Strategic Responses to International Tax Competition: Fiscal (De)Centralization versus Partial Tax Harmonization*

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Abstract

In this article we allow 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 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 and explains the observed difficulties in achieving capital tax harmonization in the EU.

Keywords: Centralization, Decentralization, Fiscal competition, Partial tax harmonization.

JEL Classification Numbers: F15, F38, H20, H87

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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 paper, 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 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 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]

[Insert Figure 1 around here]

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

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

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 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 the 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. This 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 paper 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 paper 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 paper, 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 paper is organized as follows. Section 2 sets up the model. Section 3 studies tax competition between centralized economies. Section 4 elucidates the advantages of unilateral fiscal decentralization. Section 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 6 concludes. All proofs are in the Appendix.

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. The initial capital stock per worker in jurisdiction r in country i is $\overline{k}_{ir} = \frac{1}{6}$. Capital is perfectly mobile between jurisdictions such that the net return to capital, ρ, is determined by the following arbitrage condition

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

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

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

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

$$\Pi_{ir} \equiv f_{ir}(k_{ir}) - f_{ir}'(k_{ir})\, k_{ir} = \frac{b}{2} k_{ir}^2 \tag{3}$$

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. (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

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 6T_i - 6t_{ir} + 2\sum_{j=1}^{3} T_j + \sum_{j=1}^{3}\sum_{s=1}^{2} t_{js}\right) \tag{4}$$

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

$$R_{ir} = t_{ir} k_{ir} + x\Pi_{ir} \text{ and } R_i = \sum_{i=1}^{N} \left(T_i k_{ir} + X\Pi_{ir}\right), \tag{5}$$

respectively. We assume that central governments and jurisdictions 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

[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

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 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).

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. (5), by solving

$$\max_{\tau_{i1},\tau_{i2}} TR_i = \tau_{i1}k_{i1} + \tau_{i2}k_{i2} + \chi\frac{b}{2}\left((k_{i1})^2 + (k_{i2})^2\right), \quad i = 1, 2, 3. \tag{6}$$

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

$$\tau_{ir} = \frac{3-2\chi}{30-13\chi}\left(\gamma_i + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right) + \frac{6-5\chi}{30-13\chi}\tau_{is} \tag{7}$$

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

[6] The details are in the Appendix.

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. (7) the Nash-equilibrium capital tax rates are given by

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

and the equilibrium total tax receipts in country i are

$$TR_i^C = \frac{4(3-\chi)}{b(3-2\chi)^2}\left(\tau_{ir}^C\right)^2. \tag{9}$$

From Eq. (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. (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.*

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

$$\max_{t_{1r}} R_{1r} = t_{1r}k_{1r} + x\frac{b}{2}\left(k_{1r}\right)^2,\ \ r = 1, 2, \tag{10}$$

$$\max_{T_1} R_1 = \sum_{r=1}^{2}\left(T_1 k_{1r} + X\frac{b}{2}\left(k_{1r}\right)^2\right), \tag{11}$$

$$\max_{\tau_{i1},\tau_{i2}} TR_i = \tau_{i1}k_{i1} + \tau_{i2}k_{i2} + \chi\frac{b}{2}\left(\left(k_{i1}\right)^2 + \left(k_{i2}\right)^2\right),\ \ i = 2, 3. \tag{12}$$

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

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

$$\tau_{1r}^{D} = \frac{1}{12}(27-10\chi)\frac{5b+8\epsilon-2b\chi}{33-10\chi}, r=1,2 \tag{13}$$

$$\tau_{ir}^{D} = \frac{1}{12}(3-2\chi)\frac{37b-20\epsilon-10b\chi}{33-10\chi},\ i=2,3; r=1,2. \tag{14}$$

Substituting Eqs. (13) and (14) into Eqs. (10) - (12), yields the corresponding tax revenues

$$TR_1^D = \frac{20(27-5\chi)}{b(27-10\chi)^2}\left(\tau_{1r}^{D}\right)^2 \quad \text{and} \quad TR_i^D = \frac{4(3-\chi)}{b(3-2\chi)^2}\left(\tau_{ir}^{D}\right)^2,\ i=2,3. \tag{15}$$

A comparison of Eqs. (8) and (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

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.*

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

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.

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 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

$$\max_{\tau_c} TR_1 + TR_2 = \tau_c \sum_{i=1,2} \sum_{r=1,2} k_{ir} + \frac{b}{2}\chi \sum_{i=1,2} \sum_{r=1,2} k_{ir}^2, \text{ and} \tag{16}$$

$$\max_{\tau_{31},\tau_{32}} TR_3 = \tau_{31} k_{31} + \tau_{32} k_{32} + \frac{b}{2}\chi \left((k_{31})^2 + (k_{32})^2 \right). \tag{17}$$

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

$$\tau_c^H = \frac{1}{12}(5b + 2\epsilon - 2b\chi) \text{ and } \tau_{3r}^H = \frac{1}{12}(3 - 2\chi)\frac{4b - 2\epsilon - b\chi}{3 - \chi}, \ r = 1, 2. \tag{18}$$

From the above expressions, the corresponding total tax revenues are

$$TR_i^H = \frac{1}{b}\left(\frac{6 - \chi}{3 - \chi}\tau_c - (-1)^i \frac{\epsilon}{2}\chi\right)\left(\frac{\tau_c}{3 - \chi} - (-1)^i \frac{\epsilon}{2}\right), \ i = 1, 2, \text{ and} \tag{19}$$

$$TR_3^H = \frac{4(3 - \chi)}{b(3 - 2\chi)^2}\left(\tau_{3r}^H\right)^2. \tag{20}$$

[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).

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

From a comparison of Eqs. (8) and (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.

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. 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, 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.

[Insert Figure 2 around here]

As shown in Figure 3, the results in Proposition 4 are empirically confirmed with 2014 data for a panel of selected OECD economies. Figure 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 is approximated by the share of local and regional capital tax revenues over total capital tax revenues. Potential gains from tax harmonization

[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.

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 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 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 ????? 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.

[Insert Figure 3 around here]

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 article 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, as fiscal decentralization is an important handicap to achieve partial tax harmonization, a primary objective of policy makers that want to accomplish a voluntary harmonization of capital taxation should be to reduce the degree of fiscal decentralization of the coalition member countries and to increase the level of labor taxation.

The analysis is based on a highly stylized model. Nevertheless, some final comments regarding the robustness of the results are indicated. First, we have considered a three-country model with two-jurisdictions each. However, our main results can be generalized straightforwardly to the case in which we have more countries and jurisdictions. On one hand, generally, tax harmonization is more difficult to achieve if more countries are inside the tax coalition. Similarly, it is more difficult to form a tax coalition with more countries outside the tax coalition as tax competition is more fierce. On the other hand, when there are more jurisdictions, the negative vertical externality increases and it is less compensated by a mitigation of horizontal tax competition among countries, leading an inefficient increase in the consolidated capital tax rate. Second, we have assumed that only one

country chooses strategically its strategy. If the number of countries that can choose their strategies increases, the lower level jurisdictions are the ones that would choose to form a tax coalition with another country because these lower level jurisdictions can deviate easily as are worse off in the tax harmonization. If the number of countries that decide to choose fiscal decentralization increase, the combined capital taxation would increase even more because of the negative vertical externality and for the strategic complementarity of tax rates that would increase the tax rates of the other countries. Finally, we have not allowed for endogenous labor taxes. From Zodrow and Mieszkowski (1986) and Bucovetsky and Wilson (1991) we know that allowing for immobile factors (i.e., labor taxation) would shift the tax burden from capital to labor tax rates and it would increase the horizontal tax competition. Thus, endogeneizing labor taxes would increase the consolidated capital tax rate from the unilateral fiscal decentralization but to a less extent.

Our model can be extended in several directions. Thus, it could be complemented by considering that jurisdictions not only compete in taxes but also in nontax instruments (e.g. infrastructure investments) which it would be interesting to analyze how the interplay of diverse instruments affect our results. Finally, employing a dynamic version of our model would allow to investigate under which conditions partial tax harmonization is more difficult to achieve in fiscally decentralized economies in the long run across developed countries.

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Appendix

Proof of the results in Section 3. Making use of $\tau_{ir} \equiv T_i + t_{ir}$, the amount of capital invested in jurisdiction ir in Eq. (4) writes as

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 5\tau_{ir} + \tau_{is} + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right). \tag{21}$$

Then, the first-order conditions resulting from Eq. (9) are:

$$\begin{aligned}\frac{\partial TR_i}{\partial \tau_{ir}} &= \tau_{ir}\frac{\partial k_{ir}}{\partial \tau_{ir}} + k_{ir} + \tau_{is}\frac{\partial k_{is}}{\partial \tau_{ir}} + \chi\frac{b}{2}\left(2k_{ir}\frac{\partial k_{ir}}{\partial \tau_{ir}} + 2k_{is}\frac{\partial k_{is}}{\partial \tau_{ir}}\right) \\ &= \frac{3-2\chi}{18b}\left(\gamma_i + \tau_{jr} + \tau_{js} + \tau_{hr} + \tau_{hs}\right) - \frac{30-13\chi}{18b}\tau_{ir} + \frac{6-5\chi}{18b}\tau_{is} = 0, \end{aligned} \tag{22}$$

$i, j, h = 1, 2, 3;\ j \neq i,\ h \neq i, j;\ r, s = 1, 2;\ r \neq s$. 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 (22) yields the equilibrium tax rates

$$\tau_{ir} = \frac{1}{36}\left(3-2\chi\right)\frac{3\left(3\gamma_i + \gamma_j + \gamma_h\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{5-2\chi}, \tag{23}$$

which by using $\gamma_1 = b + 4\epsilon$ and $\gamma_2 = \gamma_3 = b - 2\epsilon$ can be written as in Eq. (8). The equilibrium capital investments are

$$k_{ir}^C = \frac{2\tau_{ir}}{\left(3-2\chi\right)b}. \tag{24}$$

From Eqs. (9) and (24) we observe that sufficient conditions for positive tax revenues and capital investments are that $\tau_{ir}^C > 0$. It follows from Eq. (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,

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

which proves the statement. ■

Proof of the results in Section 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. (4) writes as

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

The first-order conditions corresponding to Eqs. (10) - (12) are

$$\begin{aligned} \frac{\partial R_{1r}}{\partial t_{1r}} &= k_{1r} + t_{1r}\left(\frac{\partial k_{1r}}{\partial t_{1r}}\right) + xbk_{1r}\left(\frac{\partial k_{1r}}{\partial t_{1r}}\right) \\ &= \frac{6-5x}{36b}\left(\gamma_1 - 4T_1 + t_{1s} + \tau_{21} + \tau_{22} + \tau_{31} + \tau_{32}\right) - \frac{5\left(12-5x\right)}{36b}t_{1r} = 0, \quad (25) \\ \frac{\partial R_1}{\partial T_1} &= k_{11} + k_{12} + T_1\left(\frac{\partial k_{11}}{\partial T_1} + \frac{\partial k_{12}}{\partial T_1}\right) + 2X\frac{b}{2}\left(k_{11}\frac{\partial k_{11}}{\partial T_1} + k_{12}\frac{\partial k_{12}}{\partial T_1}\right) \\ &= \frac{3-2X}{9b}\left(\gamma_1 - 2t_{11} - 2t_{12} + \tau_{21} + \tau_{22} + \tau_{31} + \tau_{32}\right) - \frac{8\left(3-X\right)}{9b}T_1 = 0, \quad (26) \\ \frac{\partial TR_i}{\partial \tau_{ir}} &= k_{ir} + \tau_{ir}\left(\frac{\partial k_{ir}}{\partial \tau_{ir}}\right) + \tau_{is}\left(\frac{\partial k_{is}}{\partial \tau_{ir}}\right) + 2\chi\frac{b}{2}\left(k_{ir}\left(\frac{\partial k_{ir}}{\partial \tau_{ir}}\right) + k_{is}\left(\frac{\partial k_{is}}{\partial \tau_{ir}}\right)\right) \\ &= \frac{3-2\chi}{18b}\left(\gamma_i + 2T_1 + t_{11} + t_{12} + \tau_{jr} + \tau_{js}\right) - \frac{30-13\chi}{18b}\tau_{ir} + \frac{6-5\chi}{18b}\tau_{is} = 0, \quad (27) \end{aligned}$$

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

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

Solving the system of equations in (25)-(27) yields the equilibrium tax rates

$$\begin{aligned} t_{1r} &= \frac{6-5x}{18}\frac{3\left(3\gamma_1 + \gamma_2 + \gamma_3\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{33-10\chi}, \ r = 1,2 \quad (28) \\ T_1 &= \frac{5\left(3-2X\right)}{36}\frac{3\left(3\gamma_1 + \gamma_2 + \gamma_3\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{33-10\chi} \quad (29) \\ \tau_{ir} &= \frac{3-2\chi}{36}\frac{3\left(45\gamma_1 + 103\gamma_i + 37\gamma_j\right) - 4\chi\left(26\gamma_1 + 41\gamma_i + 26\gamma_j\right) + 20\chi^2\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{\left(5-2\chi\right)\left(33-10\chi\right)}, \quad (30) \end{aligned}$$

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

$$\tau_{1r} = T_1 + t_{1r} = \frac{1}{36}\left(27-10\chi\right)\frac{3\left(3\gamma_1 + \gamma_2 + \gamma_3\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{33-10\chi}. \quad (31)$$

The equilibrium capital investments are

$$k_{1r}^D = \frac{10\tau_{1r}}{\left(27-10\chi\right)b} \quad \text{and} \quad k_{ir}^D = \frac{2\tau_{ir}}{\left(3-2\chi\right)b}, \quad i = 2,3. \quad (32)$$

Substituting $\gamma_1 = b+4\epsilon$ and $\gamma_2 = \gamma_3 = b-2\epsilon$ in Eqs. (30) and (31), we get the equilibrium tax rates in (13) and (14).

From Eqs. (15) and (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. (8) and (13) we obtain

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

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. (9) and (15)

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

and, noticing that $\tau_{ir}^D > \tau_{ir}^C$, from Eqs. (9) and (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 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. (4) writes as

$$k_{ir} = \frac{1}{6b}\left(\gamma_i - 2\tau_c + \tau_{3r} + \tau_{3s}\right),\ i = 1,2,\ r,s = 1,2 \tag{33}$$

$$k_{3r} = \frac{1}{6b}\left(\gamma_3 - 5\tau_{3r} + \tau_{3s} + 4\tau_c\right),\ r,s = 1,2. \tag{34}$$

The first-order conditions corresponding to (16) and (17) are

$$\begin{aligned}\partial\frac{TR_1 + TR_2}{\partial\tau_c} &= \sum_{i=1,2}\sum_{r=1,2} k_{ir} + \tau_c \sum_{i=1,2}\sum_{r=1,2}\frac{\partial k_{ir}}{\partial\tau_c} + b\chi\sum_{i=1,2}\sum_{r=1,2} k_{ir}\frac{\partial k_{ir}}{\partial\tau_c} \\ &= \frac{1}{3b}\left(\gamma_1 + \gamma_2 + 2\tau_{31} + 2\tau_{32}\right)\left(1 - \frac{1}{3}\chi\right) - \frac{4\left(6-\chi\right)}{9b}\tau_c = 0 \qquad (35) \\ \frac{\partial TR_3}{\partial\tau_{3r}} &= k_{3r} + \tau_{3r}\frac{\partial k_{3r}}{\partial\tau_{3r}} + \tau_{3s}\frac{\partial k_{3s}}{\partial\tau_{3r}} + b\chi\left(k_{3r}\frac{\partial k_{3r}}{\partial\tau_{3r}} + k_{3s}\frac{\partial k_{3s}}{\partial\tau_{3r}}\right) \\ &= \frac{\left(3-2\chi\right)\left(\gamma_3 + 4\tau_c\right)}{18b} - \frac{30-13\chi}{18b}\tau_{3r} + \frac{6-5\chi}{18b}\tau_{3s} = 0, \qquad (36)\end{aligned}$$

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

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

Solving the system of equations in (35) and (36) yields the equilibrium tax rates

$$\tau_c = \frac{3\left(2\gamma_1 + 2\gamma_2 + \gamma_3\right) - 2\chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{36} \tag{37}$$

$$\tau_{3r} = \frac{1}{36}\left(3-2\chi\right)\frac{3\left(\gamma_1 + \gamma_2 + 2\gamma_3\right) - \chi\left(\gamma_1 + \gamma_2 + \gamma_3\right)}{3-\chi},\ r = 1,2 \tag{38}$$

and the equilibrium capital investments

$$k_{ir}^H = \frac{\frac{1}{12}\left(3-\chi\right)\left(\gamma_i - \gamma_j\right) + \tau_c}{b\left(3-\chi\right)},\ i,j,r = 1,2;\ j \neq i \tag{39}$$

$$k_{3r}^H = \frac{2\tau_{3r}}{\left(3-2\chi\right)b},\ r = 1,2. \tag{40}$$

Finally, substituting $\gamma_1 = b + 4\epsilon$ and $\gamma_2 = \gamma_3 = b - 2\epsilon$ in Eq. (37) and (38), we get the equilibrium tax rates in (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.(18) and (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. (8) and (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. (8) and (**??**) 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. (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. (9) and (19) this yields

$$\begin{aligned} &(2-\chi)(21-8\chi)(5-2\chi)^2 \\ &+4(5-2\chi)\left(393-478\chi+188\chi^2-24\chi^3\right)\frac{\epsilon}{b} \\ &+4\left(2078\chi-2926\chi^2+1617\chi^3-396\chi^4+36\chi^5-228\right)\left(\frac{\epsilon}{b}\right)^2 > 0 \text{ for } \epsilon < 0 \end{aligned} \quad (41)$$

and

$$\begin{aligned} &(2-\chi)(21-8\chi)(5-2\chi)^2 \\ &-4(5-2\chi)\left(309-404\chi+172\chi^2-24\chi^3\right)\frac{\epsilon}{b} \\ &+4\left(3842\chi-3646\chi^2+1713\chi^3-396\chi^4+36\chi^5-1632\right)\left(\frac{\epsilon}{b}\right)^2 > 0 \text{ for } \epsilon > 0. \end{aligned} \quad (42)$$

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. (41) and $f_2(\chi)$ is the lower root of Eq. (42). Figure 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.

■

[Insert Figure 4 around here]

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. (15) and (19) this yields the conditions

$$\begin{aligned} (5-2\chi)\left(558-303\chi+40\chi^2\right) & \\ +4\left(5499-5370\chi+1780\chi^2-200\chi^3\right)\frac{\epsilon}{b} & \\ -4\left(828-5946\chi+5086\chi^2-1515\chi^3+150\chi^4\right)\left(\frac{\epsilon}{b}\right)^2 & > 0 \text{ and } (43) \\ 5166-9711\chi+6204\chi^2-1660\chi^3+160\chi^4 & \\ -4\left(24\,795-35\,946\chi+19\,308\chi^2-4560\chi^3+400\chi^4\right)\frac{\epsilon}{b} & \\ -4\left(21\,024-49\,734\chi+43\,962\chi^2-18\,547\chi^3+3780\chi^4-300\chi^5\right)\left(\frac{\epsilon}{b}\right)^2 & > 0. \quad (44) \end{aligned}$$

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. (43) and $g_2(\chi)$ is the lower root of Eq. (44). Figure 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. ■

[Insert Figure 5 around here]

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 $\frac{\epsilon}{b} \in \left(-\frac{5-2\chi}{20-6\chi}, \frac{5-2\chi}{16-6\chi}\right)$ ■

7 Figures

Capital tax decentralization by quartiles (period 1995 to 2014)

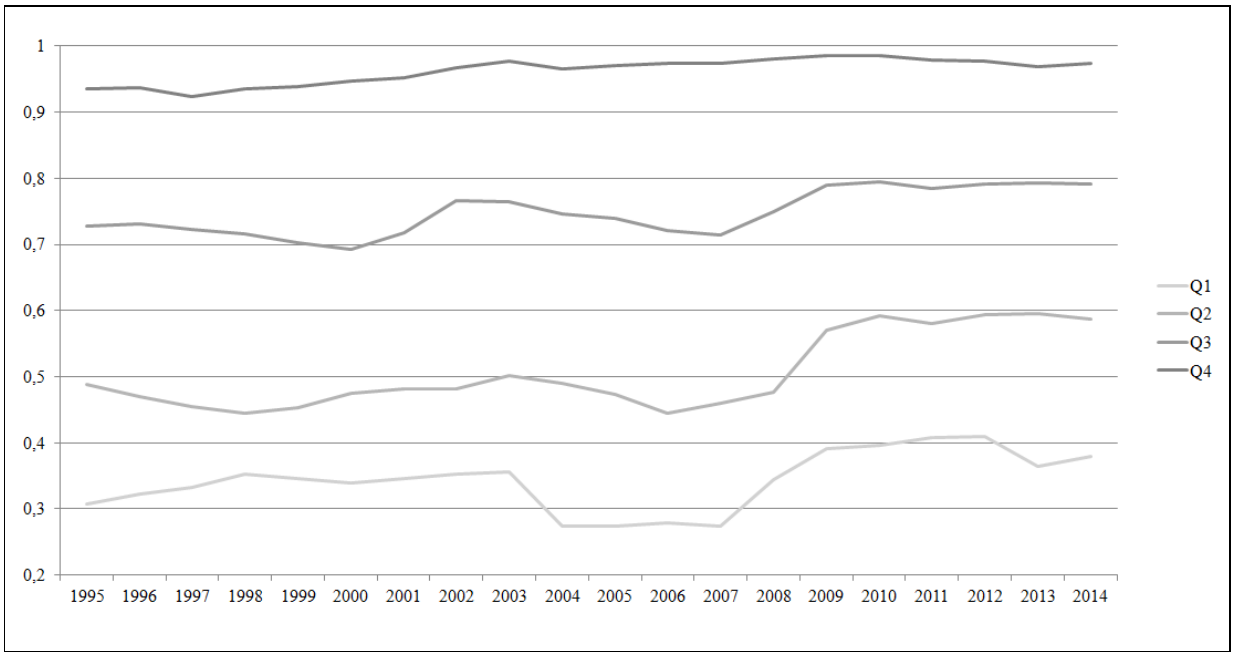

Figure 1: Countries are classified into quartiles by degree of capital tax decentralization. Quartile 1 includes Austria, Estonia, Greece, Iceland, Ireland, Italy, Luxembourg, Sweden, Turkey, and United Kingdom. Quartile 2 encompasses Chile, Czech Republic, Finland, Israel, Netherlands and Norway are 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. Source: Own calculation based on OECD (2017).

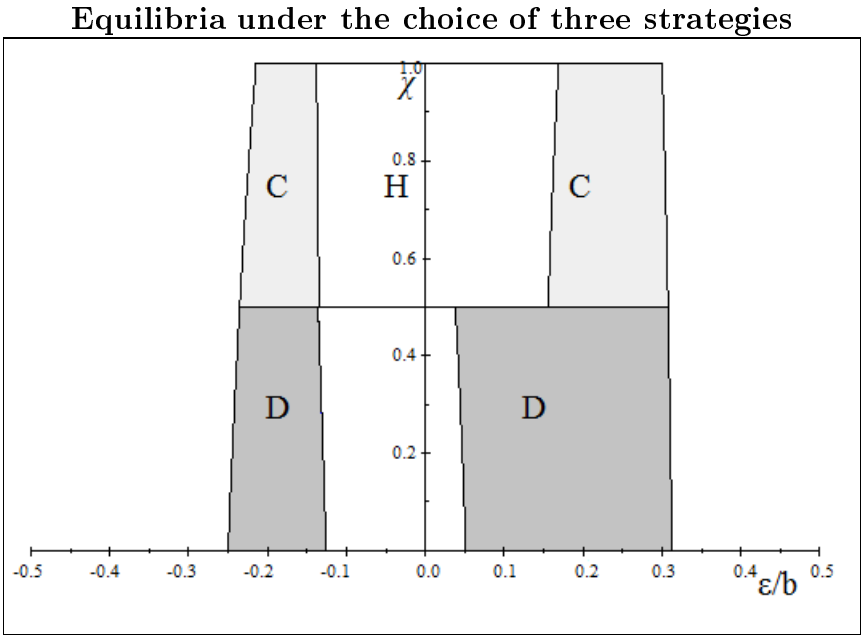

Figure 2: Equilibria are: H (partial tax harmonization), C (centralization) and D (decentralization).

Data panel for a selected OECD countries (period 2014)

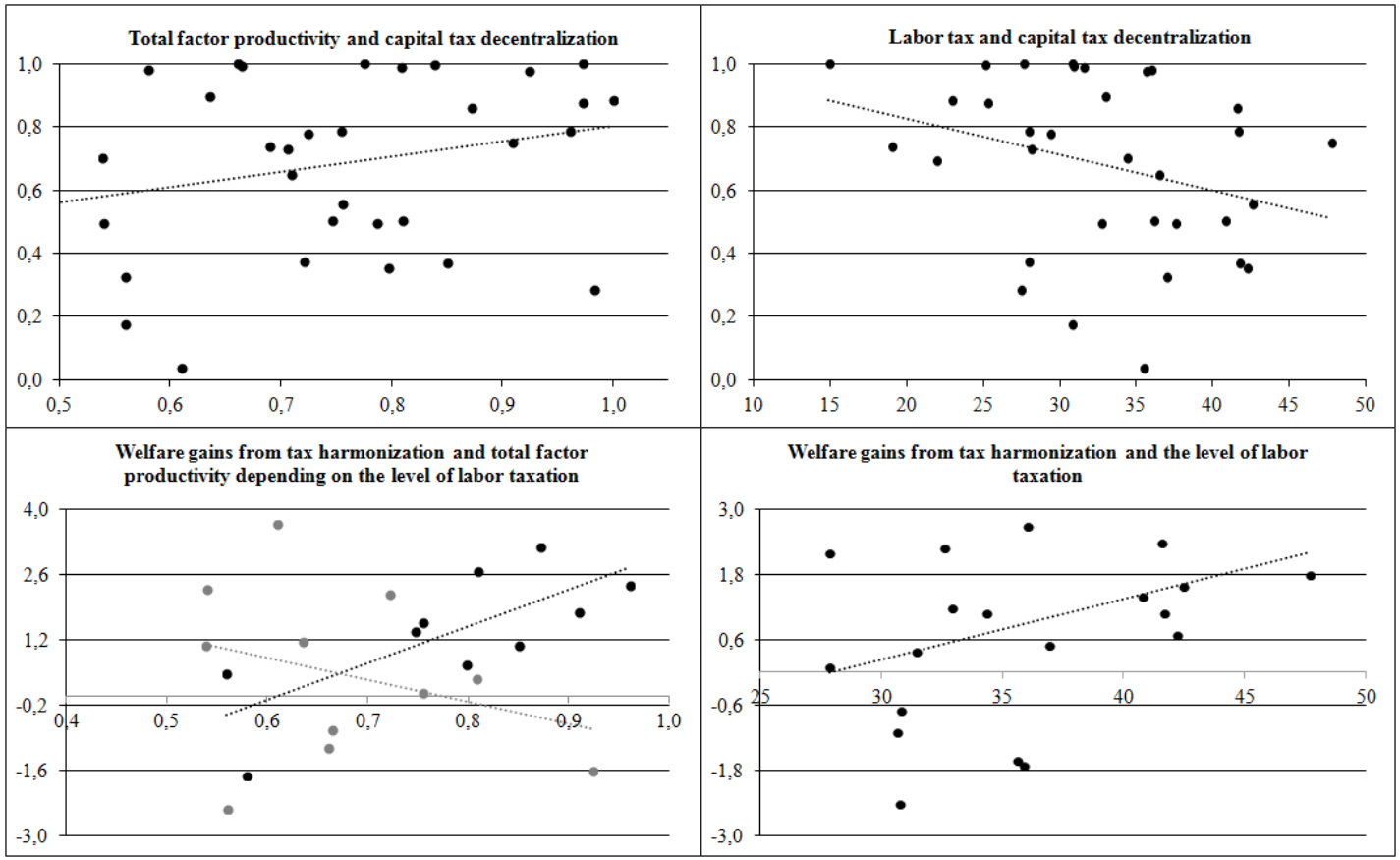

Figure 3: Countries with high levels of labor taxation are Austria, Belgium, Denmark, Finland, France, Hungary, Italy, Netherlands, Slovenia, and Sweden (black dots). Low level of labor taxation countries are Czech Republic, Estonia, Germany, Greece, Latvia, Luxembourg, Poland, Portugal, Slovak Republic, Spain, United Kingdom (grey dots).Source: Own calculation based on Brøchner et al. (2007), Feenstra, et al. (2015), and OECD (2017).

Equilibria under centralization and partial tax harmonization

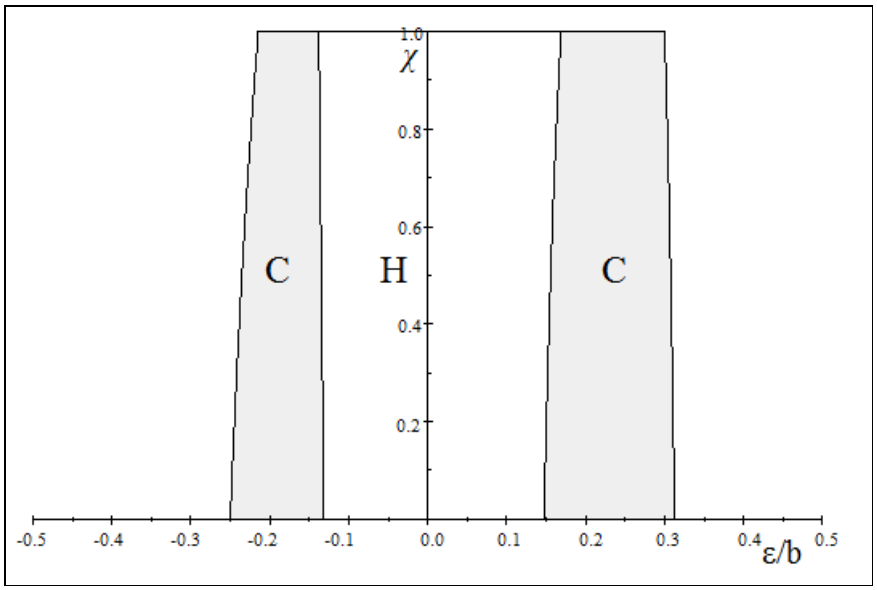

Figure 4: Equilibria are: H (partial tax harmonization), and C (centralization).

Equilibria under fiscal decentralization and partial tax harmonization

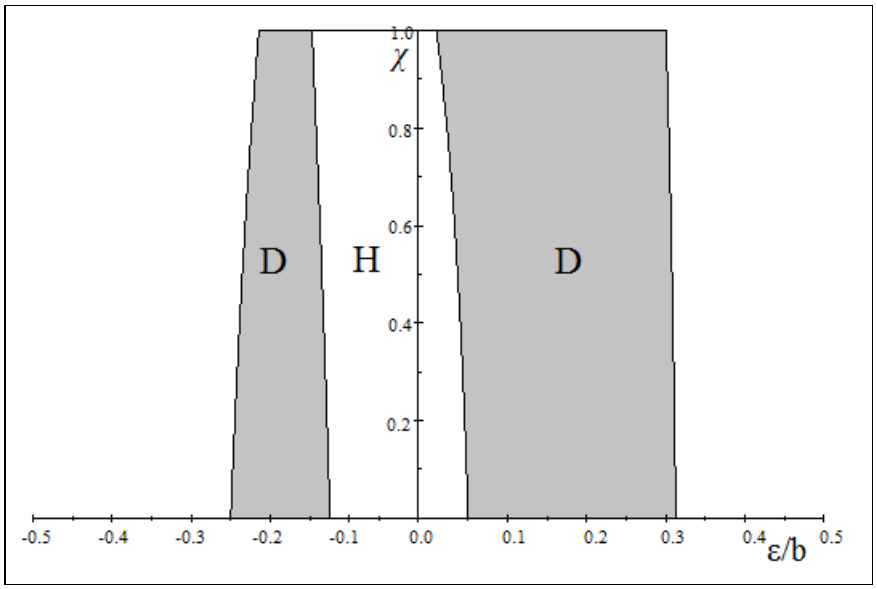

Figure 5: Equilibria are: H (partial tax harmonization), and D (decentralization).