a partial harmonization of capital tax rates are in Section 1.3. Finally, Section 1.4 presents the conclusions. The proofs are in the Appendix.

1.2 The model

Consider the tax competition model developed by Zodrow and Mieszkowski (1986) and Wilson (1986) in which, as in Konrad and Schjelderup (1999), we allow a subset of jurisdictions to form a tax coalition. The framework is modified by allowing for asymmetries in productivity between jurisdictions and by assuming that governments provide local public goods that enhance the productivity of private firms. To be precise, consider $N = 3$ jurisdictions, indexed by $i = 1, 2, 3$, each inhabited by an identical number of immobile residents with mass one who each supply one unit of labor. In each region governments choose a rate of the source-based unit tax t_i on capital and a level of public investment g_i that enhances the productivity of domestic capital. Output in each jurisdiction is produced using capital and labor and the production function is written in intensive form, $f_i(k_i; g_i)$, with the standard assumptions of $f_i' > 0$, $f_i'' < 0$, where k_i denotes the capital per worker employed in jurisdiction i. The total amount of capital is fixed and normalized to 1. The initial capital stock per worker in each jurisdiction is assumed to be symmetric, i.e., $\overline{k}_i = 1/3$. The cost of public investment is given by the convex function $c_i(g_i)$, which, for the sake of analytical tractability, is assumed to be of the form $c_i(g_i) = g_i^2/2$.

Capital is perfectly mobile between jurisdictions such that the net return to capital, ρ, is determined by the following arbitrage condition

$$\rho = f_i'(k_i; g_i) - t_i \qquad \text{for} \quad i = 1, 2, 3. \tag{1.1}$$

The government in jurisdiction i maximizes the welfare function W_i, the sum of the return to the immobile factor and tax revenue, net of the public goods cost[14]

[14]Neglecting infrastructure investments, this is a simplified version of the more general representative consumer utility function

$$W_i = f_i(k_i) - f_i'(k_i)\, k_i + \rho \overline{k}_i + u_i(G),$$

where $G = t_i k_i$, discussed in Keen and Konrad (2013). This utility function has been used to analyze the

$$W_i\left(t_i, g_i\right) = f_i\left(k_i; g_i\right) - f_i'\left(k_i; g_i\right) k_i + t_i k_i - c(g_i), \tag{1.2}$$

Following the literature (Hindriks et al., 2008; Bucovetsky, 2009; Hauptmeier et al., 2012; Han, 2013; Eichner and Pething, 2013; among others), we assume a linear quadratic production function

$$f_i\left(k_i; g_i\right) = \left(\alpha + \epsilon_i + g_i\right) k_i - k_i^2, \;\; i = 1, 2, 3, \tag{1.3}$$

where $\alpha > 0$. The production function allows for asymmetric productivity levels and exhibits decreasing returns to capital and constant returns to investment. Without loss of generality we assume $\epsilon_1 = 0$. Moreover, to guarantee nonnegative equilibrium values, we restrict the analysis to $(\epsilon_2, \epsilon_3) \;\epsilon\; R = \left\{\epsilon_2 \geq 0,\; \frac{1}{2}\epsilon_2 - \frac{19}{18} < \epsilon_3 < \min\left\{\frac{19}{9} - \epsilon_2, \frac{7}{3} - \frac{27}{5}\epsilon_2\right\}\right\}$.[15] With this production function, jurisdiction i's welfare function simplifies to

$$W_i\left(t_i, g_i\right) = k_i^2 + t_i k_i - g_i^2/2. \tag{1.4}$$

The arbitrage condition (1.1) together with the market clearing condition ($\sum k_i = 1$) implies that the amount of capital invested in jurisdiction i is given by

$$k_i = \frac{1}{3} + \frac{(2\epsilon_i - \epsilon_j - \epsilon_h) + (2g_i - g_j - g_h) - (2t_i - t_j - t_h)}{6}, \tag{1.5}$$

where $i, j, h = 1, 2, 3;\; j \neq i;\; h \neq i, j$.[16] Regions can attract more capital by increasing their infrastructure investments or by decreasing capital taxation. Under equal tax and investment levels, more productive jurisdictions attract more capital.

We assume that jurisdictions 1 and 2 are able to credibly commit to a common tax rate and, therefore, are able to form a tax coalition. A tax union is formed whenever it is beneficial for both

symmetric case. However, in the asymmetric case general results are hard to find which has led many authors to assume quadratic production functions and a linear utility function of public goods (see Keen and Konrad, 2013, 270).

We also assume that domestic capital does not enter the welfare function. This can either be justified by assuming that there is no domestic ownership of capital (Hindriks et al., 2008) or that tax rates are determined by the median voter who has no capital endowment (Borck, 2003). Notice also that considering symmetric capital ownership would not affect our results (see Keen and Konrad, 2013, 267), while the impact of asymmetric capital ownership is already well understood (see Keen and Konrad, 2013, 270) and this additional asymmetry certainly would divert the attention from our main results.

[15] As shown in the Supplementary material to this chapter, the binding restrictions to guarantee nonnegative equilibrium values stem from $t_1^N > 0$, $t_3^N > 0$, and $g_1^{TI} > 0$, respectively.

[16] When not stated otherwise, we assume these conditions for all of our further expressions.

partners where we assume that side-payments between coalition partners are not feasible.[17] Our assumptions imply that in this case jurisdiction 2 is the more productive jurisdiction in the tax coalition. The jurisdiction outside the tax coalition, jurisdiction 3, can be either more productive than both members of the tax coalition ($\epsilon_3 \geq \epsilon_2$), less productive than both jurisdictions ($\epsilon_3 < 0$), or more productive than jurisdiction 1 and less productive than jurisdiction 2 ($0 \leq \epsilon_3 < \epsilon_2$).

The timing of the game is as follows. First, in stage 1, jurisdictions 1 and 2 decide whether to coordinate tax rates and infrastructure investments. Once a decision is taken, infrastructure investments are decided in stage 2. Finally, in stage 3, for a given level of infrastructure investments, tax rates are chosen. All decisions at each stage are taken simultaneously by all jurisdictions (and the tax coalition). The game is solved by backwards induction. The solution concept is subgame perfect Nash equilibrium (SPNE).

1.2.1 The non-cooperative game

Let us first provide as a benchmark the non-cooperative game in which each jurisdiction chooses its infrastructure investment and capital tax rate separately. Beginning in stage 3, each jurisdiction maximizes its welfare function (1.4) with respect to the tax rate t_i while taking other rivals' tax rates as given. The best-response functions are given by[18]

$$t_i\left(t_j, t_h, g_i, g_j, g_h\right) = \frac{1}{4} + \frac{\left(2\epsilon_i - \epsilon_j - \epsilon_h\right) + \left(2g_i - g_j - g_h\right) + t_j + t_h}{8} \tag{1.6}$$

such that tax rates of different jurisdictions are strategic complements. Furthermore, the optimal tax rate is increasing in the jurisdiction's infrastructure investment (i.e., tax rates and investments are complementary instruments) and decreasing in the infrastructure investments of other jurisdictions. The first-order conditions yield the following unique equilibrium tax rates

$$t_i = \frac{1}{3} + \frac{2\epsilon_i - \epsilon_j - \epsilon_h + 2g_i - g_j - g_h}{9} \tag{1.7}$$

where the condition $\partial t_i / \partial t_j < 1$ in Eq. (1.6) guarantees the stability of the equilibrium. After substituting the above tax rates into the jurisdictions' welfare function in (1.4), in stage 2, jurisdiction i chooses the optimal level of infrastructure g_i that maximizes its welfare. The

[17] See Keen and Konrad (2013) for the related literature using this assumption.
[18] Notice that from substitution of Eq.(1.5) in Eq.(1.4) we have that W_i is concave in t_i.

best-response function of jurisdiction i is

$$g_i\left(g_j, g_h\right) = \frac{8}{65}\left(3 + 2\epsilon_i - \epsilon_j - \epsilon_h - g_j - g_h\right) \tag{1.8}$$

which means that infrastructure investments at stage 2 are strategic substitutes.[19] Taken together, from the reaction functions in Eqs. (1.6) and (1.8) we observe, that an increase in infrastructure investments in a rival jurisdiction is responded with a decrease in own investments ($dg_i/dg_j < 0$) and a reduction in capital taxation ($dt_i/dg_j = \left(\partial t_i/\partial g_i\right)\left(dg_i/dg_j\right) + \partial t_i/\partial g_j < 0$), while a reduction of a rival's capital tax rate is responded directly with a reduction in tax rates, too ($dt_i/dt_j < 0$). Thus, jurisdictions use tax rates instead of infrastructure investments to react to more aggressive capital attraction policies by their rivals.

From (1.8) the SPNE infrastructure investments are given by

$$g_i^N = \frac{8}{27} + \frac{8}{57}\left(2\epsilon_i - \epsilon_j - \epsilon_h\right). \tag{1.9}$$

Substituting Eq. (1.9) into Eq. (1.7) yields the equilibrium tax rates

$$t_i^N = \frac{1}{3} + \frac{3}{19}\left(2\epsilon_i - \epsilon_j - \epsilon_h\right). \tag{1.10}$$

Using this expression we can write $g_i^N = 8/9t_i^N$ and that the welfare in jurisdiction i is

$$W_i^N = \frac{130}{81}\left(t_i^N\right)^2. \tag{1.11}$$

Regarding the tax rates and infrastructure investments in the different jurisdictions we obtain from Eqs. (1.9) and (1.10) that infrastructure investments and tax rates are higher in the more productive jurisdiction (i.e., $g_i^N > g_j^N$, $t_i^N > t_j^N$ iff $\epsilon_i > \epsilon_j$). From the literature we know that in the SPNE tax rates are inefficiently low yielding an underprovision of public goods. Furthermore, when jurisdictions can choose their infrastructure investments freely, in the Nash equilibrium, infrastructure investments are too high (Keen and Marchand, 1997). We state this as a first result:

Lemma 1 *Starting from a non-cooperative subgame perfect Nash equilibrium and holding infrastructure investments constant, a small rise in tax rates increases welfare in all jurisdictions.*

[19] Concavity of W_i is given as $\frac{\partial^2 W_i}{\partial g_i^2} = -\frac{65}{81} < 0$.

Likewise, holding tax rates constant, a small reduction in infrastructure investments increases welfare in all jurisdictions.

From Lemma 1 follows that tax rates and the provision of public goods are inefficiently low and infrastructure investments are inefficiently high. This result is due to the prisoner's dilemma property of this type of games. While the coordination of tax rates and infrastructure investments increases welfare in all jurisdictions, a deviation by a single jurisdiction from this situation would allow it to realize even higher welfare gains. Therefore, in equilibrium, all countries deviate and a Pareto inferior situation is attained.

1.2.2 Partial tax harmonization

Now, consider that a subgroup of jurisdictions, 1 and 2, form a coalition subgroup that can credibly commit to a common tax rate. As we have seen before, without such a commitment both jurisdictions would deviate from any commonly agreed tax rate. Furthermore, we assume that such a commitment is not feasible for jurisdiction 3. This assumption is realistic, for example, if we consider that jurisdictions 1 and 2 are EU member countries, for which different mechanisms are available that could serve to guarantee a potential commitment, and jurisdiction 3 is a nonmember country. More precisely, following the literature, consider that jurisdictions 1 and 2 jointly maximizes the welfare of this group (i.e., $W_1 + W_2$) to choose a common tax rate, t_c, on which both jurisdictions agree publicly and to which they can credibly commit.[20] Jurisdiction 3, simultaneously, determines its tax rate t_3.

The stage 3 equilibrium tax rates are obtained from solving $max_{t_c}\ W_1 + W_2$ and $max_{t_3}\ W_3$, respectively, and are given by

$$t_c = 1 + \frac{\epsilon_2 - 2\epsilon_3 + g_1 + g_2 - 2g_3}{6},\ t_3 = \frac{1}{2} - \frac{\epsilon_2 - 2\epsilon_3 + g_1 + g_2 - 2g_3}{12}. \tag{1.12}$$

In stage 2, as in the non-cooperative benchmark case, the three jurisdictions choose their infrastructure non-cooperatively. The SPNE infrastructure investments are given by

$$g_1^T = \frac{23}{45} - \frac{4}{21}\epsilon_2 - \frac{23}{105}\epsilon_3,\ g_2^T = \frac{23}{45} + \frac{43}{105}\epsilon_2 - \frac{23}{105}\epsilon_3,\ g_3^T = \frac{14}{45} - \frac{8}{105}\left(\epsilon_2 - 2\epsilon_3\right). \tag{1.13}$$

[20]This assumption has been used, for example, by Burbidge et al. (1997), Konrad and Schjelderup (1999), Fuest and Huber (2001), Conconi et al. (2008), Bucovetsky (2009), Kammas and Philippopouslos (2010), Eggert and Itaya (2014) or Han et al. (2017).

Substituting Eqs. (1.13) into Eqs. (1.12) yields the SPNE tax rates

$$t_c^T = \frac{16}{15} + \frac{8}{35}(\epsilon_2 - 2\epsilon_3), \;\; t_3^T = \frac{7}{15} - \frac{4}{35}(\epsilon_2 - 2\epsilon_3). \tag{1.14}$$

From the above expressions, social welfare levels resulting from partial tax harmonization are[21]

$$\begin{aligned} W_i^T &= \left(\frac{5t_c^T}{4} + \frac{(-1)^i 2\epsilon_2}{5}\right)\left(\frac{t_c^T}{4} + \frac{(-1)^i 2\epsilon_2}{5}\right) - \frac{1}{2}\left(\frac{23t_c^T}{48} + \frac{(-1)^i 3\epsilon_2}{10}\right)^2, \; i = 1, 2, \\ W_3^T &= \frac{16}{9}\left(t_3^T\right)^2. \end{aligned} \tag{1.15}$$

In stage 1, jurisdictions 1 and 2 decide to form a tax coalition with a common tax rate when both jurisdictions obtain a higher welfare, i.e., when $W_i^T > W_i^N$ for $i = 1, 2$. The following result states when this is the case.

Proposition 1 *i) Partial tax harmonization yields an increase in tax rates and infrastructure investments inside the tax coalition ($t_c^T > t_i^N$ and $g_i^T > g_i^N$, $i = 1, 2$) and takes place when the jurisdictions in the tax coalition are not too different in their productivity levels (i.e., when ϵ_2 is small). Welfare gains inside the coalition are larger for the more productive jurisdiction. ii) The jurisdiction outside the tax coalition increases (decreases) its tax rate and infrastructure investment when its productivity is low (high). Therefore, partial tax harmonization is easier to achieve when the productivity level of the jurisdiction outside the tax coalition is low.*

From Proposition 1 we observe that the formation of a tax coalition induces its members to increase their (inefficiently low) capital rates to the common tax level. However, as tax rates and infrastructure investments are strategic complements, they compensate less competition in taxes with a more aggressive competition in infrastructure investments. Therefore, infrastructure investments are even more inefficient than in the non-cooperative equilibrium. This result has also been observed by other authors. If jurisdictions cooperate on one instrument they might end up acting more aggressively on another that is a strategic complement (Keen and Marchand, 1997; Keen and Konrad, 2013; Han et al., 2017).

That partial tax harmonization can be beneficial under credible commitment has already been shown by Konrad and Schjelderup (1999) and Fuest and Huber (2001) for symmetric jurisdictions. From the above result we observe the importance of the symmetry assumption.

[21] Notice that the equilibrium values of infrastructure can be written as $g_1^T = \frac{23}{48}t_c^T - \frac{3}{10}\epsilon_2$, $g_2^T = \frac{23}{48}t_c^T + \frac{3}{10}\epsilon_2$, and $g_3^T = \frac{2}{3}t_3^T$.

Benchmark equilibria

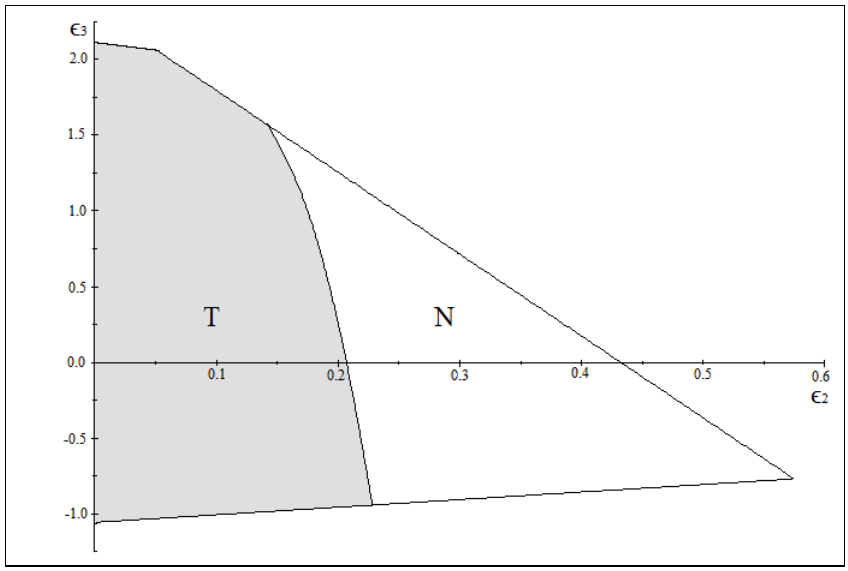

Figure 1.4: Equilibria are: T (partial tax harmonization) and N (non-cooperation).

The jurisdictions that form part of the tax coalition increase their tax rates, where the increase is superior for the less productive jurisdiction. Therefore, the more asymmetric the tax coalition partners are, the larger are the costs from capital outflows for the less productive jurisdiction. When the difference in productivity between jurisdictions becomes substantial, these costs exceed the gains from reduced tax competition for the less productive jurisdiction such that the tax coalition is not formed. Moreover, the convenience of forming a partial tax coalition between jurisdictions 1 and 2 also depends on the reaction of the nonmember jurisdiction. The response of jurisdiction 3 to the increase in tax levels depends on its productivity level. Thus, jurisdiction 3 mimics the behavior of the tax coalition and also increases its tax rate and infrastructure investment when its productivity is low. Otherwise, when jurisdiction 3's productivity is high, it reacts more aggressively and decreases its tax rate meaning that it attracts more capital from the tax coalition whose formation, therefore, becomes less beneficial. These results are represented in Fig. 1.4 in the (ϵ_2, ϵ_3)-space, where we display the areas under which partial tax harmonization (T) and non-cooperation (N) are the welfare maximization SPNE for the members of the tax coalition.

1.3 Partial tax harmonization with infrastructure coordination

1.3.1 Jurisdiction-specific investments

Now, consider that jurisdictions 1 and 2 form a coalition subgroup which chooses both, a common capital tax rate t_c and the level of infrastructure investments g_1 and g_2 that maximize the joint welfare of this group. This kind of infrastructure coordination allows to internalize the negative externalities of too fierce competition in infrastructure levels observed under both non-cooperation and partial tax harmonization. Such an infrastructure coordination policy is pursued by most of the centralized economies where infrastructure investments in the different regions of the economy are centrally decided. But also in decentralized economies a substantial part of infrastructure investments is decided by the central government. For example, in the US, the federal government is responsible for about 25% of total spending on transportation and water infrastructure where the decision in which state to invest is taken discretionary at the federal level.[22] The objective of this section is to study whether this kind of infrastructure coordination facilitates the formation of a partial tax coalition.

The stage 3 equilibrium tax rates are the same as in the partial tax coordination case and, thus, are given by Eqs. (1.12). In stage 2, jurisdictions 1 and 2 choose g_1 and g_2 to maximize the joint welfare of the coalition. Simultaneously, jurisdiction 3 determines its own level of infrastructure. The following equilibrium infrastructure investment levels are obtained[23]

$$g_1^{TI} = \frac{35}{177} - \frac{27\epsilon_2 + 5\epsilon_3}{59},\ g_2^{TI} = \frac{35}{177} + \frac{32\epsilon_2 - 5\epsilon_3}{59},\ g_3^{TI} = \frac{62}{177} - \frac{4\left(\epsilon_2 - 2\epsilon_3\right)}{59}. \tag{1.16}$$

Substituting Eqs. (1.16) into Eqs. (1.12) yields the SPNE tax rates

$$t_c^{TI} = \frac{56}{59} + \frac{12}{59}\left(\epsilon_2 - 2\epsilon_3\right),\ \ t_3^{TI} = \frac{31}{59} - \frac{6}{59}\left(\epsilon_2 - 2\epsilon_3\right). \tag{1.17}$$

A comparison of equilibrium infrastructure investments in (1.16) and tax rates in (1.17) with the corresponding ones under non-coordination in (1.9) and (1.10), shows that the common tax rate of the tax coalition is above the ones chosen in the non-cooperative case ($t_c^{TI} > t_i^N$, $i = 1, 2$). Moreover, the formation of the tax coalition means lower (higher) infrastructure

[22] See CBO (2015).

[23] Notice that sufficiency is guaranteed as $\frac{\partial^2(W_1+W_2)}{\partial g_1^2} = -\frac{103}{144} < 0$ and $\frac{\partial^2(W_1+W_2)}{\partial g_1^2}\frac{\partial^2(W_1+W_2)}{\partial g_2^2} - \left(\frac{\partial^2(W_1+W_2)}{\partial g_1 \partial g_2}\right)^2 = \frac{67}{144} > 0$.

investment in jurisdiction 2 when the productivity of the jurisdiction outside the coalition is low (high), whereas the infrastructure investment in jurisdiction 1 is always reduced ($g_1^{TI} < g_1^N$ and $g_2^{TI} \lesseqgtr g_2^N$ iff $\epsilon_3 \lesseqgtr \overline{\epsilon}$).[24] Considering Lemma 1, this means that both kinds of inefficiency (too low tax rates and too high infrastructure investments) are reduced inside the tax coalition when the productivity of the jurisdiction outside the coalition is low. Regarding the jurisdiction outside the tax coalition, we find that its behavior crucially depends on its productivity level. When jurisdiction 3's productivity is low it increases its capital tax rate and infrastructure investment. By contrast, when jurisdiction 3's productivity is high, it decreases both of them which, as we have seen before, corresponds to a more aggressive reaction.

On the other hand, a juxtaposition of the coalition's equilibrium capital tax rate in (1.17) and that under partial tax harmonization in (1.14) reveals that the coalition sets a lower capital tax when infrastructure investments are also coordinated by the coalition ($t_c^{TI} < t_c^T$). Moreover, the jurisdiction-specific investment levels chosen by the tax coalition are below those under the partial tax harmonization agreement ($g_i^{TI} < g_i^T$, $i = 1, 2$). The response of jurisdiction 3 to these reductions in tax rates and infrastructure investments is to rise both instruments. To analyze which of these two forms of tax coalition will emerge in equilibrium, we compare the corresponding social welfare levels of the coalition members. Using Eqs. (1.16) and (1.17), social welfare levels under partial tax harmonization with jurisdiction-specific investments are given by[25]

$$\begin{aligned} W_i^{TI} &= \left(\frac{5t_c^{TI}}{4} + \frac{(-1)^i \epsilon_2}{2}\right)\left(\frac{t_c^{TI}}{4} + \frac{(-1)^i \epsilon_2}{2}\right) - \frac{1}{2}\left(\frac{5t_c^{TI}}{24} + \frac{(-1)^i \epsilon_2}{2}\right)^2, \; i = 1, 2, \\ W_3^{TI} &= \frac{16}{9}\left(t_3^{TI}\right)^2. \end{aligned} \tag{1.18}$$

In stage 1, jurisdictions 1 and 2 decide whether or not to cooperate in infrastructure investments. Cooperation will take place when the social welfare of both jurisdictions is higher than in the situation analyzed in the previous section, i.e., non-cooperation and partial tax harmonization, respectively. The following proposition gives the main result of this section.

Proposition 2 *Infrastructure coordination with jurisdiction-specific investments between asymmetric jurisdictions that form a partial tax coalition facilitates (hinders) partial tax harmonization when the productivity level of the jurisdiction outside the coalition is low (high).*

[24] The details are provided in the Appendix.

[25] Notice that the equilibrium values can be written as $g_1^{TI} = \frac{5}{24}t_c^{TI} - \frac{1}{2}\epsilon_2$, $g_2^{TI} = \frac{5}{24}t_c^{TI} + \frac{1}{2}\epsilon_2$, and $g_3^{TI} = \frac{2}{3}t_3^{TI}$.

Equilibria under jurisdiction-specific infrastructure cooperation

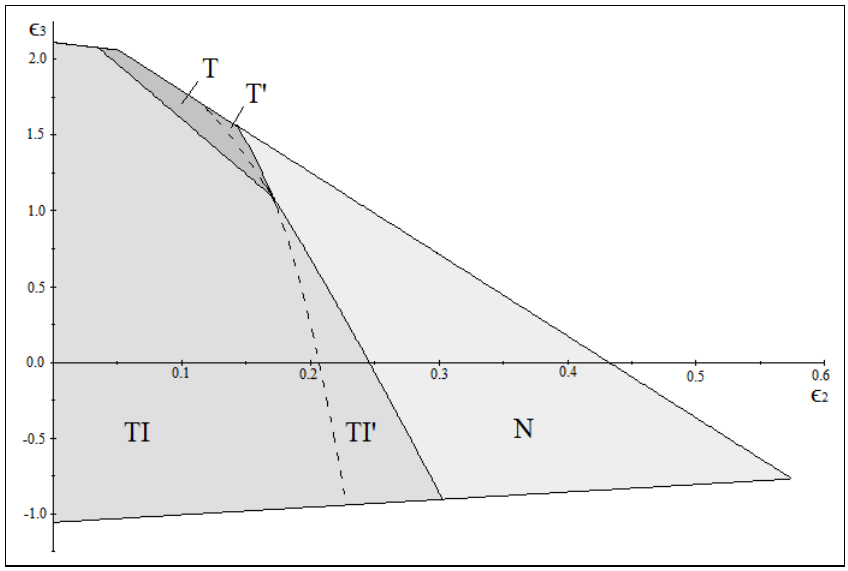

Figure 1.5: Equilibria are: TI, TI' (partial tax harmonization and infrastructure coordination with jurisdiction-specific investments), T, T' (partial tax harmonization), and N (non-cooperation).

A first message from Proposition 2 is that infrastructure coordination allows partial tax harmonization agreements between asymmetric jurisdictions to be reached when this is not possible without the coordination of infrastructure investments. This is the case when the productivity of the coalition non-member is low (see area TI' in Fig. 1.5). The intuition for this result is that infrastructure coordination allows to internalize the negative externality of overinvestment due to infrastructure competition. As a consequence, the joint coordination of tax rates and infrastructure investments avoids the more aggressive competition in infrastructure investments that is observed in the previous case where only tax rates are coordinated, and allows to obtain additional gains for both coalition members.

The second message that emerges from Proposition 2 is, however, that infrastructure coordination does not necessarily facilitate partial tax harmonization (see area T' in 1.5) or makes jurisdiction 1 even worse off compared to partial tax harmonization (see area T in 1.5). This is the case when the members of the tax coalition are rather different in their productivity levels and when the productivity of the non-member is high. The idea underlying this result can be explained as follows. When the productivity of the coalition non-member is high, as seen above, it reacts more aggressively and responds to the capital tax increase of the tax coalition by reducing its capital tax rate. The optimal response of the tax coalition is then to increase the

infrastructure investment in the more productive jurisdiction and to decrease it in the less productive jurisdiction. Accordingly, the difference in infrastructure standards inside the coalition is enlarged such that capital shifts from the less to the more productive jurisdiction. Consequently, it is not attractive for a low productivity jurisdiction to form a tax coalition with infrastructure coordination and it prefers only to harmonize capital taxation.

1.3.2 Common investment level

Finally, consider that jurisdictions 1 and 2 form a coalition subgroup which chooses both a common capital tax rate t_c and a common level of infrastructure investments g_c that maximize the joint welfare of this group. This kind of infrastructure coordination has several advantages. First, as mentioned by Dhillon et al. (1999), policy coordination might fail because of informational asymmetries. Therefore, agreeing upon a common investment level is easier to enforce than having different investment levels. Second, it allows to reduce productivity asymmetries between potential tax coalition partners that are a major handicap for the formation of such a coalition. One way to achieve the coordination of infrastructure investments can be the creation of a common fund which prioritizes investments in those regions that are characterized by lower infrastructure investments which allows to balance overall investment levels.

Such an infrastructure coordination policy is applied, for example, in the EU where structural funds are used to reduce asymmetries in infrastructure investments among EU members. To gauge whether such an infrastructure coordination policy helps facilitating partial tax harmonization, again, we compare social welfare levels of the tax coalition members under such an agreement with those obtained under mere partial tax harmonization.

Next, we solve the stage 2 and stage 3 subgames. Regarding the stage 3 equilibrium tax rates, notice, that they are the same as under partial tax coordination and, thus, are given by Eqs. (1.12). The stage 2 equilibrium infrastructure investments are obtained from maximizing $W_1 + W_2$ with respect to g_c, and W_3 with respect to g_3, respectively, and are given by

$$g_c^{TIC} = \frac{35}{177} + \frac{5\left(\epsilon_2 - 2\epsilon_3\right)}{118}, \;\; g_3^{TIC} = \frac{62}{177} - \frac{4\left(\epsilon_2 - 2\epsilon_3\right)}{59}. \tag{1.19}$$

Substituting Eqs. (1.19) into Eqs. (1.12) yields the SPNE tax rates

$$t_c^{TIC} = \frac{56}{59} + \frac{12}{59}\left(\epsilon_2 - 2\epsilon_3\right), \;\; t_3^{TIC} = \frac{31}{59} - \frac{6}{59}\left(\epsilon_2 - 2\epsilon_3\right). \tag{1.20}$$

Juxtaposing the equilibrium tax rate of the tax coalition in Eq. (1.20) and that of the former case in Eq. (1.17) reveals that the tax coalition chooses the same tax rate under both kind of infrastructure coordination (i.e., $t_c^{TIC} = t_c^{TI}$). In what concerns the equilibrium infrastructure investments, from Eqs. (1.16) and (1.19) we observe, as expected, that the common investment level is situated above (below) that of the less (more) productive member of the tax coalition with jurisdiction-specific investments (i.e., $g_1^{TI} < g_c^{TIC} < g_2^{TI}$).[26] The jurisdiction outside the tax coalition chooses the same capital tax rate and infrastructure investment under both types of infrastructure coordination agreements ($t_3^{TIC} = t_3^{TI}$, $g_3^{TIC} = g_3^{TI}$).

The resulting social welfare functions under partial tax harmonization with infrastructure coordination through a common investment level are[27]

$$\begin{aligned} W_i^{TIC} &= \left(\frac{5}{4}t_c^{TIC} + \frac{(-1)^i}{4}\epsilon_2\right)\left(\frac{1}{4}t_c^{TIC} + \frac{(-1)^i}{4}\epsilon_2\right) - \frac{1}{2}\left(\frac{5}{24}t_c^{TIC}\right)^2, \; i = 1, 2, \\ W_3^{TIC} &= \frac{16}{9}\left(t_3^{TIC}\right)^2. \end{aligned} \tag{1.21}$$

In stage 1, jurisdictions 1 and 2 form a tax coalition when both of them obtain higher social welfare than in the non-cooperation and partial tax harmonization cases (N and T, respectively). The following result elucidates the circumstances under which each type of agreement is the equilibrium outcome.

Proposition 3 *Infrastructure coordination through the choice of a common investment between asymmetric jurisdictions that form a partial tax coalition makes both members better off than under non-cooperation. When the productivity level of the jurisdiction outside the coalition is high, jurisdiction* 2 *prefers the mere harmonization of tax rates.*

As observed in Proposition 1, a major handicap to the formation of a tax coalition is the productivity asymmetry between its members (see also Keen and Konrad, 2013). Agreeing upon a common investment level allows the tax coalition members reducing this asymmetry because, as seen above, the more productive member reduces its infrastructure investment while the less productive one increases it. This equalization of productivity levels reduces the capital flows inside the tax coalition from the less productive to the more productive member which allows

[26] As $t_c^{TIC} = t_c^{TI}$, this can be easily observed from Eqs. (1.16) and (1.19) by writing $g_1^{TI} = \frac{5}{24}t_c^{TI} - \frac{1}{2}\epsilon_2 < \frac{5}{24}t_c^{TIC} = g_c^{TIC}$, and $g_2^{TI} = \frac{5}{24}t_c^{TI} + \frac{1}{2}\epsilon_2 > \frac{5}{24}t_c^{TIC} = g_c^{TIC}$.

[27] Notice that equilibrium values of infrastructure investments can be written as $g_c^{TIC} = \frac{5}{24}t_c^{TIC}$, and $g_3^{TIC} = \frac{2}{3}t_3^{TIC}$.

to achieve the harmonization of tax rates that would otherwise not be in the interest of both members (see area TIC' in 1.6). However, with a high productivity competitor outside the tax coalition, the welfare cost in terms of total capital outflows imposed on the more productive member makes him to prefer not to coordinate infrastructure investments (see area T in 1.6).

Equilibria under the choice of a common infrastructure cooperation

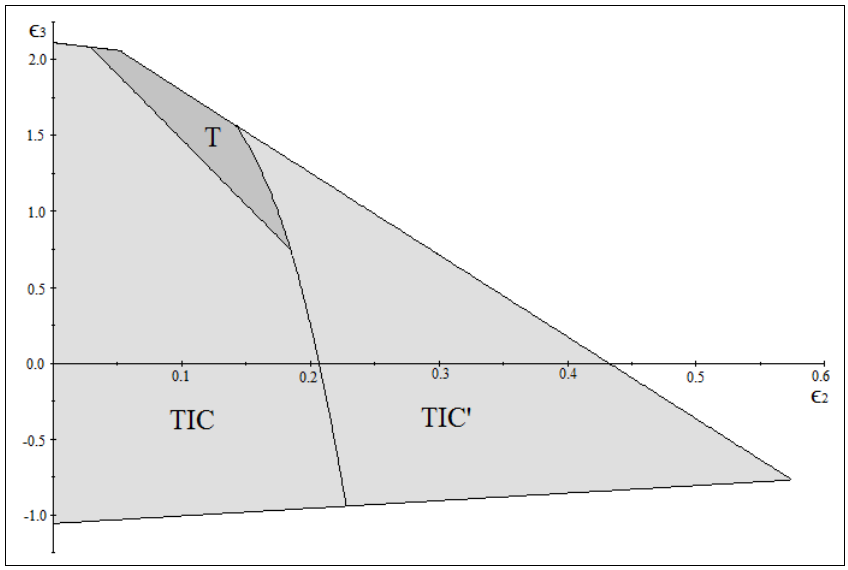

Figure 1.6: Equilibria are: TIC, TIC' (partial tax harmonization and infrastructure coordination through the choice of a common investment level), and T (partial tax harmonization).

As a major difference between infrastructure coordination through a common investment level and with jurisdiction-specific investments we observe that while the former agreement particularly benefits the less productive jurisdiction, the latter benefits the more productive one. Regarding the overall capability of both infrastructure coordination agreements in facilitating (partial) tax harmonization we obtain the following result.

Proposition 4 *Infrastructure coordination through the choice of a common investment level allows partial tax harmonization between asymmetric jurisdictions that cannot be achieved by infrastructure coordination with jurisdiction-specific investments.*

Proposition 4 is appreciated immediately by comparing areas TI' and TIC' in Figs. 1.5 and 1.6, respectively. As the coalition chooses the same common tax rate in both cases, the intuition for this result lies in the difference between the infrastructure investments chosen under the two agreements. The common investment agreement allows to reduce asymmetries between coalition members more than the jurisdiction-specific investment. Thus, it enables the formation of a tax

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coalition for a larger range of productivity asymmetries between coalition members than under infrastructure coordination with jurisdiction-specific investments.

1.4 Conclusions

Tax harmonization has become an important concern in most developed economies because tax competition has constantly decreased capital tax rates over recent decades and has led to a shift of the tax burden from capital towards labor. As the global harmonization of capital taxation is unlikely to be achieved, the literature has focused on the conditions that allow tax harmonization in a coalition of countries. In this chapter we analyze how such a partial tax harmonization is influenced by a simultaneous coordination of infrastructure investments. Two kinds of infrastructure coordination are considered: infrastructure coordination with jurisdiction-specific investments and through the choice of a common investment level. We obtain that infrastructure coordination can facilitate partial tax harmonization. This is the case when the coalition partners are not too different in their productivity levels. Furthermore, we find that infrastructure coordination with a common investment level enables partial tax harmonization even when asymmetries between coalition members are substantial. This result indicates that the EU structural funds policy can contribute to achieve tax harmonization as intended by the EU.

The results imply that, as asymmetries between jurisdictions are an important handicap to accomplish tax harmonization, a primary objective of policy makers that want to achieve a voluntary harmonization of capital taxation should be to reduce these asymmetries. The coordination of infrastructure investments can be an instrument to carry out this objective. The analysis has shown that even a reduction of public infrastructure investments in some jurisdictions can be welfare enhancing for all coalition members when this finally leads to an harmonization of tax rates in the tax coalition.

As the analysis is based on a highly stylized model, some final comments regarding the robustness of the results are indicated. First, we have considered a three-jurisdiction model. However, our main results can be generalized straightforwardly to the case in which we have more jurisdictions. Naturally, tax harmonization will be more difficult to achieve with more jurisdictions inside the tax coalition. Similarly, it will also become more difficult to form a tax coalition with more jurisdictions outside the tax coalition because, then, competition will be more fierce. Our result that asymmetries between its members will further difficult the formation of the

tax coalition and that infrastructure coordination can facilitate tax harmonization, however, will prevail under these circumstances. Second, we have assumed that tax rates and infrastructure investments are chosen sequentially. With the simultaneous choice of both instruments tax harmonization in our model is still welfare enhancing but to a less extent.[28] Third, our focus is on voluntary tax harmonization in a subgroup of countries. If countries pursue other objectives, the equalization of infrastructure investments might not be a desirable policy. Fourth, we have not explicitly allowed for side-payments between jurisdictions. From the results in Section 1.3.1 it is immediate that in such a case the optimal solution consists in combining jurisdiction-specific investments with side-payments to the less productive jurisdiction. However, the negotiation of these payments among a larger group of countries might be difficult to achieve in practice. Finally, it should be noticed that EU structural funds only affect *hard infrastructure* investments (roads, bridges, tunnels, water supply, sewers, electrical grids, telecommunications, ...) while differences in productivity levels also and perhaps even more importantly stem from differences in *soft infrastructure* that refer to standards, education systems, health systems, regulations, or law. Therefore, asymmetries in soft investments also present a handicap for tax harmonization and their reduction should be in the focus of a policy that aims to facilitate capital tax harmonization. Of course, such a 'total infrastructure coordination' is more difficult to realize or might even not be desirable for other reasons which also explains why in practice the partial harmonization of tax rates is so difficult to achieve.

The analysis also opens up interesting lines for further research. Thus, it could be complemented by considering other forms of public tax decision making. For example, as in Borck (2003) the choice of the tax structure could be considered in a majority voting model in which jurisdictions compete in tax rates. Finally, our analysis is based on a horizontal coordination of tax rates and infrastructure levels. As tax decisions are taken both at the state level and at regional and local levels, it would be interesting to analyze how the interplay of horizontal and vertical coordination of tax rates and infrastructure levels would affect our results.

[28]This result is in line with Han et al. (2017) who find that when decisions are taken simultaneously (global) tax harmonization is less beneficial or even welfare reducing. The detailed results for the case of simultaneous tax rate and infrastructure investment choice within our model can be obtained upon request from the authors.

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Appendix

Proof of Lemma 1. Suppose all jurisdictions increase tax rates by an amount λ, $\lambda > 0$. Then welfare becomes:

$$W_i(t_i^N + \lambda, t_j^N + \lambda, t_h^N + \lambda, g_i^N, g_j^N, g_h^N) = \frac{130}{81}\left(t_i^N\right)^2 + \lambda t_i^N > W_i(t_i^N, t_j^N, t_h^N, g_i^N, g_j^N, g_h^N)$$

which proves that a joint tax increase by all jurisdictions increases welfare compared to the non-cooperation case (N). As the provision of public goods equals tax revenues, $t_i k_i$ and k_i does not change when all jurisdictions increase tax rates by the same amount, it follows immediately that public goods provision is too low. Finally, consider a reduction of infrastructure investments of the amount μ in all jurisdictions ($0 < \mu < g_i^N, \forall i$). Then welfare becomes:

$$W_i(t_i^N, t_j^N, t_h^N, g_i^N - \mu, g_j^N - \mu, g_h^N - \mu) = \frac{130}{81}\left(t_i^N\right)^2 + \left(g_i^N - \frac{1}{2}\mu\right)\mu > W_i(t_i^N, t_j^N, t_h^N, g_i^N, g_j^N, g_h^N)$$

which proves the last statement.

■

Proof of Proposition 1. i) The first statement follows from a comparison of Eqs. (1.10) and (1.14), and (1.9) and (1.13), respectively, which yields

$$\begin{aligned} t_c^T - t_1^N &= \frac{11}{15} + \frac{257}{665}\epsilon_2 - \frac{199}{665}\epsilon_3 > 0, \quad t_c^T - t_2^N = \frac{11}{15} - \frac{58}{665}\epsilon_2 - \frac{199}{665}\epsilon_3 > 0, \\ g_1^T - g_1^N &= \frac{29}{135} - \frac{20}{399}\epsilon_2 - \frac{157}{1995}\epsilon_3 > 0, \quad g_2^T - g_2^N = \frac{29}{135} + \frac{257}{1995}\epsilon_2 - \frac{157}{1995}\epsilon_3 > 0 \end{aligned}$$

for $\forall\,(\epsilon_2, \epsilon_3) \in R$. From Eqs. (1.11) and (1.15) we have

$$\begin{aligned} \Delta W_2^{T-N}(\epsilon_2, \epsilon_3) \equiv\ & W_2^T - W_2^N = \frac{1699}{36\,450} + \frac{61\,527}{884\,450}\epsilon_2^2 + \frac{13\,207}{53\,865}\epsilon_2 \\ & - \frac{23\,837}{265\,335}\epsilon_2\epsilon_3 + \frac{3457}{2653\,350}\epsilon_3^2 - \frac{6427}{269\,325}\epsilon_3 \end{aligned}$$

> 0 for $\forall(\epsilon_2, \epsilon_3) \in R$. Jurisdiction 2 is always better off under partial tax harmonization. Regarding jurisdiction 1, from Eqs. (1.11) and (1.15) we have

$$\begin{aligned} \Delta W_1^{T-N}(\epsilon_2, \epsilon_3) \equiv\ & W_1^T - W_1^N = \frac{1\,699}{36\,450} - \frac{25\,166}{1\,326\,675}\epsilon_2^2 - \frac{59\,608}{269\,325}\epsilon_2 \\ & + \frac{38\,576}{442\,225}\epsilon_2\epsilon_3 + \frac{3\,457}{2\,653\,350}\epsilon_3^2 - \frac{6\,427}{269\,325}\epsilon_3 \end{aligned}$$

with $\Delta W_1^{T-N}(0,0) = 0.0466 > 0$, $\Delta W_1^{T-N}(\frac{95}{252},0) = -0.0395 < 0$ and $\partial \Delta W_1^{T-N}/\partial \epsilon_2 = 0.0872\epsilon_3 - 0.0379\epsilon_2 - 0.2213 < 0$ for $\forall(\epsilon_2,\epsilon_3)\epsilon R$. Thus, there is a unique function $f_{T-N}(\epsilon_2) = \frac{854\,791}{93\,339} - \frac{266}{93\,339}\sqrt{139\,780\,647\epsilon_2^2 - 54\,580\,500\epsilon_2 + 5921\,500} - \frac{115\,728}{3457}\epsilon_2$ defined by $\Delta W_1^{T-N}(\epsilon_2,\epsilon_3) = 0$ which separates R in two areas (displayed in Fig. 4) with $\Delta W_1^{T-N}(\epsilon_2,\epsilon_3) > 0$ for $\epsilon_2 < f_{T-N}(\epsilon_2)$ and $\Delta W_1^{T-N}(\epsilon_2,\epsilon_3) < 0$ for $\epsilon_2 > f_{T-N}(\epsilon_2)$. Finally, notice that

$$\Delta W_2^{T-N}(\epsilon_2,\epsilon_3) - \Delta W_1^{T-N}(\epsilon_2,\epsilon_3) = \left(\frac{33\,559}{379\,050}\epsilon_2 - \frac{33\,559}{189\,525}\epsilon_3 + \frac{5983}{12\,825}\right)\epsilon_2 > 0$$

for $\forall(\epsilon_2,\epsilon_3) \in R$. Thus, the welfare gains from partial tax harmonization are larger for jurisdiction 2. ii) The second statement follows from a comparison of Eqs. (1.10) and (1.14), and (1.9) and (1.13), respectively, which yields

$$\begin{aligned} t_3^T - t_3^N &= \frac{2}{15} + \frac{29}{665}\epsilon_2 - \frac{58}{665}\epsilon_3 \gtreqless 0 \quad \text{for } \epsilon_3 \lesseqgtr \frac{133}{87} + \frac{1}{2}\epsilon_2, \\ g_3^T - g_3^N &= \frac{2}{135} + \frac{128}{1995}\epsilon_2 - \frac{256}{1995}\epsilon_3 \gtreqless 0 \quad \text{for } \epsilon_3 \lesseqgtr \frac{133}{1152} + \frac{1}{2}\epsilon_2. \end{aligned}$$

■

Proof of the results in Section 1.3.1. From Eqs. (1.10) and (1.17), we observe that

$$\begin{aligned} t_c^{TI} - t_1^N &= \frac{109}{177} + \frac{405}{1121}\epsilon_2 - \frac{279}{1121}\epsilon_3 > 0 \text{ for } \forall(\epsilon_2,\epsilon_3) \in R, \\ t_c^{TI} - t_2^N &= \frac{109}{177} - \frac{126}{1121}\epsilon_2 - \frac{279}{1121}\epsilon_3 > 0 \text{ for } \forall(\epsilon_2,\epsilon_3) \in R, \\ t_3^{TI} - t_3^N &= \frac{34}{177} + \frac{63}{1121}\epsilon_2 - \frac{126}{1121}\epsilon_3 \gtreqless 0 \quad \text{for } \epsilon_3 \lesseqgtr \frac{323}{189} + \frac{1}{2}\epsilon_2 \end{aligned}$$

and from Eqs. (1.9) and (1.16) that

$$\begin{aligned} g_1^{TI} - g_1^N &= -\frac{157}{1593} - \frac{1067}{3363}\epsilon_2 + \frac{187}{3363}\epsilon_3 < 0 \quad \text{for } \forall(\epsilon_2,\epsilon_3) \in R, \\ g_2^{TI} - g_2^N &= -\frac{157}{1593} + \frac{880}{3363}\epsilon_2 + \frac{187}{3363}\epsilon_3 \gtreqless 0 \quad \text{for } \epsilon_3 \lesseqgtr \frac{2983}{1683} - \frac{80}{17}\epsilon_2, \\ g_3^{TI} - g_3^N &= \frac{86}{1593} + \frac{244}{3363}\epsilon_2 - \frac{488}{3363}\epsilon_3 \gtreqless 0 \quad \text{for } \epsilon_3 \lesseqgtr \frac{817}{2196} + \frac{1}{2}\epsilon_2. \end{aligned}$$

Finally, a comparison of Eqs. (1.14) and (1.17) reveals that

$$t_c^{TI} - t_c^T = -\frac{104}{885} - \frac{52}{2065}\epsilon_2 + \frac{104}{2065}\epsilon_3 < 0,\ t_3^{TI} - t_3^T = \frac{52}{885} + \frac{26}{2065}\epsilon_2 - \frac{52}{2065}\epsilon_3 > 0$$

and of Eqs. (1.13) and (1.16) that

$$\begin{aligned} g_1^{TI} - g_1^T &= -\frac{832}{2655} - \frac{331}{1239}\epsilon_2 + \frac{832}{6195}\epsilon_3 < 0,\ g_2^{TI} - g_2^T = -\frac{832}{2655} + \frac{823}{6195}\epsilon_2 + \frac{832}{6195}\epsilon_3 < 0, \\ g_3^{TI} - g_3^T &= \frac{104}{2655} + \frac{52}{6195}\epsilon_2 - \frac{104}{6195}\epsilon_3 > 0 \end{aligned}$$

for $\forall(\epsilon_2, \epsilon_3) \in R$. ■

Proof of Proposition 2. First, consider jurisdiction 2. We have

$$\begin{aligned} \Delta W_2^{TI-T}(\epsilon_2, \epsilon_3) \equiv\ & W_2^{TI} - W_2^T = \frac{5951\,819}{153\,512\,100}\epsilon_2^2 - \frac{467\,779}{7675\,605}\epsilon_2\epsilon_3 + \frac{467\,779}{3289\,545}\epsilon_2 \\ & + \frac{261\,092}{38\,378\,025}\epsilon_3^2 - \frac{522\,184}{16\,447\,725}\epsilon_3 + \frac{261\,092}{7049\,025} > 0 \end{aligned}$$

for $\forall(\epsilon_2, \epsilon_3) \in R$. Jurisdiction 2 is always better off under partial tax harmonization with jurisdiction-specific investments (TI) than under partial tax harmonization (T) (and under non-cooperation (N), as already shown in the proof of Proposition 1).

Second, for jurisdiction 1 we have

$$\begin{aligned} \Delta W_1^{TI-T}(\epsilon_2, \epsilon_3) \equiv\ & W_1^{TI}(\epsilon_2, \epsilon_3) - W_1^T(\epsilon_2, \epsilon_3) \\ =\ & -\frac{2359\,393}{153\,512\,100}\epsilon_2^2 + \frac{1816\,711}{38\,378\,025}\epsilon_2\epsilon_3 - \frac{1816\,711}{16\,447\,725}\epsilon_2 \\ & + \frac{261\,092}{38\,378\,025}\epsilon_3^2 - \frac{522\,184}{16\,447\,725}\epsilon_3 + \frac{261\,092}{7049\,025} \end{aligned}$$

with $\Delta W_1^{TI-T}(0,0) = 0.0370 > 0$, $\Delta W_1^{TI-T}(\frac{95}{252}, 0) = -0.0068 < 0$ and $\partial\Delta W_1^{T-N}/\partial\epsilon_2 = 0.0473\epsilon_3 - 0.0307\epsilon_2 - 0.1105 < 0$ for $\forall(\epsilon_2, \epsilon_3)\epsilon R$. Thus, there is a unique function $f_{TI-T}(\epsilon_2) = \frac{7}{3} - \frac{548\,877}{522\,184}\sqrt{13}\epsilon_2 - \frac{139\,747}{40\,168}\epsilon_2$ defined by $\Delta W_1^{TI-T}(\epsilon_2, \epsilon_3) = 0$ which separates R in two areas with $\Delta W_1^{TI-T}(\epsilon_2, \epsilon_3) > 0$ for $\epsilon_2 < f_{TI-T}(\epsilon_2)$ and $\Delta W_1^{TI-T}(\epsilon_2, \epsilon_3) < 0$ for $\epsilon_2 > f_{TI-T}(\epsilon_2)$. Furthermore, we have

$$\begin{aligned} \Delta W_1^{TI-N}(\epsilon_2, \epsilon_3) \equiv\ & W_1^{TI}(\epsilon_2, \epsilon_3) - W_1^N(\epsilon_2, \epsilon_3) \\ =\ & -\frac{1553\,449}{45\,239\,076}\epsilon_2^2 + \frac{1521\,943}{11\,309\,769}\epsilon_2\epsilon_3 - \frac{1777\,417}{5357\,259}\epsilon_2 \\ & + \frac{183\,355}{22\,619\,538}\epsilon_3^2 - \frac{297\,925}{5357\,259}\epsilon_3 + \frac{424\,555}{5075\,298} \end{aligned}$$

with $\Delta W_1^{TI-N}(0,0) = 0.0837 > 0$, $\Delta W_1^{TI-N}(\frac{95}{252}, 0) = -0.0463 < 0$ and $\partial\Delta W_1^{T-N}/\partial\epsilon_2 = 0.1346\epsilon_3 - 0.0687\epsilon_2 - 0.3318 < 0$ for $\forall(\epsilon_2, \epsilon_3)\epsilon R$. Thus, there is a unique function $f_{TI-N}(\epsilon_2) =$

$\frac{113115}{330039} - \frac{1521943}{183355}\epsilon_2 - \frac{1121}{1100130}\sqrt{2}\sqrt{35218557\epsilon_2^2 - 7712640\epsilon_2 + 696800}$ defined by $\Delta W_1^{TI-N}(\epsilon_2, \epsilon_3) = 0$ which separates R in two areas with $\Delta W_1^{TI-N}(\epsilon_2, \epsilon_3) > 0$ for $\epsilon_2 < f_{TI-N}(\epsilon_2)$ and $\Delta W_1^{TI-N}(\epsilon_2, \epsilon_3) < 0$ for $\epsilon_2 > f_{TI-N}(\epsilon_2)$.

Finally, notice that functions $f_{T-N}(\epsilon_2)$, $f_{TI-N}(\epsilon_2)$ and $f_{TI-T}(\epsilon_2)$ have a single intersection point in R at $(\epsilon_2, \epsilon_3) = (0.1711, 1.0892)$ which separates R in five areas (displayed in Fig. 5):

1. Area TI: $(\epsilon_2 < f_{TI-T}(\epsilon_2)$ and $\epsilon_2 < f_{T-N}(\epsilon_2))$ where $W_i^{TI}(\epsilon_2, \epsilon_3) > W_i^N(\epsilon_2, \epsilon_3)$ and $W_i^{TI}(\epsilon_2, \epsilon_3) > W_i^T(\epsilon_2, \epsilon_3)$, $i = 1, 2$, such that the equilibrium outcome is TI which is preferred by all jurisdictions.

2. Area TI': $(f_{T-N}(\epsilon_2) < \epsilon_2 < f_{TI-N}(\epsilon_2))$ where $W_i^{TI}(\epsilon_2, \epsilon_3) > W_i^N(\epsilon_2, \epsilon_3)$ and $W_i^{TI}(\epsilon_2, \epsilon_3) > W_i^T(\epsilon_2, \epsilon_3)$, $i = 1, 2$, such that the equilibrium outcome is also TI which is preferred by all jurisdictions.

3. Area T: $(f_{TI-T}(\epsilon_2) < \epsilon_2 < f_{TI-N}(\epsilon_2))$ where $W_1^T(\epsilon_2, \epsilon_3) > W_1^{TI}(\epsilon_2, \epsilon_3)$, $W_2^{TI}(\epsilon_2, \epsilon_3) > W_2^T(\epsilon_2, \epsilon_3)$ and $W_i^T(\epsilon_2, \epsilon_3) > W_i^N(\epsilon_2, \epsilon_3)$, $i = 1, 2$. The equilibrium outcome is T as jurisdiction 1 does not agree to coordinate infrastructure investments which is the preferred outcome for jurisdiction 2.

4. Area T': $(f_{TI-N}(\epsilon_2) < \epsilon_2 < f_{T-N}(\epsilon_2))$ where $W_1^T(\epsilon_2, \epsilon_3) > W_1^{TI}(\epsilon_2, \epsilon_3)$, $W_2^{TI}(\epsilon_2, \epsilon_3) > W_2^T(\epsilon_2, \epsilon_3)$ and $W_i^T(\epsilon_2, \epsilon_3) > W_i^N(\epsilon_2, \epsilon_3)$, $i = 1, 2$. Again, the equilibrium outcome is T as jurisdiction 1 does not agree to coordinate infrastructure investments which is the preferred outcome for jurisdiction 2.

5. Area N: $(\epsilon_2 > f_{T-N}(\epsilon_2)$ and $\epsilon_2 > f_{TI-N}(\epsilon_2))$ where $W_1^N(\epsilon_2, \epsilon_3) > W_1^{TI}(\epsilon_2, \epsilon_3)$, $W_1^N(\epsilon_2, \epsilon_3) > W_1^T(\epsilon_2, \epsilon_3)$. The equilibrium outcome is N as jurisdiction 1 loses from both partial tax harmonization (T) and partial tax harmonization with infrastructure coordination where investments are jurisdiction-specific (TI).

■

Proof of Proposition 3. First, consider jurisdiction 1. From Eqs. (1.11), (1.15) and (1.21) we have that jurisdiction 1 is always better off under partial tax harmonization with infrastructure coordination through the choice of a common investment level (TIC) than under

non-cooperation (N) and partial tax harmonization (T):

$$\begin{aligned}\Delta W_1^{TIC-N}(\epsilon_2,\epsilon_3) &\equiv W_1^{TIC}-W_1^N=\frac{424\,555}{5075\,298}-\frac{7555\,633}{180\,956\,304}\epsilon_2^2-\frac{800\,537}{10\,714\,518}\epsilon_2\\ &+\frac{551\,903}{22\,619\,538}\epsilon_2\epsilon_3+\frac{183\,355}{22\,619\,538}\epsilon_3^2-\frac{297\,925}{5357\,259}\epsilon_3>0,\\ \Delta W_1^{TIC-T}(\epsilon_2,\epsilon_3) &\equiv W_1^{TIC}-W_1^T=\frac{261\,092}{7049\,025}-\frac{13\,990\,897}{614\,048\,400}\epsilon_2^2+\frac{4822\,753}{32\,895\,450}\epsilon_2\\ &-\frac{4822\,753}{76\,756\,050}\epsilon_2\epsilon_3+\frac{261\,092}{38\,378\,025}\epsilon_3^2-\frac{522\,184}{16\,447\,725}\epsilon_3>0\end{aligned}$$

for $\forall(\epsilon_2,\epsilon_3)\in R$. Second, consider jurisdiction 2. From Eqs. (1.11) and (1.21) we have that jurisdiction 2 is always better off under partial tax harmonization with infrastructure coordination through the choice of a common investment level (TIC) than under non-cooperation (N)

$$\begin{aligned}\Delta W_2^{TIC-N}(\epsilon_2,\epsilon_3) &\equiv W_2^{TIC}-W_2^N=\frac{424\,555}{5075\,298}-\frac{1673\,569}{180\,956\,304}\epsilon_2^2+\frac{1396\,387}{10\,714\,518}\epsilon_2\\ &-\frac{918\,613}{22\,619\,538}\epsilon_2\epsilon_3+\frac{183\,355}{22\,619\,538}\epsilon_3^2-\frac{297\,925}{5357\,259}\epsilon_3>0\end{aligned}$$

for $\forall(\epsilon_2,\epsilon_3)\in R$. Thus, as both jurisdictions are better off under TIC than under N, non-cooperation (N) is not an equilibrium. Furthermore, from Eqs. (1.15) and (1.21) we have

$$\begin{aligned}\Delta W_2^{TIC-T}(\epsilon_2,\epsilon_3) &\equiv W_2^{TIC}-W_2^T=\frac{261\,092}{7049\,025}-\frac{48\,395\,449}{614\,048\,400}\epsilon_2^2-\frac{755\,677}{6579\,090}\epsilon_2\\ &+\frac{755\,677}{15\,351\,210}\epsilon_2\epsilon_3+\frac{261\,092}{38\,378\,025}\epsilon_3^2-\frac{522\,184}{16\,447\,725}\epsilon_3\end{aligned}$$

with $\Delta W_2^{TIC-T}(0,0)=0.0371>0$, $\Delta W_2^{TIC-T}(\frac{95}{252},0)=-0.0175<0$ and $\partial\Delta W_2^{TIC-T}/\partial\epsilon_2=0.0492\epsilon_3-0.15763\epsilon_2-0.11486<0$ for $\forall(\epsilon_2,\epsilon_3)\epsilon R$. Thus, there is a unique function $f_{TIC-T}(\epsilon_2)=\frac{7}{3}-\frac{1239}{1044\,368}\sqrt{13}\sqrt{1348\,521}\epsilon_2-\frac{290\,645}{80\,336}\epsilon_2$ defined by $\Delta W_2^{TIC-T}(\epsilon_2,\epsilon_3)=0$ which separates R in two areas with $\Delta W_2^{TIC-T}(\epsilon_2,\epsilon_3)>0$ for $\epsilon_2<f_{TIC-T}(\epsilon_2)$ and $\Delta W_2^{TIC-T}(\epsilon_2,\epsilon_3)<0$ for $\epsilon_2>f_{TIC-T}(\epsilon_2)$.

Finally, notice that functions $f_{T-N}(\epsilon_2)$ and $f_{TIC-T}(\epsilon_2)$ separate R in three areas (displayed in Fig. 6):

1. Area TIC: ($\epsilon_2<f_{TIC-T}(\epsilon_2)$ and $\epsilon_2<f_{T-N}(\epsilon_2)$) where $W_i^{TIC}(\epsilon_2,\epsilon_3)>W_i^T(\epsilon_2,\epsilon_3)>W_i^N(\epsilon_2,\epsilon_3)$, $i=1,2$ such that the equilibrium outcome is TIC which is preferred by all jurisdictions to T and N.

2. Area TIC': $(\ \epsilon_2 > f_{T-N}(\epsilon_2))$ where $W_1^{TIC}(\epsilon_2, \epsilon_3) > W_1^N(\epsilon_2, \epsilon_3) > W_1^T(\epsilon_2, \epsilon_3)$, and $W_2^{TIC}(\epsilon_2, \epsilon_3) > W_2^N(\epsilon_2, \epsilon_3)$. The equilibrium outcome is TIC as both jurisdictions are better off under this agreement than under non-cooperation which is the equilibrium outcome in the benchmark (see Proposition 1).

3. Area T: $(f_{TIC-T}(\epsilon_2) < \epsilon_2 < f_{T-N}(\epsilon_2))$ where $W_i^T(\epsilon_2, \epsilon_3) > W_i^N(\epsilon_2, \epsilon_3)$, $i = 1, 2$, $W_1^{TIC}(\epsilon_2, \epsilon_3) > W_1^T(\epsilon_2, \epsilon_3)$, and $W_2^T(\epsilon_2, \epsilon_3) > W_2^{TIC}(\epsilon_2, \epsilon_3)$. The equilibrium outcome is T as jurisdiction 2 does not agree to coordinate infrastructure investments which is the preferred outcome for jurisdiction 1.

■

Supplementary material

Relevant region

Given that $g_i^N = \frac{8}{9}t_i^N$ and $k_i^N = t_i^N$, and from the discussion in Section 1.2.1 we observe that sufficient conditions for positive equilibrium values in the non-cooperative case are that the tax rates in jurisdictions 1 and 3 are positive ($t_1^N > 0$, $t_3^N > 0$) which is guaranteed by

$$\frac{1}{2}\epsilon_2 - \frac{19}{18} < \epsilon_3 < \frac{19}{9} - \epsilon_2. \tag{1.22}$$

Regarding the equilibrium values under partial tax harmonization, from Proposition 1 we know that $t_c^T > t_i^N$ and $g_i^T > g_i^N$ for $i = 1, 2$. Noticing that $g_3^T = \frac{2}{3}t_3^T$, $k_1^T = \frac{1}{4}t_c^T - \frac{2}{5}\epsilon_2$, $k_2^T = \frac{1}{4}t_c^T + \frac{2}{5}\epsilon_2$, and $k_3^T = t_3^T$ sufficient conditions for positive equilibrium values are that $t_3^T > 0$ and $k_1^T > 0$ which is guaranteed by

$$\frac{1}{2}\epsilon_2 - \frac{31}{12} < \epsilon_3 < \frac{7}{3} - \frac{53}{12}\epsilon_2. \tag{1.23}$$

Now, consider partial tax harmonization with infrastructure coordination and jurisdiction-specific investments. The discussion in Section 1.3.1 has shown that $t_c^{TI} > t_i^N$ for $i = 1, 2$, $t_3^{TI} > t_3^T$ and $g_3^{TI} > g_3^T$. Using $g_1^{TI} = \frac{5}{24}t_c^{TI} - \frac{1}{2}\epsilon_2$, $g_2^{TI} = \frac{5}{24}t_c^{TI} + \frac{1}{2}\epsilon_2$, $k_1^{TI} = \frac{1}{4}t_c^{TI} - \frac{1}{2}\epsilon_2$, $k_2^{TI} = \frac{1}{4}t_c^{TI} + \frac{1}{2}\epsilon_2$, and $k_3^{TI} = t_3^{TI}$ sufficient conditions for positive equilibrium values are $g_1^{TI} > 0$ and $k_1^{TI} > 0$. This is guaranteed by

$$\epsilon_3 < \min\left\{\frac{7}{3} - \frac{27}{5}\epsilon_2, \frac{7}{3} - \frac{53}{12}\epsilon_2\right\}. \tag{1.24}$$

Finally, consider partial tax harmonization with infrastructure coordination through the choice of a common investment level. As the equilibrium tax rates are the same as in the former case, $g_1^{TIC} > g_1^{TI}$ and $g_3^{TIC} > g_3^{TI}$ a sufficient condition for positive equilibrium values is that $k_1^{TIC} > 0$ which corresponds to

$$\epsilon_3 < \frac{7}{3} - \frac{47}{24}\epsilon_2. \tag{1.25}$$

A comparison of Eqs. (1.22)-(1.25) yields, that the binding restrictions that guarantee positive equilibrium values for all cases are

$$\frac{1}{2}\epsilon_2 - \frac{19}{18} < \epsilon_3 < \min\left\{\frac{19}{9} - \epsilon_2, \frac{7}{3} - \frac{27}{5}\epsilon_2\right\}$$

which corresponds to $t_1^N > 0$, $t_3^N > 0$ and $g_1^{TI} > 0$.

Simultaneous choice of instruments

Non-cooperative equilibrium

The equilibrium values in this case are obtained from solving the following maximization problems:

$$\begin{aligned}\max_{t_i,g_i} W_i\left(t_i,g_i\right) &= \left(\frac{1}{3}+\frac{(2\epsilon_i-\epsilon_j-\epsilon_h)+(2g_i-g_j-g_h)-(2t_i-t_j-t_h)}{6}\right)^2 \\ &\quad +t_i\left(\frac{1}{3}+\frac{(2\epsilon_i-\epsilon_j-\epsilon_h)+(2g_i-g_j-g_h)-(2t_i-t_j-t_h)}{6}\right)-g_i^2/2.\end{aligned}$$

This yields the following first-order conditions:

$$\begin{aligned}\frac{\partial W_i}{\partial t_i} &= \frac{1}{3}\left(\frac{1}{3}+\frac{(2\epsilon_i-\epsilon_j-\epsilon_h)+(2g_i-g_j-g_h)-(2t_i-t_j-t_h)}{6}\right)-\frac{1}{3}t_i=0, \\ \frac{\partial W_i}{\partial g_i} &= \frac{2}{3}\left(\frac{1}{3}+\frac{(2\epsilon_i-\epsilon_j-\epsilon_h)+(2g_i-g_j-g_h)-(2t_i-t_j-t_h)}{6}\right)+\frac{1}{3}t_i-g_i=0.\end{aligned}$$

The equilibrium values are:

$$t_i^{N,S}=g_i^{N,S}=\left(\frac{1}{3}+\frac{(2\epsilon_i-\epsilon_j-\epsilon_h)}{6}\right),$$

and the equilibrium welfare levels are:

$$W_i^{N,S}\left(t_i,g_i\right)=\frac{1}{24}\left(2+2\epsilon_i-\epsilon_j-\epsilon_h\right)^2$$

such that $W_1^{N,S}<W_2^{N,S}$.

Partial tax harmonization

The equilibrium values in this case are obtained from solving the following maximization problems:

$$\max_{t_c} W_1\left(t_c,g_1\right)+W_2\left(t_c,g_2\right),\ \max_{g_1} W_1\left(t_c,g_1\right),\ \max_{g_2} W_2\left(t_c,g_2\right),\ \max_{t_3,g_3} W_3\left(t_3,g_3\right).$$

This yields the following first-order conditions:

$$\partial\frac{W_1+W_2}{\partial t_c} = \frac{1}{9}\left(\epsilon_2-2\epsilon_3+g_1+g_2-2g_3+2t_3-5t_c+4\right)=0,$$

$$\begin{aligned}
\partial\frac{W_1}{\partial g_1} &= -\frac{1}{9}\left(\epsilon_2+\epsilon_3+7g_1+g_2+g_3-t_3-2t_c-2\right)=0,\\
\partial\frac{W_2}{\partial g_2} &= \frac{1}{9}\left(2\epsilon_2-\epsilon_3-g_1-7g_2-g_3+t_3+2t_c+2\right)=0,\\
\partial\frac{W_3}{\partial t_3} &= -\frac{1}{18}\left(\epsilon_2-2\epsilon_3+g_1+g_2-2g_3+8t_3-2t_c-2\right)=0,\\
\partial\frac{W_3}{\partial g_3} &= -\frac{1}{9}\left(\epsilon_2-2\epsilon_3+g_1+g_2+7g_3-t_3-2t_c-2\right)=0.
\end{aligned}$$

The equilibrium values are:

$$\begin{aligned}
t_c^{T,S} &= 1+\frac{1}{4}\epsilon_2-\frac{1}{2}\epsilon_3,\ t_3^{T,S}=\frac{1}{2}-\frac{1}{8}\epsilon_2+\frac{1}{4}\epsilon_3,\\
g_1^{T,S} &= \frac{1}{2}-\frac{1}{8}\epsilon_2-\frac{1}{4}\epsilon_3,\ g_2^{T,S}=\frac{1}{2}+\frac{3}{8}\epsilon_2-\frac{1}{4}\epsilon_3,\ g_3^{T,S}=\frac{1}{2}-\frac{1}{8}\epsilon_2+\frac{1}{4}\epsilon_3,
\end{aligned}$$

and the equilibrium welfare levels are:

$$\begin{aligned}
W_1^{T,S} &= \frac{1}{256}\left(48-88\epsilon_2-48\epsilon_3+3\epsilon_2^2+12\epsilon_3^2+44\epsilon_2\epsilon_3\right),\\
W_2^{T,S} &= \frac{1}{256}\left(48+136\epsilon_2-48\epsilon_3+59\epsilon_2^2+12\epsilon_3^2-68\epsilon_2\epsilon_3\right),\\
W_3^{T,S} &= \frac{3}{128}\left(4-\epsilon_2+2\epsilon_3\right)^2.
\end{aligned}$$

New relevant region

Notice that $t_i^{N,S}=g_i^{N,S}=k_i^{N,S}$ and $t_2^{N,S}>t_1^{N,S}$ implies that all values are positive when $t_1^{N,S}>0$ and $t_3^{N,S}>0$ which is guaranteed by $\frac{1}{2}\epsilon_2-1<\epsilon_3<2-\epsilon_2$. Since $t_c^{T,S}=g_1^{T,S}+g_2^{T,S}$, $t_3^{T,S}=g_3^{T,S}$ and $g_2^{T,S}>g_1^{T,S}$, sufficient conditions for positive equilibrium values under partial tax harmonization are $t_3^{T,S}>0$ and $g_1^{T,S}>0$ which is guaranteed by $-2+\frac{1}{2}\epsilon_2<\epsilon_3<2-\frac{1}{2}\epsilon_2$. The binding conditions are $\frac{1}{2}\epsilon_2-1<\epsilon_3<2-\epsilon_2$.

Welfare comparisons

Comparing the welfare of jurisdiction 1 under both cases, we obtain:

$$\begin{aligned}
W_1^{T,S}-W_1^{N,S} &= \frac{1}{768}\left(16-23\epsilon_2^2+68\epsilon_2\epsilon_3-136\epsilon_2+4\epsilon_3^2-16\epsilon_3\right),\\
W_2^{T,S}-W_2^{N,S} &= \frac{1}{768}\left(16+152\epsilon_2-16\epsilon_3+49\epsilon_2^2+4\epsilon_3^2-76\epsilon_2\epsilon_3\right).
\end{aligned}$$

Jurisdiction 2 gains more than jurisdiction 1 from the formation of a tax coalition:

$$\left(W_2^{T,S} - W_2^{N,S}\right) - \left(W_1^{T,S} - W_1^{N,S}\right) = \frac{3}{32}\epsilon_2 \left(4 + \epsilon_2 - 2\epsilon_3\right) > 0.$$

Thus, the coalition is formed whenever it is beneficial for jurisdiction 1. The conditions under which this is the case are displayed in the following Figure 1.7. It can be observed by comparing the new area with that of Fig. 1.4, that under simultaneous choice of both instruments harmonization is still welfare enhancing but to a less extent.

Equilibria under the simultaneous choice of both instruments

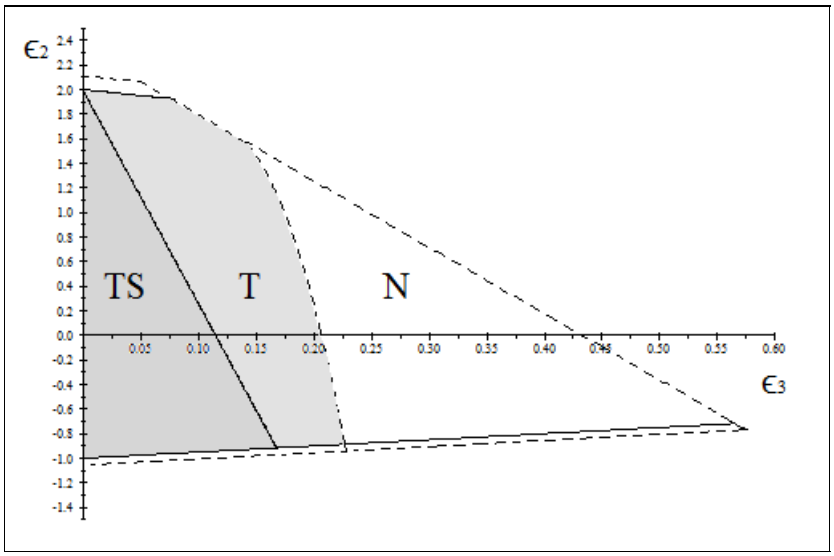

Figure 1.7: Equilibria are: T,S (partial tax harmonization with the simultaneous choice of both instruments), T (partial tax harmonization with the sequential choice of both instruments), and N (non-cooperation).

CHAPTER 2

STRATEGIC RESPONSES TO INTERNATIONAL TAX COMPETITION: FISCAL (DE)CENTRALIZATION VERSUS PARTIAL TAX HARMONIZATION

Overview. This chapter analyzes a country's optimal fiscal strategy among centralization, decentralization, and partial tax harmonization. Countries are asymmetric in productivity levels and characterized by multi-level government such that there is both horizontal and vertical tax competition. The main result from the analysis is that partial tax harmonization is more difficult to achieve in fiscally decentralized economies with high levels of productivity and low labor taxation. This result is confirmed by recent data from the OECD and explains the observed difficulties in achieving capital tax harmonization in the European Union.

Keywords: Centralization; Decentralization; Fiscal Competition; Partial Tax Harmonization.

2.1 Introduction

Tax competition is a major concern in economic policy debates as increasing international capital mobility has led to a *race to the bottom* in capital taxation. This phenomenon has led to inefficiently low capital taxation and to a shift of the tax burden from capital towards labor resulting in increased inequality in most developed countries (Zodrow and Mieszkowski, 1986; Wilson, 1986; Bucovetsky and Wilson, 1991; Piketty, 2014). A natural response to excessive (horizontal) tax competition is the coordination of capital tax rates (Bucovetsky, 1991; Kanbur and Keen, 1993; Fuest and Huber, 2001; Devereux and Fuest, 2010; Keen and Konrad, 2013). However, as the global coordination of tax rates is difficult to achieve, the economic literature has focused on the coordination of tax rates among a group of countries and has shown that such a *partial tax harmonization* is welfare enhancing under certain conditions (Burbidge et al., 1997; Konrad and Schjelderup, 1999; Beaudry et al., 2000; Sørensen, 2004; Brøchner et al., 2007; Conconi et al., 2008; Bucovetsky, 2009; Bettendorf et al., 2010; Vrijburg and de Mooij, 2010; Eichner and Pething, 2013).

While the aforementioned literature assumes that partial tax harmonization takes place among centralized countries, in this chapter, we consider tax harmonization as a strategic response to international tax competition in a more general setting where countries can also be decentralized economies. This is particularly relevant because an increasing tendency towards more *fiscal decentralization* has been observed over the last decades in most developed economies as more tax autonomy has been delegated from the central to regional and local governments (Arzaghi and Henderson, 2005). Moreover, Figure 2.1 indicates this is a tendency which does not depend on a country's initial degree of capital tax decentralization. At the same time, we observe efforts for the partial coordination of tax rates among a group of countries with large differences in their degree of fiscal decentralization. For example, the European Union (EU) whose member countries show considerable differences in their degree of fiscal decentralization has promoted several directives and proposals in order to achieve a certain degree of capital tax harmonization. The Neumark Report in 1962 and the Tempel Report in 1970 are the first that recommend corporate tax harmonization of tax bases and tax rates in the EU. The *Code of Conduct* approved in 1997 recommends to prevent the distortion and the erosion of tax bases in business taxation within the European Community. In 2011, the European Commission proposed a Common Consolidated Corporate Tax Base (CCCTB) which, however, proved to be too

Capital tax decentralization by quartiles (period 1995 to 2014)

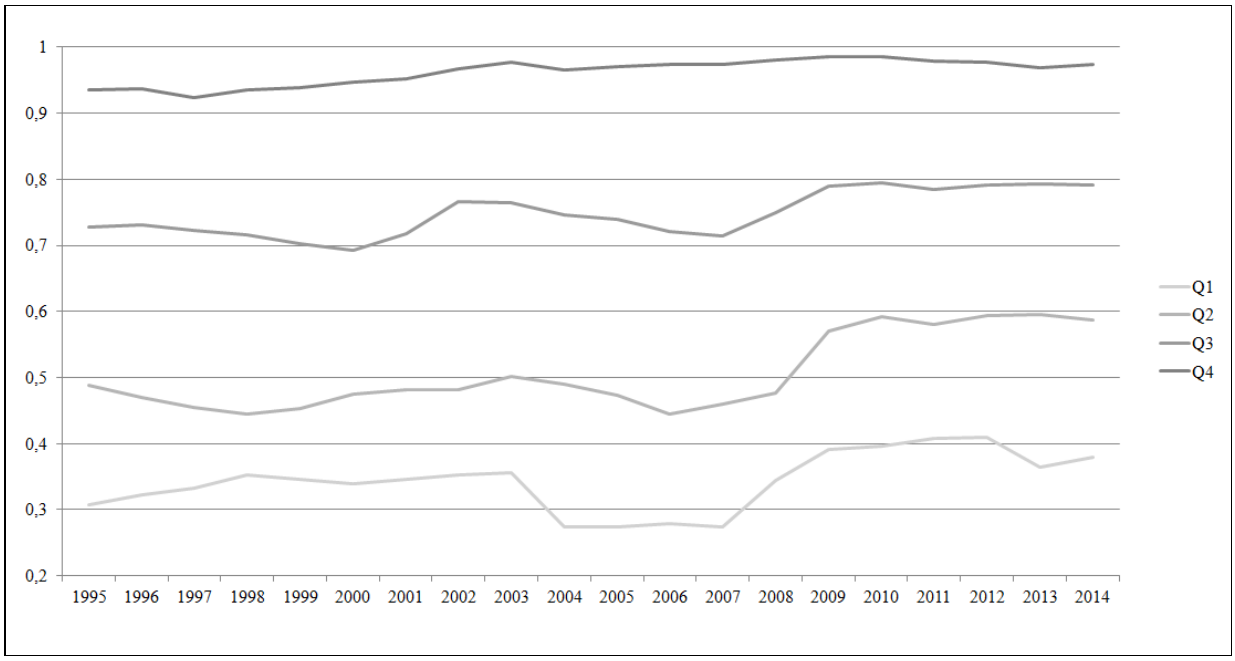

Figure 2.1: Countries are classified into quartiles by degree of capital tax decentralization. Quartile 1 includes Austria, Estonia, Greece, Iceland, Ireland, Italy, Luxembourg, Sweden, Turkey, and United Kingdom. Quartile 2 encompasses Chile, Czech Republic, Finland, Israel, Netherlands and Norway are situated. Quartile 3 comprises Belgium, Denmark, France, Japan, Korea, Latvia, Switzerland are encompassed. Quartile 4 involves Australia, Canada, Germany, New Zealand, Slovenia, Spain, and United States. Measurement: Share of local and regional capital tax revenues over total capital tax revenues. Source: Own calculation based on OECD (2017).

ambitious for several member states. In 2016, the European Commission proposed to re-launch the CCCTB by making it mandatory only for the largest companies in the EU.[1]

In this context, we build on the models of Zodrow and Mieszkowski (1986), Wilson (1986) and Keen and Kotsogiannis (2003) allowing a subset of centralized jurisdictions to form a tax coalition à la Konrad and Schelderup (1999). We consider three countries differing in their productivity levels with two jurisdictions in each. Tax rates on a common tax base are chosen by both the central and local governments. Thus, we allow for *horizontal tax competition* (between countries and among jurisdictions) and *vertical tax competition* (between central and local governments). The focus is on the optimal fiscal strategy of a country in the context of international (and national) tax competition. Three strategies are considered: i) fiscal centralization under which

[1]See Dankó (2012) and European Commission (2017) for more details on the EU directives and proposals for the coordination of taxes.

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FISCAL HARMONIZATION IN THE CONTEXT OF GLOBALIZATION AND GROWING DEMAND OF MORE REGIONAL AUTONOMY
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the central government decides all tax rates in the country; ii) fiscal decentralization under which central and local governments choose independently their capital tax rates; and iii) partial harmonization under which two countries form a tax union that commonly determines a unique tax rate for all jurisdictions. The timing of the game is as follows. In stage 1, country 1 chooses one of the three aforementioned strategies. In stage 2, central (and local) governments decide simultaneously their tax rates.

The main insight that can be obtained from our analysis is that fiscal decentralization is a handicap in achieving partial harmonization of capital taxation. Thus, it is shown that tax harmonization is more difficult to obtain for high productivity countries that are fiscally decentralized. The intuition for this result is that tax competition is less fierce in this case because, due to vertical tax competition, the consolidated tax rate is higher in a fiscally decentralized country than in a centralized economy. As tax rates are strategic complements, other countries also increment capital taxation. As it turns out, the raise in international capital taxation is the more pronounced the larger is the productivity difference between the decentralized economy and the other countries. Therefore, a possible gain from the formation of a tax union is reduced when a potential member of the tax union is a decentralized high productivity economy. Our result indicates that the recent tendency towards more fiscal decentralization in EU member countries has rendered the achievement of capital tax harmonization in the EU more difficult.

Our analysis is related to three strands of the literature. First, it builds on the tax competition literature with asymmetric jurisdictions or countries. As emphasized by Keen and Konrad (2013), allowing for asymmetries comes at the price of imposing restrictions on the functional forms of production and utility functions to obtain analytically tractable models (see e.g., Wildasin, 1991; Bucovetsky, 2009; Hindriks et al., 2008; Kempf and Rota-Graziosi, 2010). From this literature several insights are obtained. Thus, it has been shown that tax rates are higher with a stronger taste for public goods and in countries that are richer in capital, more productive, or more populated (see Keen and Konrad, 2013). As in Hindriks et al. (2008) in this chapter we focus on differences in productivity levels to allow for asymmetries between countries.

The second strand of the literature studies partial tax harmonization. As the harmonization of tax rates between all countries, despite its benefits, is difficult to achieve, the recent literature has focused on the conditions under which the formation of a tax coalition between a subset of jurisdictions is possible. Konrad and Schelderup (1999) and Sanz-Córdoba and Theilen (2017) find that such a partial tax harmonization can be welfare-enhancing for its members when tax

rates are strategic complements and when the coalition members are not too different. Brøchner et al. (2007) use a general equilibrium model to estimate empirically the effect of partial tax harmonization in the EU on its member countries. They find that this, despite its overall moderate welfare gains, would require the introduction of a compensation mechanism because some EU members states would lose from tax harmonization. The challenge for the EU is therefore either to agree upon such compensation mechanisms or to reduce the asymmetries between countries to render tax harmonization beneficial for all of its members.

Thirdly, the chapter is related to the literature on the effects of vertical tax competition in decentralized economies. That fiscal decentralization can be efficient is a classical result that has been shown, e.g., by Tiebout (1956), Oates (1972) and Brennan and Buchanan (1980). The effects of vertical tax competition in a multilevel government federation has been analyzed by Keen and Kotsogiannis (2002, 2003). They elucidate that while horizontal tax competition yields inefficiently low tax rates, vertical tax competition, in contrast, leads to inefficiently high tax rates. Furthermore, it is shown that, generally, the vertical externality dominates the horizontal tax competition such that tax rates are above the social optimum and tax revenues are unambiguously increased by a small cut in either federal or central government's tax rates. This result is empirically confirmed by Brühart and Jametti (2006) who study horizontal and vertical externalities of capital taxation with panel data for Swiss cantons and municipalities.

Finally, most related to this chapter, Haufler and Lülfesmann (2015) analyze a two-tier structure of capital taxation where asymmetric jurisdictions harmonize their federal capital tax rate in the first stage, and then non-cooperatively set local tax rates in the second stage. They show that this mechanism allows to reduce inefficiently high tax competition at the horizontal level. Moreover, it distributes the gains across asymmetric jurisdictions in a way that represents a Pareto improvement over a one-tier system in which tax rates are completely determined at the local level. The main difference between their and our model is that Haufler and Lülfesmann (2015) assume from the beginning that countries are decentralized and that tax rates can be harmonized while our focus is on the condition that render partial tax harmonization and fiscal decentralization an equilibrium outcome.

The rest of the chapter is organized as follows. Section 2.2 sets up the model. Section 2.3 studies tax competition between centralized economies. Section 2.4 elucidates the advantages of unilateral fiscal decentralization. Section 2.5 analyzes partial tax harmonization and indicates under which circumstances centralization, decentralization and tax harmonization are the

optimal fiscal strategy for a given country. Section 2.6 concludes. All proofs are in the Appendix.

2.2 The model

Consider a tax competition model in the spirit of Zodrow and Mieszkowski (1986) and Wilson (1986) with three countries, indexed by $i = 1, 2, 3$, each of which contains $N = 2$ jurisdictions indexed $r = 1, 2$. The framework is modified by allowing for asymmetries in productivity between countries and, as in Konrad and Schjelderup (1999), we allow a subset of countries to form a tax coalition. Each jurisdiction is inhabited by an identical number of immobile residents with mass one who each supply one unit of labor. Jurisdictions compete by choosing a unit per capital tax rate t_{ir} to attract mobile capital from other jurisdictions of their own country and from the rest of the world. The central government in country i levies a unit tax on capital at the rate T_i which is common to all jurisdictions. We refer to $\tau_{ir} \equiv T_i + t_{ir}$ as the consolidated capital tax rate in jurisdiction ir. Output is produced using capital and labor and the production function is written in intensive form, $f_i(k_i)$, with the standard assumptions of $f_i' > 0$, $f_i'' < 0$, where k_{ir} denotes the capital per worker employed in jurisdiction r in country i. The total amount of capital is fixed and normalized to 1. Capital is perfectly mobile between jurisdictions such that the net return to capital, ρ, is determined by the following arbitrage condition

$$\rho = f_{ir}'(k_{ir}) - \tau_{ir} \quad \text{for} \quad i = 1, 2, 3;\ r = 1, 2. \tag{2.1}$$

Following the literature, we assume the following linear quadratic production function

$$f_{ir}(k_{ir}) = a_i k_{ir} - \frac{b}{2} k_{ir}^2, \quad i = 1, 2, 3;\ r = 1, 2, \tag{2.2}$$

where $a_i > 0$ and sufficiently large (Hindriks et al., 2008; Bucovetsky, 2009; Hauptmeier, et al., 2012; Eichner and Pething, 2013). Rents or labor income in jurisdiction ir are denoted by

$$\Pi_{ir} \equiv f_{ir}(k_{ir}) - f_{ir}'(k_{ir})\, k_{ir} = \frac{b}{2} k_{ir}^2 \tag{2.3}$$

and are taxed at the rate x by local governments of the jurisdictions and at the rate X by the central government of the respective countries. As in Keen and Kotsogiannis (2003), we take these tax rates as given and common across jurisdictions and countries. The combined tax rate on labor is denoted by $\chi \equiv X + x$.

The arbitrage condition in Eq. (2.1) together with the market clearing condition ($\sum_i \sum_r k_{ir} = 1$) implies that the amount of capital invested in jurisdiction ir is given by

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 6T_i - 6t_{ir} + 2\sum_{j=1}^{3} T_j + \sum_{j=1}^{3}\sum_{s=1}^{2} t_{js}\right) \tag{2.4}$$

where $\gamma_i = b + 4a_i - 2a_j - 2a_h$.

There are no intergovernmental transfers, neither vertically between the central government and the jurisdictions of a country nor horizontally across countries or the jurisdictions of the same country.[2] Tax receipts of jurisdictions and central governments are given by

$$R_{ir} = t_{ir}k_{ir} + x\Pi_{ir} \text{ and } R_i = \sum_{i=1}^{N}\left(T_i k_{ir} + X\Pi_{ir}\right), \tag{2.5}$$

respectively. As commonly assumed in the literature (e.g. Brennan and Buchanan, 1977; Keen and Kotsogiannis, 2003; Agrawal, 2016), policymakers, i.e., central governments and jurisdictions, are revenue-maximizing Leviathans that choose capital tax rates T_i and t_{ir}, respectively, to maximize their tax revenues.[3] Thus, countries and jurisdictions compete both horizontally and vertically to attract international mobile capital to their location. We refer to $\tau_{ir} = T_i + t_{ir}$ as the consolidated capital tax rate in jurisdiction ir.

We assume that countries 1 and 2 are able to credibly commit to a common tax rate and, therefore, to form a tax coalition.[4] A tax union is formed whenever it is beneficial for both partners. We assume that such a commitment is not possible for country 3.[5] To keep the model

[2] As shown by Egger et al. (2010), intergovernmental transfers are an effective instrument to alleviate vertical tax competition.

[3] An alternative would be assuming that policy makers maximize the utility of a representative consumer with preferences

$$U_{ir} = C_{ir} + \Gamma(G_{ir}, G_i),$$

where C_{ir} defines his consumption, and G_{ir} and G_i are the level public goods provided by jurisdiction ir and the central government i, respectively. Considering that a proportion of government receipts is spent on public goods, such that $G_{ir} = \lambda R_{ir}$ and $G_i = \lambda R_i$ ($0 < \lambda < 1$), and a consumer's budget constraint $C_{ir} = e + (1-\chi)\Pi_{ir}$, where e denotes the consumer's fixed endowment, the indirect utility can be written

$$U_{ir} = e + (1-\chi)\Pi_{ir} + \Gamma(\lambda R_{ir}, \lambda R_i).$$

However, if locally and centrally provided goods are perfect (or close) substitutes and with λ large enough, more consolidated tax revenues would imply an increase in consumer utility as equilibrium tax rates and public goods provision under tax competition are inefficiently low (Zodrow and Mieszkowski, 1986; Wilson, 1986; Bucovetsky and Wilson, 1991). Therefore, in this case maximizing tax revenues is equivalent to maximizing consumer welfare.

[4] This is a common assumption in the literature (Burbidge et al., 1997; Konrad and Schjelderup, 1999; Fuest and Huber, 2001; Conconi et al., 2008).

[5] Notice that the grand coalition cannot be sustained because unilateral deviation from the grand coalition capital tax equilibrium is welfare enhancing. This is because of the Prisoner's dilemma property of this game.

tractable we also assume that countries 2 and 3 have identical productivity levels ($a_2 = a_3 = a$) while country 1's productivity level is $a_1 = a + \epsilon$ such that it can be either more ($\epsilon > 0$) or less productive ($\epsilon < 0$) than countries 2 and 3. Furthermore, to guarantee nonnegative equilibrium values, we restrict the analysis to $\left(\chi, \frac{\epsilon}{b}\right) \in R = \left\{0 < \chi < 1, -\frac{5-2\chi}{20-6\chi} < \frac{\epsilon}{b} < \frac{5-2\chi}{16-6\chi}\right\}$.[6]

The timing of the game is as follows. First, in stage 1, country 1 decide whether to coordinate capital taxes with country 2. Once a decision is taken, central governments (in centralized economies) and both central and local governments (if country 1 is a decentralized economy) decide simultaneously their capital tax rates in stage 2. All decisions at each stage are taken simultaneously by all jurisdictions (and the tax coalition).

2.3 Centralized economies

Consider first the case in which all economies are centralized such that the central government in each country decides all tax rates which, in this case, is equivalent to choosing the consolidated tax rates τ_{ir}. The optimal tax rates are obtained from maximizing total tax receipts $TR_i = R_i + \sum_{r=1}^{2} R_{ir}$, i.e., after making use of Eqs. (2.5), by solving

$$\max_{\tau_{i1},\tau_{i2}} TR_i = \tau_{i1}k_{i1} + \tau_{i2}k_{i2} + \chi\frac{b}{2}\left(\left(k_{i1}\right)^2 + \left(k_{i2}\right)^2\right), \quad i = 1, 2, 3. \tag{2.6}$$

From the first-order conditions we obtain the following reaction functions

$$\tau_{ir} = \frac{3-2\chi}{30-13\chi}\left(\gamma_i + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right) + \frac{6-5\chi}{30-13\chi}\tau_{is} \tag{2.7}$$

where the condition $\partial\tau_{ir}/\partial\tau_{jr} < 1$ guarantees the stability of the equilibrium. We observe that a reduction of a rival's capital tax rate is responded directly with a reduction in tax rates such that tax rates of different jurisdictions are strategic complements. From Eq. (2.7) the Nash-equilibrium capital tax rates are given by

$$\tau_{1r}^C = \frac{1}{12}\left(3-2\chi\right)\frac{5b+8\epsilon-2b\chi}{5-2\chi},\ \tau_{2r}^C = \tau_{3r}^C = \frac{1}{12}\left(3-2\chi\right)\frac{5b-4\epsilon-2b\chi}{5-2\chi} \tag{2.8}$$

and the equilibrium total tax receipts in country i are

The existence of a commitment device is therefore essential to avoid deviation by tax coalition members.

[6]The details are in the Appendix.

$$TR_i^C = \frac{4\,(3-\chi)}{b\,(3-2\chi)^2}\left(\tau_{ir}^C\right)^2. \tag{2.9}$$

From Eq. (2.8) we find that equilibrium tax rates are larger in more productive countries ($\tau_{1r}^C \gtreqless \tau_{ir}^C$ iff $\epsilon \gtreqless 0$, $i = 2,3$) and decrease with labor taxation ($\partial\tau_{ir}^C/\partial\chi < 0$).[7] As can be seen from Eq. (2.6), this is because the marginal returns from labor taxation (i.e., labor income which is $b\left[k_{i1}^2 + k_{i2}^2\right]/2$) decreases with capital taxation as $\partial k_{ir}/\partial\tau_{ir} < 0$.

From the literature is well-known that the Nash equilibrium outcome is Pareto inefficient and that all countries would benefit from a small uniform increase in capital tax rates. This is due to the prisoner's dilemma property of this type of games. Thus, a deviation by a single country from the Pareto efficient equilibrium would allow it to realize higher welfare gains. In equilibrium, all countries deviate by reducing their tax rates to attract foreign capital and a Pareto inferior situation is attained. We summarize this as

Lemma 1 *Starting from the non-cooperative Nash equilibrium, a small increase in capital taxation in all countries increases their consolidated tax revenue.*

2.4 Fiscal decentralization

Now, consider that country 1 is a decentralized economy. Then, the local government in jurisdiction $1r$ chooses the tax rate t_{1r} to maximize its tax receipts R_{1r}, while the central government chooses T_1 to maximize tax revenues R_1. Countries 2 and 3, as centralized economies, choose the consolidated tax rates for both of their jurisdictions τ_{21} and τ_{22}, and τ_{31} and τ_{32} to maximize TR_2 and TR_3, respectively. The optimal tax rates are the solution of the following maximization problems

$$\max_{t_{1r}} R_{1r} \;=\; t_{1r}k_{1r} + x\frac{b}{2}\left(k_{1r}\right)^2,\;\; r = 1,2, \tag{2.10}$$

$$\max_{T_1} R_1 \;=\; \sum_{r=1}^{2}\left(T_1 k_{1r} + X\frac{b}{2}\left(k_{1r}\right)^2\right), \tag{2.11}$$

[7] We have that $\frac{\partial\tau_{ir}^C}{\partial\chi} = -\tau_{ir}^C\frac{4}{(3-2\chi)(5-2\chi)} - \frac{1}{12}(3-2\chi)\frac{2b}{(5-2\chi)} < 0$, $i = 1,2,3$; $r = 1,2$.

$$\max_{\tau_{i1},\tau_{i2}} TR_i = \tau_{i1}k_{i1} + \tau_{i2}k_{i2} + \chi\frac{b}{2}\left((k_{i1})^2 + (k_{i2})^2\right), \quad i = 2,3. \tag{2.12}$$

It can be easily shown that the equilibrium consolidated tax rates are given by[8]

$$\tau_{1r}^D = \frac{1}{12}(27 - 10\chi)\frac{5b + 8\epsilon - 2b\chi}{33 - 10\chi}, r = 1,2, \tag{2.13}$$

$$\tau_{ir}^D = \frac{1}{12}(3 - 2\chi)\frac{37b - 20\epsilon - 10b\chi}{33 - 10\chi}, \; i = 2,3; r = 1,2. \tag{2.14}$$

Substituting Eqs. (2.13) and (2.14) into Eqs. (2.10) - (2.12), yields the corresponding tax revenues

$$TR_1^D = \frac{20(27 - 5\chi)}{b(27 - 10\chi)^2}\left(\tau_{1r}^D\right)^2 \quad \text{and} \quad TR_i^D = \frac{4(3 - \chi)}{b(3 - 2\chi)^2}\left(\tau_{ir}^D\right)^2, \; i = 2,3. \tag{2.15}$$

A comparison of Eqs. (2.8) and (2.13) shows that decentralization yields an increase in the consolidated tax rate in country 1. As pointed out by Keen and Kotsogiannis (2003), this stems from the common pool nature of the tax base and it is similar in nature to the double-marginalization problem in a vertically disintegrated industry (Spengler, 1950). An increase in capital taxation at the local or the central level reduces capital investments in that country. Under decentralization, local and central governments ignore the negative externality that a raise in own tax rates has on other governments' tax revenues such that they choose inefficiently high tax rates. As tax rates are strategic complements, countries 2 and 3 will react to the increase in capital taxation in country 1 with a raise of their tax rates. From the results in Lemma 1 follows that this simultaneous increase in all countries' capital tax rates is beneficial for all of them. Therefore, in case of country 1, we have that decentralization has two opposed effects. One the one hand, it reduces the consolidated tax revenues because it yields a *negative vertical externality* as it causes an inefficient increase in tax rates. On the other hand, decentralization works as a credible commitment to increase tax rates which causes an increase of tax rates in other countries. This efficient increase in tax rates allows to reduce mutually damaging horizontal tax competition among countries and has a *positive horizontal externality* on country 1's consolidated tax revenue. We summarize these considerations as follows

[8]The detailed derivation of the results is in the Appendix.

Lemma 2 *Fiscal decentralization in a country yields an increase in its consolidated capital tax rate and a capital outflow that is increasing in the combined tax rate on labor χ. The negative externality of increased vertical tax competition in the decentralized economy is partially compensated by a mitigation of horizontal tax competition among countries.*

From Lemma 2 we observe that decentralization has two opposed effects on country 1's consolidated tax revenue. The following result states under which conditions fiscal decentralization allows a country to increase its total tax revenues.

Proposition 1 *Unilateral fiscal decentralization increases a country's consolidated tax revenue when the combined tax rate on labor is low ($\chi < \frac{1}{2}$) and decreases it when the combined tax rate on labor is high ($\chi > \frac{1}{2}$). The consolidated tax revenue in third countries increases.*

The intuition of this result can be obtained from Lemmas 1 and 2. As mentioned before, on the one hand, decentralization causes an inefficient increase in tax rates in country 1. On the other hand, decentralization allows to reduce the inefficiency of too low tax rates at the international level as it causes countries 2 and 3 to raise their tax rates. This lessens the negative impact of decentralization on capital investments in country 1. From Lemma 2 we observe that this mitigating effect is smaller when labour taxation is high because, then, countries 2 and 3 will not raise their tax rates to the same extent as with low levels of labor taxation. Thus, the efficiency gain of having less damaging horizontal tax competition decreases with the combined tax rate on labor and dominates (is dominated by) the efficiency cost of vertical tax competition under a low (high) regime of labor taxation.

2.5 Partial tax harmonization

Finally, consider that a subgroup of countries, i.e., countries 1 and 2, form a coalition subgroup, and publicly and credibly commit to a common capital tax rate.[9] As we have seen before, without such a commitment both countries would deviate from any commonly agreed tax rate. Furthermore, we assume that such a commitment is not possible for country 3. This assumption is realistic if we consider that countries 1 and 2 are already members of a trade or economic coalition as the EU, for example. In such a case different mechanisms could be used to guarantee

[9]This assumption has been used by Burbidge et al. (1997), Konrad and Schelderup (1999), Fuest and Huber (2001), Conconi et al. (2008), Bucovetsky (2009), Kammas et al. (2010), Egger et al. (2014), or Han et al. (2017).

a commitment. In line with the literature, we consider that the tax coalition maximizes the joint total revenues of central and local governments of both countries (i.e., $TR_1 + TR_2$) to choose a common combined capital tax rate, τ_c. Country 3, simultaneously, chooses τ_{31} and τ_{32} to maximize its total tax revenue (TR_3). The optimal tax rates are obtained by solving

$$\max_{\tau_c} TR_1 + TR_2 = \tau_c \sum_{i=1,2} \sum_{r=1,2} k_{ir} + \frac{b}{2}\chi \sum_{i=1,2} \sum_{r=1,2} k_{ir}^2, \text{ and} \tag{2.16}$$

$$\max_{\tau_{31},\tau_{32}} TR_3 = \tau_{31}k_{31} + \tau_{32}k_{32} + \frac{b}{2}\chi\left((k_{31})^2 + (k_{32})^2\right). \tag{2.17}$$

The Nash-equilibrium tax rates under partial tax harmonization, τ_c^H and τ_{3r}^H, are given by[10]

$$\tau_c^H = \frac{1}{12}(5b + 2\epsilon - 2b\chi) \text{ and } \tau_{3r}^H = \frac{1}{12}(3 - 2\chi)\frac{4b - 2\epsilon - b\chi}{3 - \chi}, \ r = 1, 2. \tag{2.18}$$

From the above expressions, the corresponding total tax revenues are

$$TR_i^H = \frac{1}{b}\left(\frac{6 - \chi}{3 - \chi}\tau_c^H - (-1)^i \frac{\epsilon}{2}\chi\right)\left(\frac{\tau_c^H}{3 - \chi} - (-1)^i \frac{\epsilon}{2}\right), \ i = 1, 2, \text{ and} \tag{2.19}$$

$$TR_3^H = \frac{4(3 - \chi)}{b(3 - 2\chi)^2}\left(\tau_{3r}^H\right)^2. \tag{2.20}$$

From a comparison of Eqs. (2.8) and (2.18) we find that the tax coalition chooses a common tax rate above the tax rates under non-cooperation (i.e., $\left(\tau_c^H - \tau_{1r}^C\right) > 0$, $\left(\tau_c^H - \tau_{2r}^C\right) > 0$). As tax rates are strategic complements, the country outside the tax coalition also increases its tax rate ($\tau_{3r}^H - \tau_{3r}^C > 0$) but to a lower proportion (i.e., $\tau_c^H > \tau_{3r}^H$). As a consequence, partial tax harmonization yields an capital outflow from the members of the tax coalition to country 3. Finally, as the increase in tax rates inside the tax coalition is superior in the less productive country, the capital outflow is larger there. We resume these results in the next Lemma.

Lemma 3 *Partial tax harmonization yields an increase in the consolidated capital tax rate inside the tax coalition and a capital outflow towards the non-member country that also increases its capital tax rate but to a lower extent.*

In stage 1, countries 1 and 2 decide to form a tax coalition with a common combined capital tax when both countries obtain higher total tax receipts, i.e., when $TR_i^H > TR_i^C$, for $i = 1, 2$. The following result states when this is the case.

[10]The detailed derivation of the results is in the Appendix.

Proposition 2 *Starting from a non-cooperative equilibrium with centralized economies, partial tax harmonization increases the consolidated tax revenues of the tax coalition members when their productivity levels are not too different. The gain in tax receipts is larger for the more productive country.*

From Lemma 3 we observe that the formation of the tax coalition induces its members to increase capital tax rates to the common tax level. The resulting capital outflow is mitigated since the country outside the tax coalition also rises its tax rates such that international tax competition is less fierce. Therefore the formation of the tax coalition allows its members to increase their tax revenues. However, when the members of the tax coalition differ in their productivity, agreeing upon a common tax rate means that the less productive member suffers larger capital outflows. Consequently, partial tax harmonization is not in the interest of the less productive member when these productivity differences are large. That partial tax harmonization under credible commitment can be an equilibrium outcome has also been observed by Konrad and Schelderup (1999) and Fuest and Huber (2001) for the case of symmetric economies. Thus, Proposition 2 also highlights the importance of the symmetry assumption in order to obtain these results.

Now, consider the situation in which country 1 is a decentralized economy. Then, a tax coalition with a common combined capital tax between countries 1 an 2 is formed when $TR_i^H > TR_i^D$, for $i = 1, 2$. The following result states when this is the case.

Proposition 3 *Starting from non-cooperative equilibrium in which country 1 is decentralized, partial tax harmonization increases the consolidated tax revenues of the tax coalition members when their productivity levels are not too different. The gain in tax receipts is larger for the more productive country.*

The intuition behind this result is similar to the one of Proposition 2. Interestingly, however, if country 1 is a high productivity economy tax harmonization is less likely to occur when country 1 is a decentralized economy than when it is a centralized one. This is because in this case tax competition is already less fierce than under centralization such that the gains for country 2 from the formation of a tax coalition are lower. By contrast, if country 1 is a low productivity economy, tax harmonization is more beneficial for it than decentralization because tax competition is mitigated through the direct increase of tax rates in country 2 and not only

through the indirect response of other countries to increased vertical taxation. Again, this holds as long as the productivity differences inside the tax coalition are not substantial.

The results in Propositions 1, 2 and 3 allow to determine under which circumstances centralization, decentralization and tax harmonization are the optimal fiscal strategy for country 1. This gives rise to the following general result.

Proposition 4 *Fiscal centralization of capital taxation occurs in economies with high income taxation. Fiscal decentralization of capital taxation occurs i) in high productivity economies, and ii) economies with low income taxation. Partial capital tax harmonization is more likely to occur in i) low productivity economies with low income taxation and ii) high productivity economies with high income taxation.*

The results in Proposition 4 are illustrated in Figure 2.2. As observed in Proposition 1, country 1 decides to centralize capital taxation when it is a high income tax economy and, otherwise, to decentralized it. Moreover, Propositions 2 and 3 show that the formation of a partial tax coalition requires its members to have similar productivity levels such that tax harmonization is the optimal strategy for low absolute values of ϵ. These results allow to identify different clusters of economies with similar fiscal capital taxation strategies. Thus, high productivity countries with low income taxation would preferably decentralize capital taxation, as can be observe, for example, for the United States where local tax authorities have considerable freedom in setting capital taxes. By contrast, high productivity countries with high capital taxation adopt a centralized capital taxation structure. This can be observed in Japan, for example. Finally, the harmonization of taxes as pursued by the European Commission requires countries with similar productivity levels. The use of structural funds in the EU to even out differences in infrastructure investments can be seen as an intent to reduce productivity differences among member countries in order to facilitate tax harmonization.

As shown in Figure 2.3, the results in Proposition 4 are empirically confirmed with 2014 data for a panel of selected OECD economies. Figure 2.3 relates the degree of capital tax decentralization (or centralization) and the benefits of capital tax harmonization, respectively, to total factor productivity and the level of labor taxation.[11] The degree of capital tax decentralization

[11] Countries included in the analysis are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. New Zealand and Ireland have been excluded because of missing data for one of the variables.

Equilibria of the tax competition game

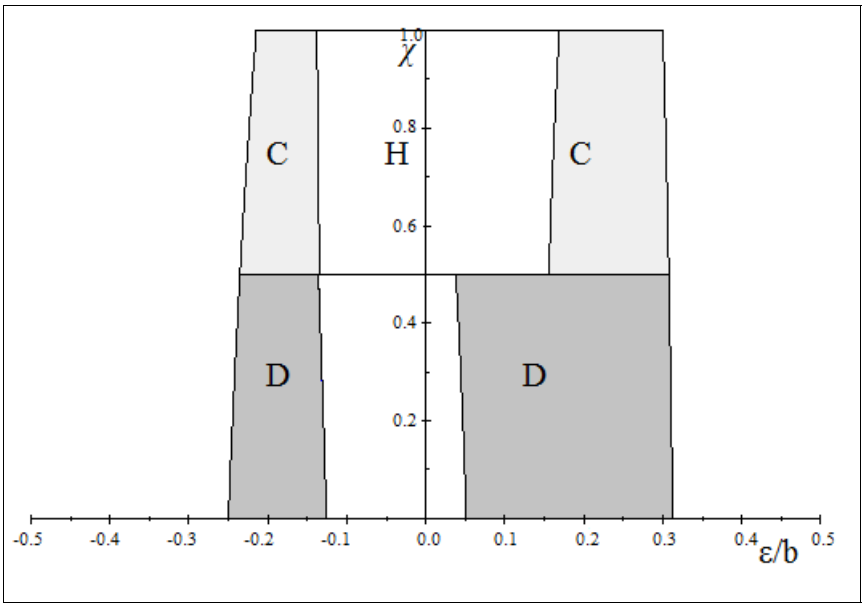

Figure 2.2: Equilibria are: H (partial tax harmonization), C (centralization) and D (decentralization).

is approximated by the share of local and regional capital tax revenues over total capital tax revenues. Potential gains from tax harmonization measured in percentage increases of GDP are from Brøchner et al. (2007) who estimate welfare gains from a harmonized corporate tax rate at 27.2 percent in the EU25. Total factor productivity levels are at current purchasing power parities and labor tax rates are measured as non-capital tax revenues as a share of GDP. As can be observed in the upper panel of Figure 2.3, capital tax decentralization increases with total factor productivity and decreases with the level of labor taxation which is in line with the first two statements in Proposition 4. Moreover, in the lower left panel of Figure 2.3 we observe that the welfare gains from tax harmonization increase with total factor productivity for high labor tax countries while they decrease with total factor productivity for low labor tax countries. Overall, the lower right panel of Figure 2.3 indicates a positive relationship between the gains from tax harmonization and the level of labor taxation. These results are totally consistent with the last statement in Proposition 4 and what is shown in Figure 2.2.

Data panel for a selected OECD countries (period 2014)

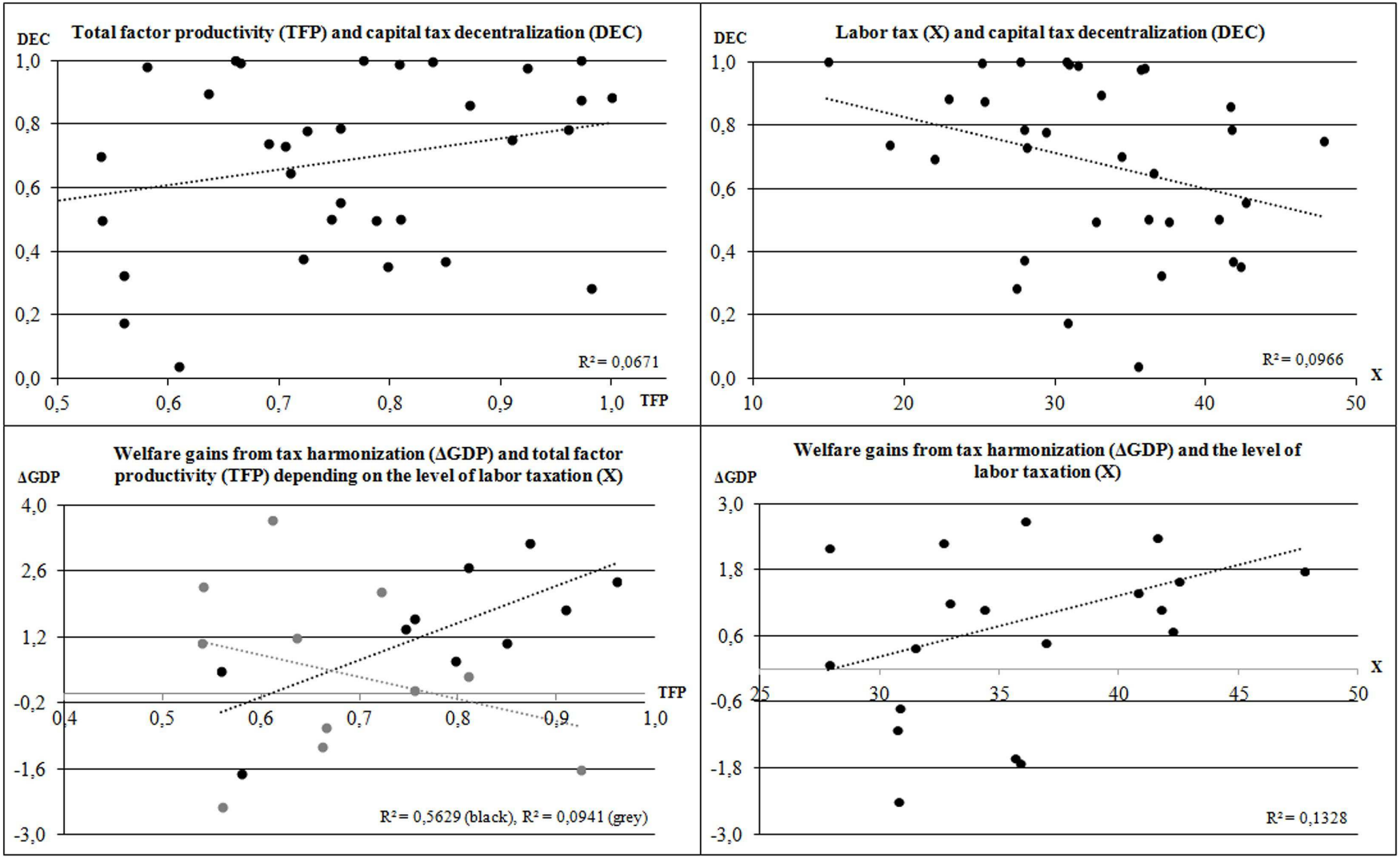

Figure 2.3: Countries with high levels of labor taxation are Austria, Belgium, Denmark, Finland, France, Hungary, Italy, Netherlands, Slovenia, and Sweden (black dots). Countries with low level of labor taxation are Czech Republic, Estonia, Germany, Greece, Latvia, Luxembourg, Poland, Portugal, Slovak Republic, Spain, United Kingdom (grey dots). Source: Own calculation based on Brøchner et al. (2007), Feenstra et al. (2015), and OECD (2017).

2.6 Conclusions

Tax harmonization is a major concern in many developed economies because excessive international tax competition has led to an erosion of capital tax bases and tax rates. For instance, the European Commission has made considerable efforts to achieve the convergence of capital taxation in the EU. Another tendency in capital taxation that has been observed over the last decades in these countries is the decentralization of capital taxation as more tax autonomy has been delegated from the central to regional and local governments. Against this background in this chapter we built up a model that allows for both horizontal and vertical tax competition and analyze a countries optimal fiscal strategy among: fiscal centralization, fiscal decentralization, and partial tax harmonization. The main result from our analysis is that partial capital taxation harmonization is more difficult to achieve in fiscally decentralized economies that are characterized by levels of high productivity and low labor taxation. This result is confirmed by recent data and explains the observed difficulties in achieving capital tax harmonization in the EU.

Our results imply that a primary objective of policy makers that want to accomplish a voluntary harmonization of capital taxation should be to reduce productivity asymmetries between potential tax coalition members. The current usage of structural funds in the EU which are orientated to reduce infrastructure deficits (i.e., productivity differences) between its members can serve, for example, as an instrument for this objective. Another handicap for tax coalition formation is the existence of fiscal decentralization of capital taxation since tax harmonization is easier to achieve between centralized than decentralized economies. As a consequence, policy makers should advocate for the usage of other than capital taxes to finance the needs of lower-tier governments in fiscally decentralized economies.

Our analysis is based on a highly stylized model. Therefore, some final comments regarding the robustness of the results are indicated. First, we have considered a three-country model with two jurisdictions in each. However, the main insights from our analysis can be generalized straightforwardly to the case with more countries and jurisdictions. On the one hand, with more countries, horizontal tax competition becomes more fierce such that the formation of a tax coalition among two (or more) countries will be more difficult to achieve in general. On the other hand, with more jurisdictions inside a country horizontal tax competition between jurisdictions is more intense such that vertical tax competition is less fierce which facilitates partial tax

harmonization. By contrast, with more than two tiers of government the negative externality of vertical tax competition becomes larger and, consequently, partial tax harmonization is harder to accomplish.

Second, following the literature, we have assumed that labor taxes are exogenously given. We have observed that in this case partial tax harmonization is easier to achieve under high labor taxation. However, a consequence of a tax harmonization agreement will be a shift from more capital to less labor taxation inside the tax coalition. Our results indicate that this might turn the tax coalition agreement unstable because high productivity economies prefer fiscal decentralization in such a case. It follows that tax harmonization between countries with multi-level governments is even more difficult to achieve with endogenous labor taxation than under the assumptions in this paper.

Finally, we have assumed that one country chooses between fiscal centralization and decentralization while the other countries are centralized economies. A generalization of the analysis in this direction certainly would require some additional assumptions on the model parameters to keep the analysis tractable and is left for future research. However, our results can be generalized to the case in which there are differences in the degree of capital tax decentralization among countries. Our results indicate that economies with high productivity levels and low labor taxation are more decentralized than others and that the formation of a tax coalition with these countries is more difficult to achieve. Another possible direction for an extension of the analysis is to consider simultaneous tax competition with other nontax instruments (e.g. infrastructure investments).

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Appendix

Proof of the results in Section 2.3. Making use of $\tau_{ir} \equiv T_i + t_{ir}$, the amount of capital invested in jurisdiction ir in Eq. (2.4) writes as

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 5\tau_{ir} + \tau_{is} + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right). \tag{2.21}$$

Then, the first-order conditions resulting from Eq. (2.9) are:

$$\begin{aligned}\frac{\partial TR_i}{\partial \tau_{ir}} &= \tau_{ir}\frac{\partial k_{ir}}{\partial \tau_{ir}} + k_{ir} + \tau_{is}\frac{\partial k_{is}}{\partial \tau_{ir}} + \chi\frac{b}{2}\left(2k_{ir}\frac{\partial k_{ir}}{\partial \tau_{ir}} + 2k_{is}\frac{\partial k_{is}}{\partial \tau_{ir}}\right) \\ &= \frac{3-2\chi}{18b}\left(\gamma_i + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right) - \frac{30-13\chi}{18b}\tau_{ir} + \frac{6-5\chi}{18b}\tau_{is} = 0, \end{aligned} \tag{2.22}$$

$i, j, h = 1, 2, 3$; $j \neq i$, $h \neq i, j$; $r, s = 1, 2$; $r \neq s$. Notice, that these are sufficient conditions for a maximum as the second-order conditions are fulfilled, i.e.,

$$\frac{\partial^2 TR_i}{\partial \tau_{ir}^2} = -\frac{30-13\chi}{18b} < 0, \text{ and } \frac{\partial^2 TR_i}{\partial \tau_{ir}^2}\frac{\partial^2 TR_i}{\partial \tau_{is}^2} - \left(\frac{\partial^2 TR_i}{\partial \tau_{ir}\partial \tau_{is}}\right)^2 = \frac{4\left(2-\chi\right)\left(3-\chi\right)}{9b^2} > 0.$$

Solving the system of equations in (2.22) yields the equilibrium tax rates

$$\tau_{ir} = \frac{1}{36}\left(3-2\chi\right)\frac{3\left(3\gamma_i + \gamma_j + \gamma_h\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{5-2\chi}, \tag{2.23}$$

which by using $\gamma_1 = b + 4\epsilon$ and $\gamma_2 = \gamma_3 = b - 2\epsilon$ can be written as in Eq. (2.8). The equilibrium capital investments are

$$k_{ir}^C = \frac{2\tau_{ir}}{\left(3-2\chi\right)b}. \tag{2.24}$$

From Eqs. (2.9) and (2.24) we observe that sufficient conditions for positive tax revenues and capital investments are that $\tau_{ir}^C > 0$. It follows from Eq. (2.8) that this is the case when $-\frac{5}{8} + \frac{1}{4}\chi < \frac{\epsilon}{b} < \frac{5}{4} - \frac{1}{2}\chi$. Finally, a sufficiently large guarantees positive net returns to capital in equilibrium. ■

Proof of Lemma 1. Suppose that all countries increase their tax rates by a small amount λ such that $\tau_{ir}^* = \tau_{ir}^C + \lambda$. Then, tax revenues are

$$TR_i^* = 4\frac{3-\chi}{b\left(3-2\chi\right)^2}\left(\tau_{ir}^C + \lambda\right)^2.$$

Thus,

$$TR_i^* - TR_i^C = 4\lambda\,(3-\chi)\,\frac{\lambda + 2\tau_{ir}^C}{b\,(3-2\chi)^2} > 0,$$

which proves the statement. ■

Proof of the results in Section 2.4. Considering that economies 2 and 3 are centralized such that only the consolidated tax rates can be determined, the amount of capital invested in jurisdiction ir in Eq. (2.4) writes as

$$\begin{aligned} k_{1r} &= \frac{1}{6b}\left(\gamma_1 - 4T_1 - 5t_{1r} + t_{1s} + \tau_{21} + \tau_{22} + \tau_{31} + \tau_{32}\right) \quad \text{and} \\ k_{ir} &= \frac{1}{6b}\left(\gamma_i - 5\tau_{ir} + \tau_{is} + 2T_1 + t_{11} + t_{12} + \tau_{jr} + \tau_{js}\right), \;\; i,j = 2,3,\; j \neq i. \end{aligned}$$

The first-order conditions corresponding to Eqs. (2.10) - (2.12) are

$$\begin{aligned} \frac{\partial R_{1r}}{\partial t_{1r}} &= k_{1r} + t_{1r}\left(\frac{\partial k_{1r}}{\partial t_{1r}}\right) + xbk_{1r}\left(\frac{\partial k_{1r}}{\partial t_{1r}}\right) \\ &= \frac{6-5x}{36b}\left(\gamma_1 - 4T_1 + t_{1s} + \tau_{21} + \tau_{22} + \tau_{31} + \tau_{32}\right) - \frac{5\,(12-5x)}{36b}t_{1r} = 0, \qquad (2.25) \\ \frac{\partial R_1}{\partial T_1} &= k_{11} + k_{12} + T_1\left(\frac{\partial k_{11}}{\partial T_1} + \frac{\partial k_{12}}{\partial T_1}\right) + 2X\frac{b}{2}\left(k_{11}\frac{\partial k_{11}}{\partial T_1} + k_{12}\frac{\partial k_{12}}{\partial T_1}\right) \\ &= \frac{3-2X}{9b}\left(\gamma_1 - 2t_{11} - 2t_{12} + \tau_{21} + \tau_{22} + \tau_{31} + \tau_{32}\right) - \frac{8\,(3-X)}{9b}T_1 = 0, \qquad (2.26) \\ \frac{\partial TR_i}{\partial \tau_{ir}} &= k_{ir} + \tau_{ir}\left(\frac{\partial k_{ir}}{\partial \tau_{ir}}\right) + \tau_{is}\left(\frac{\partial k_{is}}{\partial \tau_{ir}}\right) + 2\chi\frac{b}{2}\left(k_{ir}\left(\frac{\partial k_{ir}}{\partial \tau_{ir}}\right) + k_{is}\left(\frac{\partial k_{is}}{\partial \tau_{ir}}\right)\right) \\ &= \frac{3-2\chi}{18b}\left(\gamma_i + 2T_1 + t_{11} + t_{12} + \tau_{jr} + \tau_{js}\right) - \frac{30-13\chi}{18b}\tau_{ir} + \frac{6-5\chi}{18b}\tau_{is} = 0, \qquad (2.27) \end{aligned}$$

$i,j = 2,3;\; j \neq i;\; r = 1,2$. Again, these are sufficient conditions for a maximum as the second-order conditions are fulfilled, i.e.,

$$\begin{aligned} &\frac{\partial^2 R_{1r}}{\partial t_{1r}^2} = -\frac{5\,(12-5x)}{36b} < 0, \;\; \frac{\partial^2 R_1}{\partial T_1^2} = -\frac{8\,(3-X)}{9b} < 0, \;\; \frac{\partial^2 TR_i}{\partial \tau_{ir}^2} = -\frac{18-7\chi}{12b} < 0, \text{ and} \\ &\frac{\partial^2 TR_i}{\partial \tau_{ir}^2}\frac{\partial^2 TR_i}{\partial \tau_{is}^2} - \left(\frac{\partial^2 TR_i}{\partial \tau_{ir}\partial \tau_{is}}\right)^2 = \frac{(11-5\chi)\,(7-2\chi)}{36b^2} > 0 \end{aligned}$$

Solving the system of equations in (2.25)-(2.27) yields the equilibrium tax rates

$$t_{1r} = \frac{6-5x}{18}\frac{3\left(3\gamma_1+\gamma_2+\gamma_3\right)-2\chi\left(\gamma_1+\gamma_2+\gamma_3\right)}{33-10\chi},\ r=1,2 \tag{2.28}$$

$$T_1 = \frac{5\left(3-2X\right)}{36}\frac{3\left(3\gamma_1+\gamma_2+\gamma_3\right)-2\chi\left(\gamma_1+\gamma_2+\gamma_3\right)}{33-10\chi} \tag{2.29}$$

$$\tau_{ir} = \frac{3-2\chi}{36}\frac{3\left(45\gamma_1+103\gamma_i+37\gamma_j\right)-4\chi\left(26\gamma_1+41\gamma_i+26\gamma_j\right)+20\chi^2\left(\gamma_1+\gamma_2+\gamma_3\right)}{\left(5-2\chi\right)\left(33-10\chi\right)}, \tag{2.30}$$

$i,j=2,3;\ j\neq i;\ r=1,2$, such that

$$\tau_{1r}=T_1+t_{1r}=\frac{1}{36}\left(27-10\chi\right)\frac{3\left(3\gamma_1+\gamma_2+\gamma_3\right)-2\chi\left(\gamma_1+\gamma_2+\gamma_3\right)}{33-10\chi}. \tag{2.31}$$

The equilibrium capital investments are

$$k_{1r}^D=\frac{10\tau_{1r}}{\left(27-10\chi\right)b}\ \text{ and }\ k_{ir}^D=\frac{2\tau_{ir}}{\left(3-2\chi\right)b},\ \ i=2,3. \tag{2.32}$$

Substituting $\gamma_1=b+4\epsilon$ and $\gamma_2=\gamma_3=b-2\epsilon$ in Eqs. (2.30) and (2.31), we get the equilibrium tax rates in (2.13) and (2.14).

From Eqs. (2.15) and (2.32) we observe that sufficient conditions for positive tax revenues and capital investments are that $t_{1r}>0$, $T_1>0$, $\tau_{2r}^D=\tau_{3r}^D>0$, which is satisfied by the condition $-\frac{5}{8}+\frac{1}{4}\chi<\frac{\epsilon}{b}<\frac{37}{20}-\frac{1}{2}\chi$. Again, a sufficiently large guarantees positive net returns to capital in equilibrium. ■

Proof of Lemma 2. From Eqs. (2.8) and (2.13) we obtain

$$\tau_{1r}^D-\tau_{1r}^C=\frac{1}{3}\left(9-2\chi\right)\frac{5b+8\epsilon-2b\chi}{\left(5-2\chi\right)\left(33-10\chi\right)}>0\quad\text{for }\forall\ (\chi,\frac{\epsilon}{b})\in R$$

which proves the first part of the first statement.

To prove the second statement, consider the situation that country 1 decentralizes such that $\tau_{1r}^D=\tau_{1r}^C+\lambda$ (with $\lambda>0$) but that countries 2 and 3 maintain their tax rates at τ_{ir}^C. Then, using the fact that capital investments in country 1 can be written as $\widetilde{k}_{1r}^D=k_{1r}^C-\frac{2}{3b}\lambda$, the consolidated tax revenue in country 1 is

$$\widetilde{TR_1^D}=2\left(\tau_{1r}^C+\lambda\right)\left(k_{1r}^C-\frac{2}{3b}\lambda\right)+\chi b\left(k_{1r}^C-\frac{2}{3b}\lambda\right)^2=TR_1^C-\frac{4}{9}\lambda^2\frac{3-\chi}{b}.$$

So $\widetilde{TR}_1^D < TR_1^C$. The reaction of countries 2 and 3 to such an unilateral increase in tax rates in country 1 is an increase in their tax rates by

$$\tau_{ir}^D = \tau_{ir}^C + \lambda \frac{3-2\chi}{9-2\chi},\ i = 2,3;\ r = 1,2$$

which raises capital investments in country 1 by

$$\widetilde{\widetilde{k}}_{1r}^D = k_{1r}^C + \frac{2\lambda}{3b}\frac{3-2\chi}{9-2\chi}.$$

The total impact of decentralization on capital investments in country 1, $k_{1r}^D = \widetilde{k}_{1r}^D + \widetilde{\widetilde{k}}_{1r}^D$, is a reduction of capital investments by

$$k_{1r}^D - k_{1r}^C = -\frac{4\lambda}{b\,(9-2\chi)}$$

which is increasing in χ, which proves the second part of the first statement. ■

Proof of Proposition 1. This follows directly from a comparison of Eqs. (2.9) and (2.15)

$$TR_1^D - TR_1^C = \frac{1}{9}(1-2\chi)(27-10\chi)\frac{(5b+8\epsilon-2b\chi)^2}{b\,(5-2\chi)^2(33-10\chi)^2} \gtreqless 0 \ \text{ iff } \quad \chi \lesseqgtr \frac{1}{2}$$

and, noticing that $\tau_{ir}^D > \tau_{ir}^C$, from Eqs. (2.9) and (2.15)

$$TR_i^D - TR_i^C = \frac{4\,(3-\chi)}{b\,(3-2\chi)^2}\left(\left(\tau_{ir}^D\right)^2 - \left(\tau_{ir}^C\right)^2\right) > 0,\ i = 2,3.$$

■

Proof of the results in Section 2.5. Making use of $\tau_c \equiv \tau_{1r} \equiv T_1 + t_{1r} \equiv \tau_{2r} \equiv T_2 + t_{2r}$, the amount of capital invested in jurisdiction ir in Eq. (2.4) writes as

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 2\tau_c + \tau_{3r} + \tau_{3s}\right),\ i = 1,2,\ r,s = 1,2 \tag{2.33}$$

$$k_{3r} = \frac{1}{6b}\left(\gamma_3 - 5\tau_{3r} + \tau_{3s} + 4\tau_c\right),\ r,s = 1,2. \tag{2.34}$$

The first-order conditions corresponding to (2.16) and (2.17) are

$$\begin{aligned}\partial\frac{TR_1+TR_2}{\partial\tau_c} &= \sum_{i=1,2}\sum_{r=1,2}k_{ir}+\tau_c\sum_{i=1,2}\sum_{r=1,2}\frac{\partial k_{ir}}{\partial\tau_c}+b\chi\sum_{i=1,2}\sum_{r=1,2}k_{ir}\frac{\partial k_{ir}}{\partial\tau_c}\\ &= \frac{1}{3b}\left(\gamma_1+\gamma_2+2\tau_{31}+2\tau_{32}\right)\left(1-\frac{1}{3}\chi\right)-\frac{4\left(6-\chi\right)}{9b}\tau_c=0 \qquad (2.35)\\ \frac{\partial TR_3}{\partial\tau_{3r}} &= k_{3r}+\tau_{3r}\frac{\partial k_{3r}}{\partial\tau_{3r}}+\tau_{3s}\frac{\partial k_{3s}}{\partial\tau_{3r}}+b\chi\left(k_{3r}\frac{\partial k_{3r}}{\partial\tau_{3r}}+k_{3s}\frac{\partial k_{3s}}{\partial\tau_{3r}}\right)\\ &= \frac{\left(3-2\chi\right)\left(\gamma_3+4\tau_c\right)}{18b}-\frac{30-13\chi}{18b}\tau_{3r}+\frac{6-5\chi}{18b}\tau_{3s}=0, \qquad (2.36)\end{aligned}$$

$r,s=1,2;\ s\neq r$. Again, these are sufficient conditions for a maximum as the second-order conditions are fulfilled, i.e.,

$$\begin{aligned}\partial^2\frac{TR_1+TR_2}{\partial\tau_c^2} &= -\frac{4\left(6-\chi\right)}{9b}<0,\ \frac{\partial^2TR_3}{\partial\tau_{3r}^2}=-\frac{30-13\chi}{18b}<0, \text{ and}\\ \frac{\partial^2TR_3}{\partial\tau_{3r}^2}\frac{\partial^2TR_3}{\partial\tau_{3s}^2}-\left(\frac{\partial^2TR_3}{\partial\tau_{3r}\partial\tau_{3s}}\right)^2 &= \frac{4\left(2-\chi\right)\left(3-\chi\right)}{9b^2}>0.\end{aligned}$$

Solving the system of equations in (2.35) and (2.36) yields the equilibrium tax rates

$$\begin{aligned}\tau_c &= \frac{3\left(2\gamma_1+2\gamma_2+\gamma_3\right)-2\chi\left(\gamma_1+\gamma_2+\gamma_3\right)}{36} \qquad (2.37)\\ \tau_{3r} &= \frac{1}{36}\left(3-2\chi\right)\frac{3\left(\gamma_1+\gamma_2+2\gamma_3\right)-\chi\left(\gamma_1+\gamma_2+\gamma_3\right)}{3-\chi},\ r=1,2 \qquad (2.38)\end{aligned}$$

and the equilibrium capital investments

$$\begin{aligned}k_{ir}^H &= \frac{\frac{1}{12}\left(3-\chi\right)\left(\gamma_i-\gamma_j\right)+\tau_c}{b\left(3-\chi\right)},\ i,j,r=1,2;\ j\neq i \qquad (2.39)\\ k_{3r}^H &= \frac{2\tau_{3r}}{\left(3-2\chi\right)b},\ r=1,2. \qquad (2.40)\end{aligned}$$

Finally, substituting $\gamma_1=b+4\epsilon$ and $\gamma_2=\gamma_3=b-2\epsilon$ in Eq. (2.37) and (2.38), we get the equilibrium tax rates in (2.18). As positive tax rates and capital revenues imply that tax revenues are positive, sufficient conditions for positive equilibrium values are $k_{1r}>0$, $k_{2r}>0$, $\tau_c^H>0$, and $\tau_{3r}^H>0$ (which implies $k_{3r}>0$). From Eqs.(2.18) and (2.40) follows that this is guaranteed by the conditions $-\frac{5-2\chi}{20-6\chi}<\frac{\epsilon}{b}<\frac{5-2\chi}{16-6\chi}$ and $-\frac{5}{2}+\chi<\frac{\epsilon}{b}<2-\frac{1}{2}\chi$, where the binding conditions are $-\frac{5-2\chi}{20-6\chi}<\frac{\epsilon}{b}<\frac{5-2\chi}{16-6\chi}$. Again, a sufficiently large guarantees positive net returns to capital in equilibrium. ■

Proof of Lemma 3. From Eqs. (2.8) and (2.18) we obtain that

$$\tau_c^H - \tau_{1r}^C = \frac{1}{6}\frac{5b - 7\epsilon - 2b\chi + 6\epsilon\chi}{5 - 2\chi} > 0 \text{ iff } \frac{\epsilon}{b} < \frac{5 - 2\chi}{7 - 6\chi}$$

and

$$\tau_c^H - \tau_{2r}^C = \frac{1}{6}\frac{5b + 11\epsilon - 2b\chi - 6\epsilon\chi}{5 - 2\chi} > 0 \text{ iff } \frac{\epsilon}{b} > -\frac{5 - 2\chi}{11 - 6\chi}$$

which is observed for all $\left(\chi, \frac{\epsilon}{b}\right) \in R$. Regarding country 3's tax rate, from Eqs. (2.8) and (2.18) we obtain that

$$\tau_3^H - \tau_{3r}^C = \frac{1}{12}(3 - 2\chi)\frac{5b + 2\epsilon - 2b\chi}{(5 - 2\chi)(3 - \chi)} > 0 \text{ iff } \frac{\epsilon}{b} > -\frac{5}{2} + \chi$$

which also holds for all $\left(\chi, \frac{\epsilon}{b}\right) \in R$. Finally, from Eq. (2.18) we observe that

$$\tau_c^H - \tau_{3r}^H = \frac{1}{4}\frac{b + 4\epsilon + 2\epsilon\chi}{3 - \chi} > 0 \text{ iff } \frac{\epsilon}{b} > \frac{-1}{4 - 2\chi}$$

which is observed for all $\left(\chi, \frac{\epsilon}{b}\right) \in R$. ■

Proof of Proposition 2. Notice that the gains from tax harmonization are larger for the more productive country

$$\left(TR_1^H - TR_1^C\right) - \left(TR_2^H - TR_2^C\right) = 2\frac{39 - 36\chi + 8\chi^2}{(3 - \chi)(5 - 2\chi)^2}\frac{\epsilon}{b}\tau_c \gtreqless 0 \quad \text{for} \quad \epsilon \gtreqless 0.$$

Therefore, partial tax harmonization takes place whenever the less productive country gains from it, i.e., when $TR_1^H > TR_1^C$ for $\epsilon < 0$ and $TR_2^H > TR_2^C$ for $\epsilon > 0$. From Eqs. (2.9) and (2.19) this yields

$$\begin{aligned} &(2 - \chi)(21 - 8\chi)(5 - 2\chi)^2 \\ &+4(5 - 2\chi)\left(393 - 478\chi + 188\chi^2 - 24\chi^3\right)\frac{\epsilon}{b} \\ &+4\left(2078\chi - 2926\chi^2 + 1617\chi^3 - 396\chi^4 + 36\chi^5 - 228\right)\left(\frac{\epsilon}{b}\right)^2 > 0 \text{ for } \epsilon < 0 \end{aligned} \tag{2.41}$$

and

$$\begin{aligned}(2-\chi)(21-8\chi)(5-2\chi)^2 \\ -4(5-2\chi)\left(309-404\chi+172\chi^2-24\chi^3\right)\frac{\epsilon}{b} \\ +4\left(3842\chi-3646\chi^2+1713\chi^3-396\chi^4+36\chi^5-1632\right)\left(\frac{\epsilon}{b}\right)^2 &> 0 \text{ for } \epsilon>0. \quad (2.42)\end{aligned}$$

This can be summarized to the condition

$$f_1(\chi) < \frac{\epsilon}{b} < f_2(\chi)$$

where $f_1(\chi)$ is the upper root of Eq. (2.41) and $f_2(\chi)$ is the lower root of Eq. (2.42). Figure 2.4 displays the areas in which partial tax harmonization (H) and centralization (C) are revenue maximizing equilibria in the $\left(\frac{\epsilon}{b},\chi\right)$-space.

■

Proof of Proposition 3. Partial tax harmonization increases the consolidated tax revenues of the tax coalition members when $TR_i^H - TR_i^D > 0$, for $i = 1, 2$. From Eqs. (2.15) and (2.19) this yields the conditions

$$\begin{aligned}(5-2\chi)\left(558-303\chi+40\chi^2\right) \\ +4\left(5499-5370\chi+1780\chi^2-200\chi^3\right)\frac{\epsilon}{b} \\ -4\left(828-5946\chi+5086\chi^2-1515\chi^3+150\chi^4\right)\left(\frac{\epsilon}{b}\right)^2 &> 0 \text{ and } \quad (2.43)\\ 5166-9711\chi+6204\chi^2-1660\chi^3+160\chi^4 \\ -4\left(24\,795-35\,946\chi+19\,308\chi^2-4560\chi^3+400\chi^4\right)\frac{\epsilon}{b} \\ -4\left(21\,024-49\,734\chi+43\,962\chi^2-18\,547\chi^3+3780\chi^4-300\chi^5\right)\left(\frac{\epsilon}{b}\right)^2 &> 0. \quad (2.44)\end{aligned}$$

This can be summarized to the condition

$$g_1(\chi) < \frac{\epsilon}{b} < g_2(\chi)$$

where $g_1(\chi)$ is the upper root of Eq. (2.43) and $g_2(\chi)$ is the lower root of Eq. (2.44). Figure 2.5 displays the areas in which partial tax harmonization (H) and decentralization (D) are revenue maximizing equilibria in the $\left(\frac{\epsilon}{b},\chi\right)$-space. ■

Equilibria under centralization and partial tax harmonization

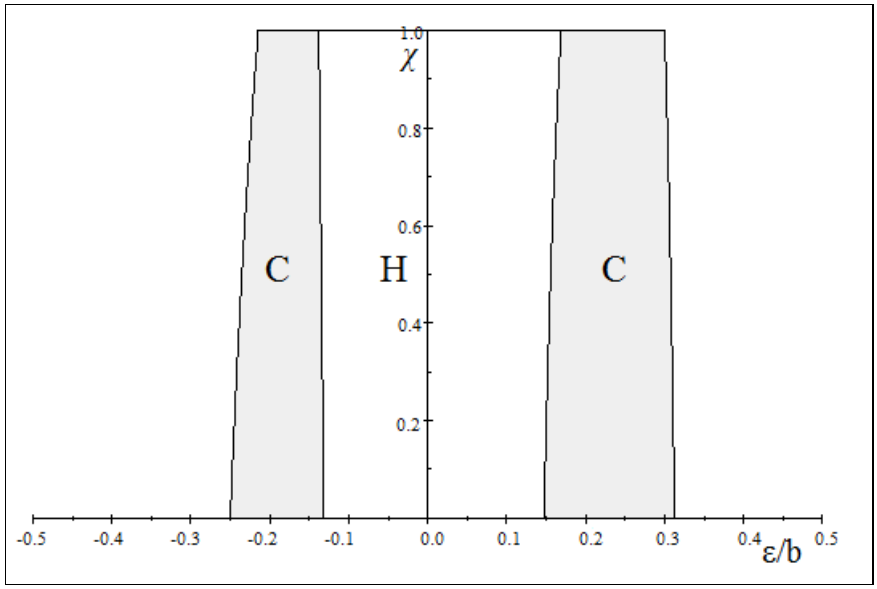

Figure 2.4: Equilibria are: H (partial tax harmonization), and C (centralization).

Equilibria under fiscal decentralization and partial tax harmonization

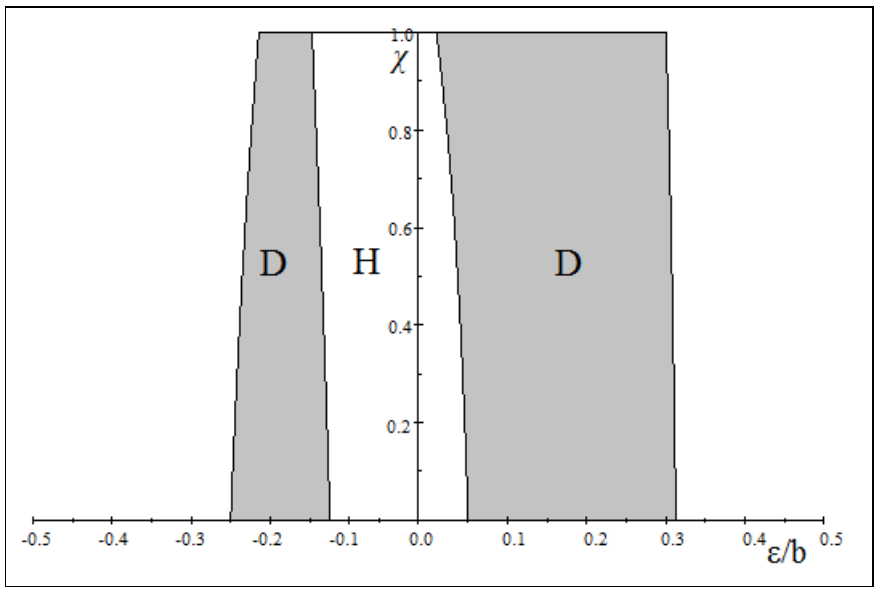

Figure 2.5: Equilibria are: H (partial tax harmonization), and D (decentralization).

Relevant region. As observed before, positive equilibrium values are guaranteed by the conditions $-\frac{5}{8}+\frac{1}{4}\chi<\frac{\epsilon}{b}<\frac{5}{4}-\frac{1}{2}\chi$, $-\frac{5}{8}+\frac{1}{4}\chi<\frac{\epsilon}{b}<\frac{37}{20}-\frac{1}{2}\chi$, and $-\frac{5-2\chi}{20-6\chi}<\frac{\epsilon}{b}<\frac{5-2\chi}{16-6\chi}$, where the former two conditions are guaranteed by the third one. Therefore, the relevant region with positive equilibrium values is given by $\chi\in[0,1)$ and $\frac{\epsilon}{b}\in\left(-\frac{5-2\chi}{20-6\chi},\frac{5-2\chi}{16-6\chi}\right)$ ■

CHAPTER 3

NEW EVIDENCE ON FISCAL INTERACTIONS

Overview. This chapter evaluates the existence of international tax competition among OECD countries using the spatial panel data model. We test whether fiscal interactions between governments exist and whether governments with similar public infrastructure investment levels increase these fiscal interdependence among them. Results indicate the existence of tax interdependence in the closest neighboring OECD countries where international tax competition occurs. These tax interactions are higher for countries with similar public infrastructure investment levels.

Keywords: International Tax Competition; Public Investment; Fiscal Interactions; Spatial Panel Data model; OECD.

3.1 Introduction

The processes of economic integration have increased international mobility of capital over the last three decades. This has led to a *race to the bottom* in capital taxation with inefficiently low levels of capital tax rates and the underprovision of public goods (Zodrow and Mieszkowski, 1986; Wilson, 1986; Bucovetsky, 1991). Consequently, the tax burden has been shifted from capital towards labor to maintain a certain level of public good provision. As a response to increasing tax competition, the literature has focused on the coordination of capital taxation (Bucovetsky, 1991; Kanbur and Keen, 1993; Fuest and Huber, 2001; Baldwin and Krugman, 2004; Konrad, 2009; Devereux and Fuest, 2010; Keen and Konrad, 2013). It is generally recognized that global tax harmonization is difficult to achieve. Therefore, the conditions that allow for *partial tax harmonization* among a group of countries have been widely discussed (Konrad and Schjelderup, 1999; Burbidge et al., 1997; Brøchner et al., 2007; Bucovetsky, 2009; Vrijburg and De Mooij, 2010).

This chapter has two main objectives. First, we address the question whether or not fiscal interactions between OECD governments exists. There are three main theoretical explanations why countries heeds its neighborings' fiscal decisions. The first explanation is the existence of *international tax competition* among OECD countries.[1] Governments reduce capital taxation to attract foreign capital. The empirical analysis of tax competition has become an important issue in the literature (Besley et al., 2001; Cassette and Paty, 2008; Devereux et al., 2008). Both the European Union (EU) and the OECD have introduced initiatives in the late 1990s designed to combat "harmful" tax competition (Devereux et al., 2008).[2] Therefore, analyzing the intensity of tax competition among OECD countries would help policy makers to develop better actions against these harmful practices. The second explanation is that voters judge their governments by comparing their performance with those of neighbor countries (denominated *yardstick competition*). As a consequence, governments mimic the fiscal decisions applied by their neighbors (Besley and Case, 1995; Besley and Smart, 2007; Bordignon et al., 2003). Finally, the existence of expenditure externalities on public investments in core infrastructures (e.g. transport and communications) whose benefits have *spillover effects* on neighboring countries can diminish their level of investments due to free riding (Redoano, 2014). Accordingly, the analysis

[1] OECD: Organisation for Economic Cooperation and Development.

[2] See, for example, the *Code of Conduct* from the European Commission (1997) and *Harmful Tax Competition: An Emerging Global Issue* from the OECD (1998) as two initiatives to curb harmful tax practices.

of fiscal interdependence among OECD countries is rather complex because it is simultaneously caused by these three processes: tax competition, yardstick competition, and spillover effects. We focus on fiscal interactions in terms of corporate tax choices because fiscal interactions are more likely to affect capital than labor due to its greater mobility.

Second, we test the theoretical assumption that countries with similar public investment levels incur in higher fiscal interdependence. Many authors argue that jurisdictions compete not only in taxes but also in the provision of infrastructure (see Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011). Some institutions have increased the level of infrastructure in order to ensure some similarity on the level of public investment between countries. For example, the European Commission has created the *European Structural and Investment Funds* to support economic development across all EU member countries from 2014 to 2020 (European Commission, 2017). In this case, governments can be more likely to set similar tax policies if they have similar investment levels. Therefore, fiscal interdependence will increase if countries share certain similarities in their levels of public investments.

For this purpose, we use a spatial panel data model from Elhorst (2010) which has been widely used in the literature. This model allows testing for contemporaneous fiscal interactions (Besley and Case, 1995; Cassette and Paty, 2008; Devereux, et al., 2008; Redoano, 2014). The weighting matrix used to model the relationship between countries is the geographical distance. Moreover, in order to test whether public investment plays a role in international tax competition among OECD countries, a specific matrix is constructed.

The main results of the chapter can be summarized as follows. We confirm the existence of tax interdependence in the closest neighboring OECD countries where international tax competition occurs. This fiscal interdependence is higher for countries with similar public investments levels and this weighting scheme seems more appropriate to model corporate tax rate interactions. Therefore, we can accept the hypothesis that countries with similar public investment levels incur in higher fiscal interactions.

The analysis is most related to the following literature. First, on the one hand, the existence of contemporaneous strategic fiscal interactions between countries is analyzed theoretically and empirically (Cassette and Paty, 2008; Devereux et al., 2008; Deskins and Hill, 2010; Redoano, 2014; Altshuler et al., 2015; Reiter, 2015; Streif, 2015; among others). These authors find positive fiscal interdependence among the studied countries. The main focus of these studies is international tax competition. Yardstick competition, on the other hand, is tested among states

or municipalities (see for example Bordignon et al. (2003) for Italian municipalities or Duvois and Paty (2010) for French municipalities who find positive local fiscal interactions). Second, Hauptmeier et al. (2012) estimate a model of strategic fiscal interactions in both tax and public investments for local governments. They find that governments use both capital taxation and public infrastructure investment to compete for international capital.

The main difference of the model to those of the literature is that it tests fiscal interactions between countries that have similar infrastructure investment levels. To the best of my knowledge, this is the first empirical analysis of international tax competition that allows the inclusion of for public infrastructure investment in fiscal interactions.

The remainder of the chapter is organized as follow. Section 3.2 presents the theoretical model of tax and public investments competition, Section 3.3 describes the estimation approach, Section 3.4 shows the data used in the model, and results are shown in Section 3.5. Finally, Section 3.6 concludes. Tables of the results are in the Appendix.

3.2 Theoretical model

Fiscal competition models can be presented following the essence of a simple model of tax competition. The model is built on the strategic tax competition literature such as Zodrow and Mieszkowski (1986), Wilson (1986), and Wildasin (1991). In these models, governments compete for capital using taxes as a policy instrument. Consider a federation of two asymmetric jurisdictions, indexed by $N = i, j$, each inhabited by an identical number of immobile residents with mass one who each supply one unit of labor. Each jurisdiction produces a homogeneous consumption good using a mobile capital k_i and a publicly provided input, g_i. The total amount of capital is fixed and normalized to one. The cost of public investment is convex and is given by $c_i(g_i) = (k_i g_i)^2/2$. Moreover, each jurisdiction chooses a source-based unit capital tax t_i, capable of influencing the location of mobile capital per worker k_i. The simple quadratic production function is

$$F_i(k_i; g_i) = (a_i + g_i)k_i - \frac{b}{2}k_i^2, \tag{3.1}$$

where a_i is the productivity level parameter of the jurisdiction i and b the curvature of the production function parameter. The output fulfill with the standard assumptions of $F_i'(k_i; g_i) > 0$, $F_i''(k_i; g_i) < 0$. As capital is mobile, the net return to capital, ρ, is determined by

$$\rho = F_i'(k_i; g_i) - t_i, \tag{3.2}$$

such that ρ across jurisdictions is equalized,

$$F_i'(k_i; g_i) - t_i = F_j'(k_j; g_j) - t_j. \tag{3.3}$$

The capital employed in jurisdiction i can be obtained from Eq. (3.2) and with the world capital stock ($\sum k_i = 1$)

$$k_i = \frac{(b + a_i - a_j + g_i - g_j - t_i + t_j)}{2b} \tag{3.4}$$

where $i \neq j$. Governments maximize the welfare function U_i in their own jurisdictions, the sum of the return to the immobile factor and tax revenue, net of public good cost[3]

$$U_i = F_i(k_i; g_i) - F_i'(k_i; g_i)k_i + t_i k_i - \frac{(k_i g_i)^2}{2}. \tag{3.5}$$

Using Eq. (3.4) and (3.5), we derive the welfare level as

$$U_i = \frac{\delta_i}{4b}(\frac{\delta_i}{2} + \frac{\delta_i}{2b}(2t_i - g_i^2)), \tag{3.6}$$

where $\delta_i \equiv b + a_i - a_j + g_i - g_j - t_i + t_j$. The main interest of this section is the slopes of the tax reaction functions, $t_i = f_t(t_j; g_i; g_j; \mid g_i - g_j \mid)$, around the equilibrium. An optimal policy change of a government would be capital tax that takes into account the competitors responses who use both taxes and public inputs. To obtain the slopes of tax rates, the government's first order conditions with respect to t_i are differentiated. The reaction function of t_i is

$$t_1 = (b + g_i^2)\frac{b + a_i - a_j + g_i - g_j + t_j}{3b + g_i^2}, \tag{3.7}$$

Using the specific derivatives in the equilibrium, the four effects of interest are

$$\frac{\partial t_i}{\partial t_j} = \frac{b + g_i^2}{3b + g_i^2} > 0, \quad \frac{\partial t_i}{\partial g_i} = \frac{g_i^4 + 4bg_i(a_i - a_j - g_j + t_j) + b(3b + 4bg_i + 8g_i^2)}{(3b + g_i^2)^2} > 0, \tag{3.8}$$

[3]The government objective function is widely used in the literature, for example Hindriks et al. (2008) and Hauptmeier et al. (2012). Including the cost of public input provision in the welfare function us justified in Hauptmeier et al. (2012).

$$\frac{\partial t_i}{\partial g_j} = -\frac{(b+g_i^2)}{3b+g_i^2} < 0, \text{ and } \frac{\partial t_i}{\partial \mid g_i - g_j \mid} = \frac{b}{3b+g_i^2} > 0. \tag{3.9}$$

The upward sloping of $\partial t_i/\partial t_j$ in Eq. (3.8) shows that if the competitor decreases its capital tax rates, the optimal respond of the government would be also a decrease of its own taxation. The reaction function depends on the curvature of the production function and on its public input. The expression $\partial t_i/\partial g_i$ in Eq. (3.8) denotes that an increase in the level of public good in jurisdiction i also increases in its level of capital taxation. Moreover, it depends on the levels of the productivity of both jurisdictions and negatively on the competitor public input level. Evaluating $\partial t_i/\partial g_j$ in Eq. (3.9), the reaction function is downward sloping. This means that if the opponent deviates from the equilibrium by increasing its level of public input, the jurisdiction will decrease its capital taxation as an optimal response but to a lower extent. This response does not depend on the level of jurisdictions' productivity level. Finally, the difference between the level of public input provision's reaction function, i.e., $\partial t_i/\partial \mid g_i - g_j \mid$, in Eq. (3.9) is positive. This means that when jurisdictions share similar levels of public inputs, jurisdiction i decreases its capital taxation more than before as an unique instrument for attracting more capital than its competitor.

3.3 Empirical model

In this section, the empirical methodology is presented. The literature on fiscal strategic interactions among governments agrees that the spatial panel data models are theoretically consistent in situations where capital taxation and public infrastructure investments interact with those of neighboring countries (Brueckner 2003). Therefore, a spatial panel data model from Elhorst (2010) that accounts for contemporaneous cross-sectional dependence is used in this case

$$y_{n,t} = \lambda W_n y_{n,t} + X_{n,t}\beta + v_n + \varepsilon_{n,t} \tag{3.10}$$

where $y_{n,t}$ is the $n \times 1$ vector of corporate tax rates for the n countries at time t, $X_{n,t}$ is the $n \times k$ matrix containing specific control variables at time t for the n countries, v_n is a $n \times 1$ vector of country fixed effects, and $\varepsilon_{n,t}$ is a vector of error term which is assumed to be normally distributed. W_n is the weighting matrix used to model interactions between countries. The choice of W_n is discussed below. $W_n y_{n,t}$ is the spatially lagged variable. It measures the

(potential) contemporaneous interactions among tax decisions across countries. Therefore, λ measures the intensity of the contemporaneous interactions. Starting from this general model, we can conclude that fiscal interactions exist only when λ is significant. Non significance of λ indicates that the use of spatial econometrics is not appropriate.

The weighting matrix is used to model the relationship between countries. It is composed of elements $w_{i,j}$ that measure the link between country i and country j. More specifically, each weight $w_{i,j}$ measures the impact of country j on country i. In the case of tax interactions, the weighting matrix models the transmission channels between the implementation of tax policy in each country. A high $w_{i,j}$ assumes that fiscal choices of country j strongly affect the fiscal choices in country i. Estimating Eq. (3.10) using a specific weighting matrix allows to conclude that there are (no) interactions between countries that pass through the specific channel modeled by the matrix.

A way to model interactions between corporate tax rates among governments is using the geographical distance. First, countries that are close are more likely to be competitors for international capital investments. Second, the closer countries are, the stronger commercial relationships they have, such that the probability of international tax competition between neighbor countries is significantly higher. Another advantage of using the geographical distance to construct the weighting matrix is that it is fully exogenous. To measure the geographical distance, the radial distance between capitals of countries i and j ($d_{i,j}$) is used. Moreover, to test the robustness of the estimation, three matrices are constructed. The first one considers the inverse distance between countries: the closer countries are, the stronger the associated weight is. The elements of this matrix are computed as follow

$$w_{i,j} = \frac{1}{d_{i,j}}. \tag{3.11}$$

With the second matrix, another functional form is considered to model the geographical distance: We use the exponential distance. Each element is computed as follow

$$w_{i,j} = exp(-d_{i,j}). \tag{3.12}$$

Finally, consider only the 5-nearest neighbors: $w_{i,j}$ takes the value $1/d_{i,j}$ if j is one of the five nearest neighbors of i, 0 otherwise.

If the coefficient associated to the spatially lagged variable $W_n y_{n,t}$ is not significant, this

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means that there are not tax interactions between countries according to the weighting schemes used. In contrast, if the coefficient associated to the spatially lagged variable $W_n y_{n,t}$ is significant, this means that countries interact more with close neighbors than with other countries. A positive coefficient implies that there is a degree of interdependence among countries. Therefore, countries increase their corporate tax rates when neighbor countries do so.

The estimation of Eq. (3.10) requires the normalization of the weighting matrix. Therefore, each matrix is row-normalized. This means the transformed variable $W_n y_{n,t}$ can be interpreted as the average of the y values in neighboring countries at time t.

3.4 Data

The dataset comprises annual data for 22 OECD economies over the period 1996 to 2014.[4] Further details on data measurement and sources can be found in Table 3.1. Table 3.2 reports the descriptive statistics.

The endogenous variable is corporate tax rates (*Tax*). This measure has been widely used in the literature of fiscal interactions (Keen and Simone, 2004; Cassette and Paty, 2008; Devereux et al., 2008; Cassette et al., 2013; Redoano, 2014). Measuring tax competition by corporate tax rates has the advantage of being easily accessible and, moreover, it is commonly recognized that it plays an important role in the international tax competition. We use combined (statutory) corporate income tax rates as percentage units from the OECD Tax database. Thereby, our dependent variable is broadly available in a comparable format.

To estimate fiscal interactions between OECD governments, we include two sets of control variables: socio-economic factors, and political factors. The first set include variables such as gross domestic product per capita (*GDP*), total inland transport infrastructure investment per capita (*Investment*), the unemployment rate (*Unemployment*), public debt (*Debt*), and trade openness (*Trade*).[5] Regarding *GDP*, the expected effect is ambiguous. The sign for *GDP* is negative if countries use higher levels of wealth to reduce their corporate tax rates, otherwise, the sign should be positive. *Invest* is used to control for the nontax instruments that governments use in the tax competition. An increase in public investments is expected to decrease corporate

[4]Countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Japan, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, and the United Kingdom.

[5]Missing values for the variable *Investment* where imputed using the values of the former period. These were in Portugal at 2011 and 2014, and in Japan and Switzerland at 2014.

tax rates. This is because governments would use both capital taxation and infrastructure investments as an instruments to attract capital investments. The sign of *Unemployment* is also expected to be ambiguous. On the one hand, if *Unemployment* increases governments would need more tax revenues because of the fiscal stress. On the other hand, the increase of *Unemployment* would encourage governments to use their fiscal policy to be more aggressive in attracting capital and, therefore, they would decrease corporate taxation. A high value of *Debt* is expected to increase corporate taxation because governments face higher revenue requirements Countries with more *Trade* are expected to decrease their corporate tax rates since they are more heavily engaged in international tax competition.

The second set of variables contains: membership in the Economic and Monetary Union (*EMU*), the ideology of the leading party in government (*Left*), and the date of election (*Election*). *EMU* takes the value 1 for countries that belong to the Euro Area, and 0 otherwise. Countries that form part of the EMU are expected to have less corporate tax rates because mobility costs of capital are lower within the EU where the degree of international tax competition is significantly higher. *Left* is introduced to control for the ideology of the leading party in the government as it is often argued that left-wing parties rely more on corporate taxation to increase public revenues than right-wing parties (Profeta and Scabrosetti, 2016). Alluding to *Election*, it is expected that governments reduce corporate tax rates in order to attract some voters and to increase their re-election probability. However, as corporate taxation is a controversial issue the effect might be rather small. Referring to Franzese (2000), the date of elections is quantified as

$$Election = \frac{(M-1) + d/D}{12} \tag{3.13}$$

where M and d are respectively the month and the day of an election, and D is the total number of days in the election month. Note that *Election = 0* for years without elections. The model is also estimated with a common trend in order to ensure that interactions are not only due to a coincidence or to common changes among countries.

3.5 Results

In what follows, the results on fiscal interactions between governments using the three weighting schemes presented above are discussed. Results are represented in Table 3.3. For each weighting matrix, the two left columns shows the results without a *Trend*, and the two right ones depict the results with a *Trend*. All matrices give very similar results, in terms of sign and of the estimates. *Trend* has a negative coefficient and is statistically significant for all weighting matrices. This result reveals that corporate tax rates decrease 2% on average for all countries per year. This is consistent with the existence of a *race to the bottom* in corporate taxation among OECD countries.

Regarding the spatial correlation all weighting matrices show that there are positive contemporaneous fiscal interactions. This means that governments' corporate tax rates depend positively on their neighbors' corporate tax rates. When a neighbor countries increases (decreases) its corporate tax rate (due to higher demand for public spending, for example), governments do the same. As it is shown in Eq. (3.8) in Section 3.2, the reaction function in tax rates t_i is positive with respect to t_j, proving that tax rates are strategic complements. This is compatible with the existence of the international tax competition. *GDP* is only significant when *Trend* is included in the model and impacts positively on *Tax*. As expected. *Unemployment* is not significant and does not have an effect on *Tax*. *Debt* positively affects *Tax*. Governments have higher revenue requirements when they have higher levels of public debt and, consequently, increase corporate tax rates. *Trade* has a significant negative effect on *Tax*. Countries with higher trade openess have less mobility costs. Therefore, international tax competition is more fierce and countries are forced to decrease capital taxation.

Concerning the political variables included in the estimations, *Election* does not have an impact on *Tax*. However, *Left* has a significantly positive effect on *Tax*. This result confirms that left-wing parties rely more on corporate taxation to increase public revenues than right-wing parties. *EMU* also impacts positively on *Tax* if a common trend is included (with exception to the exponential distance). This result reveals that forming part of the European Monetary Union increases corporate taxation, which is contrary to what is expected.

Interestingly, *Investment* has a significant negative effect on *Tax*. When governments increase their level of infrastructure investment, at the same time, they decrease the level of corporate tax rates. Note that this finding is well in line with the evidence presented in Eq. (3.9) in Section

3.2. This result confirms that governments compete in both capital taxation and the provision of infrastructure (Hindriks et al., 2008; Zissimos and Wooders, 2008; Pieretti and Zanaj, 2011). From a tax competition perspective, we observe that fiscal interactions are higher if countries have similar infrastructure investment levels. Therefore, it is important to analyze whether fiscal interactions increase when countries are similar in nontax instruments (e.g., infrastructure investment levels).

To test if governments with similar infrastructure investment levels have higher fiscal interactions, a weighting matrix is constructed that accounts for the distance in terms of public infrastructure investment levels. Each element $w_{i,j}$ is computed as follow

$$w_{i,j} = |\frac{1}{invest_j - invest_i}| \tag{3.14}$$

We consider the average of public infrastructure investment in 1995 (which is before the beginning of the estimation period) to avoid endogeneity problems.

Estimations are represented in Table 3.4. The results are similar to the ones obtained with the geographical weighting distance matrices. Thus, we find positive fiscal contemporaneous interactions. It reveals that countries with similar public investment levels incur in fiscal interdependence between their neighbors. From Eq. (3.9) we find that when jurisdictions share similar public input provision, the jurisdiction i decreases its capital taxation in order to be more competitive. Therefore, fiscal interactions are more aggressive between these jurisdictions. Moreover, the coefficients associated to the spatially lagged variables are higher than the geographical distance weighting matrices, meaning that this weighting scheme seems to be more appropriate to model corporate tax interactions. Thus, countries with similar public investment levels incur in higher fiscal interdependence than with countries geographically close. Finally, as it was expected, the other explanatory variables maintain the same coefficients and significance.

3.6 Conclusions

The coordination of capital taxation has been an important issue for both politicians and economists because of inefficiently high international tax competition. As the global harmonization of capital tax rates is difficult to achieve, the literature has focused on the conditions that allow partial tax harmonization. This chapter tests the existence of fiscal interactions among OECD countries, whether or not fiscal interactions are caused by international tax competition, and if fiscal interactions increase when countries have similar levels of public infrastructure investments. We fins that governments compete in both capital taxation and public infrastructure investments in order to attract capital. This fiscal interdependence is higher for countries with similar public investment levels. Therefore, this weighting scheme seems more appropriate to model corporate tax rates interactions. Moreover, we accept the hypothesis that countries with similar public investment levels have higher fiscal interactions in corporate tax rates.

The results imply that, as fiscal interactions are higher for countries with similar public investments, policy makers should focus more to accomplish tax harmonization between the OECD members. The similarity of infrastructure investments can be an instrument to carry out this objective. Sanz-Córdoba & Theilen (2016) show that the coordination of infrastructure investments (i.e. similar levels of public investments) leads countries to be more likely to achieve tax harmonization. Therefore, this might help to reduce the fierce international tax competition that governments are dealing with currently.

Regarding lines of further research, it would be interesting to analyze spatially lagged control variables in order to add new information about the variables that affect corporate tax rates and the interactions of these variables between countries. Taking into account different policy instruments could yield further insights into the rather complex process of fiscal policy decision making at the macro level. Additionally, it would be interesting to analyze a spatial dynamic panel data model including both contemporaneous and time-delayed fiscal interactions.

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Appendix

Table 3.1: Data definitions and sources

Variables	Definition	Measurement	Source
Tax	Combined (statutory) corporate income tax rates	Percentage points, in logaritms.	OECD (2016a); Tax database.
Investment	Total inland transport infrastructure investment	Investment per inhabitant at constant hundreds Euro prices, base year 2010 in logaritms.	OECD (2016c); International Transport Forum.
GDP	Gross domestic product per capita	Per capita in constant thousands US dollars, in logaritms.	World Bank (2016a); World Development Indicators.
Unemployment	Unemployment rate	Percentage points of total working force, in logaritms.	Ameco (2016); OECD (2016c).
Debt	Public debt	Percentage of GDP, in logaritms.	IMF (2016); Historical Public Debt database (HPDD).
Trade	Exports and imports as share of GDP	Percentage of GDP, in logaritms.	World Bank (2016a); World Development Indicators.
Election	Date of election	Date of election as time share over year in election years, 0 in years without elections.	Döring and Manow (2011); Parliament and government composition database (ParGov); Data for the USA is from Benoit and Laver (2006).
Left	Ideology of the leading party in government	Between 1 (hegemony of right-wing parties) to 5 (hegemony of social-democratic and left-wing parties).	Klaus et al. (2015); Comparative Political dataset.
EMU	Economic and Monetary Union of the European Union countries	Dummy variable. 1 = country belongs to EMU, 0 otherwhise.	Own calculation using European Commission historial data.

Table 3.2: Summary Statistics

Variables	Mean	Std. Dev.	Min.	Max.
Tax	29.76	7.87	12.5	56.79
Investment	6.02	8.56	0.04	53.55
GDP	35.73	10.35	11.98	65.07
Unemployment	7.85	3.87	2.24	26.09
Debt	63.09	37.57	9.68	246.17
Trade	83.30	38.39	18.76	209.08
Election	0.15	0.27	0	0.96
Left	2.55	1.51	1	5
EMU	0.35	0.49	0	1

Table 3.3: Results using geographical distance weighting matrices-Row-normalization

	Inverse Distance				Exponential Distance				5-nearest neighbors			
Variables	Coefficient (Std. Error)											
W*Tax	0.15	(0.01)***	0.14	(0.01)***	0.14	(0.01)***	0.13	(0.01)***	0.13	(0.03)***	0.12	(0.02)***
Investment	-0.02	(0.00)**	-0.02	(0.01)**	-0.02	(0.01)**	-0.02	(0.01)**	-0.02	(0.01)**	-0.02	(0.01)***
GDP	-0.08	(0.04)*	0.04	(0.04)	-0.07	(0.04)†	0.04	(0.04)	-0.04	(0.04)	0.08	(0.04)*
Unemployment	-0.03	(0.03)	0.01	(0.03)	-0.03	(0.03)	0.01	(0.03)	-0.03	(0.03)	0.02	(0.03)
Debt	0.07	(0.02)***	0.08	(0.02)***	0.07	(0.02)***	0.09	(0.02)***	0.08	(0.02)***	0.10	(0.02)***
Trade	-0.29	(0.03)***	-0.24	(0.03)***	-0.30	(0.03)***	-0.26	(0.03)***	-0.35	(0.03)***	-0.31	(0.03)***
Election	-0.01	(0.03)	0.00	(0.03)	-0.01	(0.04)	0.01	(0.03)	-0.01	(0.04)	0.01	(0.03)
Left	0.02	(0.01)*	0.01	(0.01)†	0.02	(0.01)*	0.01	(0.01)†	0.02	(0.01)*	0.01	(0.01)†
EMU	0.02	(0.02)	0.03	(0.02)†	0.02	(0.02)	0.03	(0.02)†	0.03	(0.02)	0.04	(0.02)*
Trend		-	-0.02	(0.00)***		-	-0.02	(0.00)***		-	-0.02	(0.00)***

Number of observations: 418. The model include individual fixed effects. ***Significant at 0.1 percent, **Significant at 1 percent, *Significant at 5 percent, and † Significant at 10 percent.

Table 3.4: Results using investment distance weighting matrix

	Distance in investment levels			
Variables	Coefficient (Std. Error)			
W*Tax	0.17	(0.02)***	0.18	(0.02)***
Investment	-0.02	(0.01)*	-0.02	(0.01)**
GDP	-0.06	(0.04)†	0.05	(0.04)
Unemployment	-0.02	(0.03)	0.02	(0.02)
Debt	0.07	(0.02)***	0.08	(0.02)***
Trade	-0.31	(0.03)***	-0.25	(0.02)***
Election	0.00	(0.03)	0.02	(0.03)
Left	0.01	(0.01)*	0.01	(0.01)
EMU	0.02	(0.02)	0.04	(0.02)†
Trend		-	-0.02	(0.00)***

Number of observations: 418. The model include individual fixed effects. ***Significant at 0.1 percent, **Significant at 1 percent, *Significant at 5 percent, and † Significant at 10 percent.

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