Limits to Competition: Strategies for Promoting Jurisdictional Cooperation*

David R. Agrawal†

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Abstract

Inefficiencies from tax competition may result in governments seeking to limit fiscal competition via tax treaties, harmonization, minimum tax rates, or interjurisdictional cooperation. I propose a general model applicable to studying many types of taxing instruments, which allows for the comparison of various policy responses to promote jurisdictional cooperation. Comparing across policies, the model suggests a clear dominance of partial harmonization among a subset of jurisdictions. Minimum tax rates revenue-dominate complete harmonization, but fail to raise revenues as much as partial harmonization. A selective review of the empirical literature identifies evidence consistent with the predictions of the theoretical model. The framework sketched in this paper can be further enriched by researchers seeking to determine the welfare effects of policy responses to interjurisdictional competition.
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†University of Kentucky, Martin School of Public Policy & Administration and Department of Economics, 433 Patterson Office Tower, Lexington, KY 40506-0027; email: dragrawal@uky.edu; phone: 001-859-257-8608. Agrawal is also a Fellow of CESifo.

1 Introduction

Technological change, economic integration, and globalization are increasing pressure on decentralized fiscal systems, spurring calls for policy coordination among jurisdictions to mitigate harmful tax competition. Tax competition is the process by which independent jurisdictions noncooperatively set taxes and where each government's tax policies influence the allocation of the mobile tax base among competing jurisdictions.[1] The noncooperative setting of tax policies in an open economy setting results in interjurisdictional tax differentials that creates incentives for interjurisdictional tax avoidance by people, factors, firms, profits and shoppers. This tax-induced mobility imposes interjurisdictional fiscal and economic externalities on other jurisdictions—a tax increase in one jurisdiction expands the tax base of other jurisdictions and may expand economic activity in other jurisdictions—possibly resulting in strategic interactions among governments. These externalities on other jurisdictions imply that the tax competition equilibrium will be inefficient, as the jurisdiction enacting the policy will not account for the externalities. As a result, there generally exists a coordinated equilibrium that would be chosen by a social (federal) planner that yields strictly higher welfare in *every* country.

Within federal systems, the inefficiencies from local tax competition—*usually* viewed as resulting in tax rates that are too low—may result in a central governments seeking to limit competition.[2] The tools that central governments have to limit competition among subnational jurisdictions are abundant, ranging from complete tax harmonization of local tax rates to minimum taxes. In addition, federal systems may facilitate intermunicipal cooperation where taxes and services are delegated to a higher level of government, allowing for partial harmonization of taxes among a subset of jurisdictions. More generally, at the state level, jurisdictions may enter into tax treaties or interstate compacts that change how taxes are sourced or enforced. Despite how common these policy limits are in federal systems, cooperation and coordination remains understudied. In this article, I review the existing theoretical and empirical evidence on these limits, derive new results for interjurisdictional cooperation using a simple model that allows me to compare a wide *variety* of policy limits on competition, and reflect on possible future research on the topic. The recent debate on the global minimum tax highlights both the policy importance of the topic, as well as the need for additional research on the topic.

Despite the policy importance of potential limits to tax competition, many unanswered questions in open economy public economics remain. How diverse are tax rates in

[1] See Wilson and Wildasin (2004).

[2] Of course, there are reasons one would want to encourage competition among governments. For example, if governments are Leviathan, then tax competition can be useful to discipline the Leviathan (Brülhart and Jametti 2019).

an increasingly globalized and "border-free" world when there is no central coordination of tax policies across jurisdictions? What forms of coordination could benefit *all* jurisdictions? Benefit *some* jurisdictions? If allowed to cooperate in setting fiscal policies, with whom will jurisdictions form coalitions, and how do these coalitions influence the patterns of tax rates set across jurisdictions? Does coordination raise or lower tax rates and revenues? Does coordination influence the location of firms, factors, people, and economic activity? What coordination policies improve world-wide total revenue the most? Improve welfare the most? Should we have more or less decentralization of tax policy?

Although many questions remain, a significant literature and many surveys have been devoted to the study of tax competition and coordination (Agrawal, Hoyt and Wilson 2022; Keen and Konrad 2013; Wilson 1999; Brülhart, Bucovetsky and Schmidheiny 2015; Wilson and Wildasin 2004; Wildasin 2021; Brueckner 2003). However, a major challenge facing the literature on policy limits to tax competition is that most theoretical models of tax coordination are designed to focus on either a *particular* tax (corporate tax, consumption tax, etc.) or a *particular* policy remedy (harmonization, minimum tax rates, cooperation, etc.). As a result, the ability to make generalizations across various taxes, and perhaps more importantly, across various remedies to tax competition is limited. But governments often debate which coordination policies are best and for which tax bases, so a framework that is broadly applicable is necessary. A major goal of this paper is to propose a general model that is applicable to the study of many types of taxing instrument and across many types of policy responses.

To do this, I build on the Kanbur and Keen (1993) model—which while designed to study commodity tax competition—has been shown by Keen and Konrad (2013) to be applicable to any tax policies where the tax base can be *shifted* across jurisdictions at some cost to the taxpayer. The generality of the shifting behavior—profit shifting, migration, capital flight, cross-border shopping—allows for potential applications to corporate taxes, capital taxes, commodity taxes, or income taxes, among others. Jurisdictions in the model maximize tax revenues and interact strategically—game theoretically—when setting equilibrium tax rates. The general model is then used to compare various policy responses to tax competition, including tax harmonization, minimum tax rates, forced cooperation (resulting in partial harmonization), voluntary cooperation with endogenous coalition formation, and tax treaties on sourcing rules. The comprehensive scope of the policies considered allows for novel comparisons of the pros and cons of various policy responses not possible in the prior literature. Of course, any such general model must make some assumptions and simplifications. I believe the model is general enough to capture the central features of tax competition and tax base mobility, but *simple* enough that it yields *sharp* insights into the policy debates to limit competition. The simplifications made here can be relaxed in future research.

The model, featuring two symmetrically sized jurisdictions and an single jurisdiction that may be larger or smaller, yields several key insights:

1. If most jurisdictions are small, harmonization will only increase tax revenues in all jurisdictions if harmonization is to a tax rate that is sufficiently close to the highest uncoordinated tax rate. If instead, if most jurisdictions are large, tax harmonization may harm the smaller jurisdiction, while benefiting the larger ones.

2. If most jurisdictions are small, a binding minimum tax rate will improve tax revenues in all jurisdiction *regardless* of the level of the minimum tax rate. If instead, most jurisdictions are large, a binding minimum tax rate will still improve tax revenues in all jurisdictions if the size differences between the jurisdictions are sufficiently small.

3. If a subset of jurisdictions are forced to cooperate, regardless of the combination of the jurisdictions forced to cooperate, tax rates rise in all jurisdictions relative to the uncoordinated equilibrium, but tax revenues may fall in some jurisdictions. There exist scenarios when revenues increase in all jurisdictions, including non-members of the coalition, under cooperation.

4. If jurisdictions can choose with whom to cooperate, assuming that side-payments are not possible, a coalition between two asymmetric jurisdictions can only arise if the jurisdictions are sufficiently similar in their sizes.

5. From the perspective of total (combined) tax revenue across all jurisdictions, a coalition resulting in a common tax rate within the coalition revenue-dominates minimum tax rates, which in turn, dominate complete harmonization. If there are more smaller jurisdictions than larger jurisdictions, then a coalition between an asymmetric and symmetric jurisdiction revenue-dominates any other coalition, while if the reverse is true, a coalition of two symmetric jurisdictions revenue-dominates all alternative policies.

Comparing across policies, the model suggests a clear dominance of minimum tax rates over complete harmonization. However, with minor caveats, interjurisdictional cooperation (partial harmonization among a subset of jurisdictions) also dominates both harmonization and minimum tax rates. The reason for this dominance of partial harmonization is important for policy: with cooperation, the coalition government harmonizes tax rates to its best value—taking as given the taxes of nonmembers—without any centrally imposed constraints. With minimum tax rates or centralized harmonization, policy proposals restrict the set of coordinated tax rates to be in *between* the uncoordinated equilibrium tax rates. But if tax competition results in taxes being too low in the uncoordinated equilibrium, a reform that uses those low-rates to limit competition, will be less effective than those reforms that do not constrain the coordinated equilibrium tax rates to be between the observed equilibrium rates. Indeed, there are a whole host of coordinated tax rates that are revenue-superior to the non-cooperative equilibrium and also revenue improving for *all* jurisdictions, suggesting that there exist many policies limiting tax competition that may be welfare improving.

After detailing the theoretical model and its results, I selectively survey the empirical evidence on the efficacy of policies limiting tax competition. In particular, I emphasize empirical studies that use mobility elasticities to construct counterfactual exercises following the implementation of various policy implementations. I also discuss the empirical evidence on the effects of intermunicipal cooperation, commonly used around the world, on the level of tax rates, the costs imposed on municipalities from joining, and the effect of cooperation on strategic tax competition. Overall, the empirical literature generally confirms the predictions of the theoretical model.

Finally, I conclude with directions for future research. While the model I present is stylized, it represents a starting point for researchers seeking to systematically compare different policy interventions. Given the increase in data availability for subnational taxing policies and the advances in spatial empirical designs, the empirical future for studying the efficacy of these policies is ripe for further study.

2 Policies to Limit Cooperation

Fiscal federations and supra-national institutions such as the European Union have numerous tools at their disposal to limit tax competition.[3] And more recently, the global minimum tax (Johannesen 2022) highlights the possibility that these policy tools may be implementable at the international level. In this section, I classify various types of policy responses into various intervention categories.

2.1 The Level of Government

Within federal systems, which level of governments should be assigned particular spending and tax policies? A state or federal government could limit tax competition by granting taxing rights to a higher level of government—in the most extreme case, this would

[3] Of course, as in the tradition of Tiebout (1956), an argument can be made that we want to facilitate rather than limit tax competition in the same way we want to facilitate competition between private firms. When thinking about limits to tax competition, policymakers addressing the parasitic effects arising from interjurisdictional fiscal externalities.

involve centralizing the tax base entirely.[4] Some of these rules may be codified in state constitutions. The argument for centralization is that tax base mobility is more limited across international borders than across state and local borders. However, centralization comes at the cost of limiting local autonomy.

There are many examples of taxes or expenditures that have been centralized over time. For example, departments in France have taken over many function of the French Communes and Dutch regional police forces were centralized. Sometimes, however, the responses to centralization are unpopular and may lead to a renewed wave of decentralization (for debate on the topic, see, Inman and Rubinfeld 1997; Musgrave 1997; Donahue 1997; Qian and Weingast 1997). Other examples of the extent of centralization from the United States are that local sales taxes are allowed in over thirty U.S. states, but the remainder of states have outright bans on localities levying local sales taxes. In some of these cases, the state government elects to levy a state sales tax, but prohibits the use of local tax rates on the same base. Of course, there are varying degrees to these types of restrictions and the extent of decentralization: some states might allow municipalities to set the rates, while in other states the rates might be set by the higher-level county. Delegating tax authority to a higher level of government may mitigate tax competition by reducing the number of competitors. Hoyt (1991) shows that as the number of jurisdictions decreases, tax rates rises. Loosely speaking, decreasing the number of jurisdictions acts to reduce the tax base externality produced by a single jurisdiction's policy on other jurisdiction in the federal system (shifting of capital to other jurisdictions from a tax change).

Of course, federal systems might also reduce the externality produced by a single jurisdiction's policy by forcing local governments to amalgamate. Municipal mergers may reduce tax competition, but may also come with economies of scale in the provision of public services. Amalgamations are sometimes forced upon lower-level governments by higher level governments seeking to consolidate the number of jurisdictions, but some mergers arise voluntarily. Amalgamations were a key part of 1970s reforms in the UK, which were aimed at increasing the population sizes of municipalities. To a lesser extent, amalgamations were common in Sweden and Germany, but are perhaps less common in the United State (Epple and Romer 1989).

2.2 Tax Coordination

Tax coordination broadly refers to policies that place limitations on the tax rates that governments can set. These policies include harmonization, minimum tax rates, max-

[4] For a complete discussion of the assignment problem, see Boadway and Shah (2009). Janeba and Wilson (2011) discuss the tradeoffs of centralization and decentralization.

imum tax rates, or tax and expenditure limitations. One common policy proposal is that jurisdictions harmonize tax rates to a single centrally determine tax rate. Harmonization effectively closes the borders to tax-induced avoidance schemes, which benefits jurisdictions, but may come with a revenue cost of lowering tax rates for some jurisdictions. Proposals for tax harmonization usually stimulate the single harmonized rate is a weighted average of the tax rates that arise in the non-cooperative equilibrium (Keen 1987; Keen 1989; Keen, Lahiri and Raimondos-Möller 2002). As will become clear in the analysis below, such a harmonization proposal, however, fails to entirely eliminate the negative consequences of tax competition. In particular, tax competition distorts taxes, perhaps downward, in a way that taking an average of these observed taxes may not actually move some jurisdictions to a more efficient tax rate. Indeed, harmonization might move some jurisdictions away from their efficient rate.

A simple way to see this is that in a standard tax competition model, if all jurisdictions are symmetric, all taxes will be equalized in the noncooperative equilibrium. But the presence of fiscal externalities still implies that coordination could be welfare improving, but as there are no tax differentials, uncoordinated tax rates are already harmonized. As a result, there are no gains from harmonization to a weighted average of the noncooperative rates. Thus, in an ideal world, harmonization proposals would best be to a weighted average to the optimal tax rates in the absence of tax competition. But, these rates are unobserved, making such a hypothetical rate impossible. Thus, in practice, uncoordinated equilibrium rates act as a proxy for this ideal rate, but using this proxy misses the *level* effects that tax competition has on all jurisdictions' tax rates. Harmonization also comes with the challenge that jurisdictions need to agree on the tax rate—or the weights determining that rate—to which to harmonize.

A possible alternative might be that jurisdictions establish a minimum tax rate (or perhaps alternatively depending on whether taxes are "too high" or "too low", a maximum tax rate).[5] The global minimum tax on corporate profits is one such prominent example (Johannesen 2022; Janeba and Schjelderup 2022; Hebous and Keen 2022). Minimum tax rates force low-tax jurisdiction (potentially tax havens) to raise their tax rates. These minimum tax rates then reduce interjurisdictional tax differentials, reducing mobility of the tax base. But, unlike harmonization, the minimum tax rate places no restriction on high-tax jurisdiction, potentially allowing high-tax jurisdictions to reoptimize their tax rates by strategically responding to the higher tax rates in the haven countries.

Another form of coordination includes restrictions either on the levels or the growth

[5]The use of both a maximum or a minimum tax rate might be viewed as government agreeing upon a "range" of tax rates that would be appropriate, and thus requires a less stringent agreement to harmonize taxes to a single rate. See Luna, Bruce and Hawkins (2007) for an example of a maximum tax rate and Lyytikäinen (2012)/Lyytikäinen (2023) for examples of both a minimum and maximum rate.

of tax instruments via tax or expenditure limitations.[6] One challenge with these rules as a tool to limit tax competition, is that they are usually implemented as a means to constrain the size of governments. Thus, these policies might be effective at mitigating tax competition if tax competition makes taxes "too high" rather than "too low" or if fiscal competition occurs in expenditures rather than taxes (Wildasin 1988).

2.3 Cooperation and Partial Harmonization

Tax harmonization among the entire set of countries in the world or among all localities in a country is likely hard to achieve. However, harmonization among a subset of jurisdictions may be more feasible. I call this partial harmonization, which occurs through the formation of coalitions among a subset of jurisdictions. A theoretical literature on coalition formation and partial harmonization exists (Konrad and Schjelderup 1999; Burbidge et al. 1997; Abidi and Taugourdeau 2023). One common form of such coalition formation is intermunicipal cooperation (Hulst and van Montfort 2007; Breuillé and Duran-Vigneron 2023). Intermunicipal cooperation may occur on a single fiscal policy or multiple fiscal policies, with localities ceding one or several taxes to the cooperative. In more informal cases, the cooperation simply involves consultation on setting policies (without any transfer any power but simply advising each other). But there are many examples around the world where the cooperative actually conducts joint operations and the provision of services with intermunicipal agencies and tax revenues. Finally, and the focus of subsequent theory, cooperation may be forced (statutory obligation under federal law) or may be a result of voluntarily established cooperative bodies.

Local policymaking is an especially opportune area for jurisdictions to engage in cooperation: municipalities are small, with a median population less than 1000 people in many countries. One reason for cooperation in public services is that the presence of many small jurisdictions does not allow for municipalities to exploit economies of scale. Second, perhaps more relevant on the revenue side of the budget, a very large number of competing jurisdictions can foster intense competition for mobile factors, which yield an inefficient equilibrium. Thus, reducing the number of jurisdictions can mitigate the effects of harmful tax competition (Hoyt 1991).[7]

Examples of municipal cooperation, as detailed in Hulst and van Montfort (2007), are extensive. France has one of the longest and most comprehensive histories of intermunicipal cooperation. The French "establishment for inter-municipal cooperation" (EIMC), commonly provides some public services across all member municipalities using a common

[6]For example, Poterba and Rueben (1995) discuss limits on property taxation and Eliason and Lutz (2018) study fiscal rules more generally.

[7]Of course, reducing the number of jurisdictions may reduce Tiebout sorting benefits across municipalities.

tax or several shared taxes which it has the authority to set independent of the individual municipal governments. In France, municipalities can levy tax rates on four main tax bases: the business tax base, the residence tax base, the developed property tax base and the undeveloped property tax base. But, after agreeing to cooperate, some taxing powers are surrendered to the EIMC.[8] EIMCs were historically preceded by syndicates, which were a weaker form of cooperation over public service provision, but without tax authority. In Finland, the 1995 Finnish Local Government Act allowed local governments to perform their functions either alone or in cooperation with other local governments. In Germany, one possible form of informal cooperation is via regional conferences (Regionalkonferenzen). In Belgium, 2001 reforms allowed for municipal cooperation. The most extensive forms of cooperation are the service association (dienstverlenende vereniging) and the mandated association (opdrachthoudende vereniging). In the Netherlands, the 1950 Joint Provisions Act explicitly allowed towns the power to cooperate and for provinces to promote the joint interests. The act allows municipalities, with restrictions, to transfer decision-making powers of local government to the cooperative bodies. Italy has several different forms of purely inter-municipal cooperation in single- and multi-purpose service delivery (conventions, agreements, consortia, unions) and mixed public-private cooperation in social economic development (area pacts). Finally, the U.S. allows for the formation of special districts (Goodman 2020). While many of these cooperative groups focus on public services provision, suggesting economies of scale are the primary reason for their formation, some of the cooperative structure also allow for tax authority to be delegated to the tier. Finally, town twinning is an example where towns may even cooperate across international borders through informal agreements. Mainly, this form of cooperation is aimed at benefiting businesses working across international borders.

While the focus of this article is on the effect on horizontal tax competition (Wilson 1999; Wilson and Wildasin 2004), some forms of intermunicipal cooperation such as the French case, create a new tier of government in the federalist hierarchy. Although municipalities cede some taxing authority to the EIMC, they also maintain some local taxing autonomy. As a result, although intermunicipal cooperation may affect the intensity of horizontal tax competition, it may also create a new form of vertical tax competition (Keen 1998; Keen and Kotsogiannis 2002; Hoyt 2017). Vertical tax competition is the strategic interactions between higher and lower levels of government resulting from both tiers of government cohabitating the tax base. Even if the municipality and the newly formed cooperative are prohibited from taxing the same bases, distinct tax bases may still overlap in real terms or have interdependencies. However, horizontal tax competition usually places downward pressure on tax rates; but vertical tax competition

[8]See Breuillé and Duran-Vigneron (2023) for a survey of the institutional details of EIMCs.

places upward pressure on tax rates. Intuitively, with horizontal fiscal externalities, a tax increase expands the tax base elsewhere, whoever, a higher-level government's tax increase reduces the tax base of lower-level governments via changes in demand for labor, goods, or factors. Thus, intermunicipal cooperation ray raise tax rates due to reductions in horizontal competition, but also because of the vertical tax externalities resulting from a new tier of government. A concern arises if this results in taxes being too high.

2.4 Tax Rules or Tax Treaties

Another possible way that jurisdictions can mitigate the effects of tax competition is to enter into a bilateral tax treaty or an interstate compact.[9] The surge of subsidy competition for large firms has recently spurred state agreements banning subsidy deals, along with a recent proposal for an interstate compact on the issue (Kim 2023).[10]

One common example of tax treaties arises in the personal income tax. There is great debate over how to tax nonresident income, and as a result, states resort to tax treaties to allocate taxing rights on multijurisdictional income. In the United States, the default is to tax nonresident earnings in the that where it is physically earned, with the resident state then asserting taxing rights on the income as well, but offering a tax credit to eliminate double taxation. However, if states enter into bilateral tax treaties, reciprocity agreements (Coomes and Hoyt 2008; Agrawal and Hoyt 2018; Rohlin, Rosenthal and Ross 2014), then the states agree that nonresident workers only need to pay and file taxes in the resident state. Beyond U.S. state income taxes, bilateral tax treaties govern the taxation of cross-border workers in the international setting. These tax treaties, which often concern sourcing rules over where income is taxed, have important implications for tax competition. Intuitively, if taxes bases are differentially mobile under the source than under the residence principle, tax competition will be less intense under rule that makes the tax base more inelastic. At a basic level, for the taxation of personal income, the difference is between firm versus worker mobility. If firms are more mobile than people, the residence-principle is preferred to a source-principle based on the location of the employer.

As a result, the tax rules governing where income, sales, or factors are taxed—at source/residence or at origin/destination—are critical determinants of the extent and existence of tax competition (Fox, Bruce and Shute 2023). Beyond sourcing rules, rules governing the enforcement of these sourcing principles have the potential to also influence the extent of tax competition. In particular, if a strict sourcing rule cannot be enforced,

[9] Voit and Nitting (1999) identify interstate compacts and agreements in the United States.

[10] See Brülhart et al. (2023) for the agreements in Switzerland defining a common corporate tax base and instruments.

then the tax base will remain mobile.

Finally, institutional rules and intergovernmental relationships also influence tax competition. For example, state constitutional restrictions may limit taxing authority by requiring municipalities to obtain super-majorities on tax increases. Such political constraints have important implications for tax competition, though the implications for tax competition are ambiguous. Beyond constitutional issues, intergovernmental grants are a feasible way to influence the extent and existence of tax competition (Clemens and Veuger 2023; Köthenbürger 2002; Wildasin 1989) and the state and local tax deduction may also fiscal externalities of states taxing high income earners (Cullen and Gordon 2008).

3 A Simple Fiscal Competition Model

The prior literature is filled with numerous examples of models to study minimum tax rates, tax harmonization, sourcing rules, tax treaties, and interjurisdictional cooperation. However, a limitation of the literature is that it often studies only a single or a couple types of tax coordination. The diversity of modeling strategies used to study each policy makes it challenging to compare the outcomes and feasibility of various tax coordination policies, as it is unclear if the differences are driven by the policies or the model structures. Moreover, with the exception of the literature on coalition formation and intermunicipal cooperation, the prior literature often focuses on two jurisdictions. The focus on two jurisdictions then prevents a comparison of complete tax coordination policies with partial harmonization or policies that require jurisdictions to endogenously cooperate with other jurisdictions.

In this section, I sketch a simple model of tax competition, originally developed to study commodity tax competition in the context of cross-border shopping. The model originates with Kanbur and Keen (1993), but I sketch a simpler variant proposed by Nielsen (2001).[11] Despite its initial application to commodity taxation, Keen and Konrad (2013) and Agrawal and Wildasin (2019) show the Kanbur and Keen (1993) model can be extended to characterize many different types of fiscal competition with tax base shifting—profit shifting, real relocation/migration, capital flight, or commuting. The model originally featured two jurisdictions, but I extend it to multiple jurisdictions following Agrawal and Mardan (2022), allowing me to study partial harmonization and coalition formation.

[11] See also Haufler (1996) and Trandel (1994). If the convex transportation costs in Haufler (1996) are quadratic, the cutoff rules in Haufler (1996) are the same as in the model of Nielsen (2001) with costs that are linear in distance to the border. Haufler (1996), however, is more general along many other dimensions including the welfare-maximizing governments rather than revenue-maximizing governments.

For simplicity, consider three jurisdictions, indexed by i. The three jurisdictions set tax rates T_i to maximize tax revenues in a Nash game. Jurisdictions have some market power and thus interact strategically with other jurisdictions when setting tax rates. The assumption of revenue maximization is obviously a simplification of reality, where governments may maximize welfare of residents, property values, and political economy objectives.[12] The assumption that governments are Leviathan, as in Kanbur and Keen (1993), can be viewed as a political economy model of tax setting or can be interpreted as a welfare maximizing government where there is a very high marginal value of public services financed by the tax revenues. The Leviathan assumption allows me to focus on tax rates and revenues, but misses issues related to economies of scale in public services. And unlike many models of welfare maximization, tax competition can help discipline the Leviathan to prevent taxes from being too high. For purposes of this paper, I think of revenue maximization as a way to understand the provision of public services and consider ranking policies simply on the basis of tax revenues. Although I cannot make welfare conclusions, most models of tax competition imply that public good provision is too low. Studying tax revenues therefore allows me to make claims as to whether revenues (and thus public services) can be made more efficient by limiting tax competition.

Jurisdictions are asymmetric in size. If borders are closed, the sizes of the tax bases of the jurisdictions are Θ_i. This parameter determines the relative sizes (residents, profits, etc.) of the jurisdictions. Tax changes do not change the total amount of economic activity in the world. Thus, in the presence of closed borders, the tax base is fixed. But, open borders allow for some shifting of economic activity to low-tax jurisdictions and thus, the tax base across jurisdictions. The amount of shifted activity from jurisdiction i to jurisdiction j is denoted s_{ij} where $s_{ij} \geq 0$ if $T_i \geq T_j$ and $s_{ij} < 0$ if $T_i < T_j$. In this model, all shifting is tax-driven so the shifting variable is positive if the shifting is outward and negative if the shifting is inward. The total tax base of a country is given by its initial base net of any activity shifted out of the jurisdiction plus any activity shifted into the jurisdiction:

$$B_i = \Theta_i - \textstyle\sum_{j \neq i} s_{ij}. \tag{1}$$

If, for example, jurisdiction 2 sets a tax rate lower than jurisdiction 1, but higher than jurisdiction 3, its tax base is $B_2 = \Theta_2 - s_{23} - s_{21}$ where $s_{23} > 0$ and $s_{21} < 0$. Taxes only affect the location of the activity, but do not influence the total amount of economic activity in the jurisdictions.

Shifting activity comes at some cost to the firm or individual doing it. I assume

[12] Trandel (1994) shows that many of the Kanbur and Keen (1993) results are robust to welfare maximizing governments.

that shifting costs are bilateral and are convex in the amount of shifting.[13] I assume that the cost functions are identical in each jurisdiction, so that shifting the first unit to any jurisdiction incurs the same marginal and total cost regardless of where it is shifted from. For tractability, I assume this cost function is quadratic. This implies a cost function for outward shifting from a jurisdiction:

$$c(s_{ij}) = \frac{\delta(s_{ij})^2}{2}, \tag{2}$$

where δ is a cost parameter and the cost function is defined for values of $s_{ij} \geq 0$. Several points are in order. First, the quadratic cost function is standard in spatial models such as Kanbur and Keen (1993). Second, shifting costs are bilateral, meaning that for a resident of jurisdiction $i = 1$, the cost function of shifting into $i = 2$ is a function of the amount of activity shifted into 2 and not a function of the total amount of shifting into both jurisdiction 2 and 3. In the case of cross-border shopping, bilateral shifting costs correspond to transport costs being border specific (e.g., related to the distance from each border). In the case of profit shifting, this assumption means that the cost of profit shifting to one jurisdiction is independent of the amount of shifting to other jurisdictions.[14] If relaxing the quadratic assumption, in a more general model such as Haufler (1996), the cost function would need to be continuously differentiable with properties that satisfy $c'_{ij} > 0$ and $c''_{ij} > 0$ if $s_{ij} > 0$; $c_{ij}(0) = c'_{ij}(0) = 0$; and $c''_{ij}(0) > 0$, $\forall i$.

In the presence of open borders, an arbitrage condition will determine the amount of tax-base shifting. In particular, the marginal benefit of shifting must equal the marginal cost of shifting. The marginal benefit of shifting another unit is simply equal to the tax savings, while the marginal cost is determined by differentiating (2). Solving the arbitrage condition for the amount of shifting then yields

$$s_{ij} = \frac{T_i - T_j}{\delta}. \tag{3}$$

which is positive if $T_i \geq T_j$. Armed with this optimality condition which solves the shifting problem of the economic agents, government revenues can easily be constructed as

$$R_i = \; T_i B_i = T_i \; \left(\Theta_i - \textstyle\sum_j \frac{T_i - T_j}{\delta}\right) \tag{4}$$

where the first term indicates larger jurisdictions have a larger base, all else equal. And the second term with the summation captures both the inflows of shifted activity, as well

[13]Under an alternative framing, individuals may be heterogeneous in the cost of shifting activity into each other jurisdiction.

[14]See Huizinga, Laeven and Nicodème (2008) and van't Riet and Lejour (2018) for empirical evidence that multinational firms base their decisions on bilateral costs.

as outflows of shifted activity. Notice that when the sign of the tax differential is positive the shifting is outward, but when it is negative, the shifting is inward.

Some discussion of what is meant by the shifted tax base is in order. The phenomenon of tax competition, especially in the area of international capital income taxation, features many different types of shifting behavior. The distinction between base shifting in the form of shifting real investment and production versus the virtual shifting of the tax base through various "tax havens" or institutional structures is of great importance. Both types of shifting are closely intertwined and the two are not independent of each other depending on the tax argument considered. For purposes of this article, I make no distinction between whether the activity shifted is real economic activity or tax evasion or avoidance and, more generally, the model features standard jurisdictions and not jurisdictions featuring the special features of tax havens. In the context of a federation and competition between subnational entities, which is focal in this paper, the issue is much less relevant but would merit more distinctions in the international tax setting. For a survey of these issues, see Keen and Konrad (2013).

A model with three jurisdictions, each differing in size, allows for a wide range of tax equilibria. To simplify the model, and to express taxes as a function of a single relative size parameter, I consider the case where two jurisdictions are symmetric in their sizes, but one jurisdiction is smaller or larger. This corresponds to the axially symmetric case in Agrawal and Mardan (2022). To simplify notation, let the jurisdictions now be indexed by $i = a, s, \sigma$ where a stands for the asymmetric jurisdiction and s and σ stand for the symmetric jurisdictions. The asymmetric jurisdiction ($i = a$) has a different size—possibly smaller or larger than the other two jurisdictions. To implement this, suppose that the total amount of taxable economic activity in the world is fixed and is normalized to 3 units, such that if all three jurisdictions were the same size they would have one unit of activity. To model the asymmetries, let $-1 < \theta < 1$ denote the relative size advantage (or disadvantage) of jurisdiction a. Thus, in the absence of shifting $\Theta_a = 1 + \theta$. As the total amount of activity in the world is fixed, then sizes of the two symmetric jurisdictions are $\Theta_s = \Theta_\sigma = 1 - \theta/2$. Critically, if $\theta < 0$ jurisdiction a is smaller, if $\theta > 0$ jurisdiction a is larger, and if $\theta = 0$ all jurisdictions are symmetric.

All subsequent proofs to solve this model are in Appendix A. As the θ parameter is critical to the analysis below, Table (1) summarizes the asymmetries in the model.

3.1 The Uncoordinated Nash Equilibrium

Because of the finite number of jurisdictions, each jurisdiction has some market power in this closed system and thus are strategic—game theoretic—in their tax behavior. The existence of strategic interactions are common in many models of tax competition and

Table 1: Notation: Asymmetries in the Model

Case	Asymmetries
$\theta > 0$	a is larger than s, σ
$\theta = 0$	a, s, σ are symmetric
$\theta < 0$	s, σ are larger than a

This table summarizes the notation concerning jurisdictional asymmetries.

arise naturally in models of commodity tax competition where the tax base is locally mobile. If jurisdictions do not have market power, perhaps because they are atomistic in size or there are infinitely many jurisdictions, then jurisdictions are not strategic in their tax setting behavior. But, even jurisdictions that are not strategic engage in competition—of the perfectly competitive form—and as a result the tax competition equilibrium is inefficient. The strategic model here is best suited for competition within a metropolitan area, but even at the international level, jurisdictions may be strategic in their tax setting behavior. Differentiating the revenue functions yields the best response functions:

$$\begin{array}{rcl} T_s & = & \frac{1}{4}\delta(1-\frac{1}{2}\theta)+\frac{1}{4}T_a+\frac{1}{4}T_\sigma \\ T_\sigma & = & \frac{1}{4}\delta(1-\frac{1}{2}\theta)+\frac{1}{4}T_a+\frac{1}{4}T_s \\ T_a & = & \frac{1}{4}\delta(1+\theta)+\frac{1}{4}T_s+\frac{1}{4}T_\sigma \end{array} . \quad (5)$$

The slopes of these functions indicate that for a one unit increase in a competitor's tax rate, a jurisdiction will strategically match that increase with a 1/4 unit tax increase. Thus, as in all models of revenue maximization, tax rates are strategic complements.

And solving for the uncoordinated Nash equilibrium yields uncoordinated tax rates of

$$\begin{array}{rcl} T^U \equiv T^U_s = T^U_\sigma & = & \frac{1}{2}\delta - \frac{1}{10}\delta\theta \\ T^U_a & = & \frac{1}{2}\delta + \frac{1}{5}\delta\theta \end{array} \quad (6)$$

where the superscript U denotes the uncoordinated Nash tax rates. This implies a tax differential of

$$T^U_a - T^U = \frac{3}{10}\delta\theta \quad (7)$$

which indicates that the larger of the jurisdictions, always sets the higher tax rate. This result is consistent with the prior literature: starting from equal tax rates, a larger jurisdiction perceives a smaller elasticity because its base is larger. Then, following a Ramsey rule, the lower elasticity implies a higher tax rate. Total revenues are given by

$$\begin{array}{rcl} R^U \equiv R^U_s = R^U_\sigma & = & \frac{1}{50}d(\theta-5)^2 \\ R^U_a & = & \frac{1}{50}d(2\theta+5)^2 \end{array} \quad (8)$$

Under the assumptions of the model, such a Nash equilibrium is guaranteed to exist because the best response functions slope upward and the game is supermodular (Topkis 1979). The equilibrium satisfies the standard results in the literature: the larger jurisdiction sets a higher tax rate and taxes are increasing in the shifting cost parameter. The existence of tax differentials in the Nash equilibrium then implies that shifting occurs from the big jurisdiction(s) to the smaller jurisdiction(s). Moreover, the bigger jurisdiction realizes more tax revenue.

It is clear that the uncoordinated equilibrium is inefficient. To see this, I can solve the social problem, which maximizes aggregate tax revenues of all three jurisdictions:

$$R_{joint} = \sum_i T_i \left(\Theta_i - \sum_j \frac{T_i - T_j}{\delta} \right) = \sum_i T_i \Theta_i. \tag{9}$$

The second equality follows because one jurisdictions gain from shifting is another jurisdiction's loss ($s_{ij} = -s_{ji}$). Then maximizing (9), because the tax base is inelastic except for shifting, would result in governments setting a tax rate that is so high that it extracts all private surplus from the taxed individuals or firms. Calling this tax rate T^*, it is then clear that $T_a^U < T^*$ and $T^U < T^*$. In other words, the tax competition equilibrium is inefficient: it will yield lower government spending than in the absence of tax competition.

4 Tax Coordination

Having solved for the uncoordinated equilibrium, in this section, I consider various policies that are designed to limit the effects of tax competition: harmonization, minimum tax rates, partial harmonization with forced cooperation, partial harmonization with coalition formation, and sourcing rules. I analyze what happens to tax rates, whether tax revenues improve in all jurisdictions, and whether tax revenues improve for the entire system of jurisdictions.

4.1 Harmonization

One commonly talked about policy intervention is tax harmonization, which requires all jurisdictions to set a common tax rate. Harmonization might be achieved by a federal mandate within a country or within a supra-national institution such as the European Union. While the harmonized rate could conceivably be to any tax rate, a common proposal is to harmonize to a weighted average of the Nash equilibrium (uncoordinated) tax rates:

$$\tau = \omega T_a^U + (1 - \omega) T^U, \tag{10}$$

where weight $\omega \in [0,1]$ is given to the asymmetric jurisdiction—potentially higher or lower tax depending on its size—and equal weights of $(1-\omega)/2$ are given to each of the symmetric jurisdictions.

Before proceeding to the formal analysis, there are two policy relevant points to note about this type of harmonization. First, in the perfectly symmetric case where all three jurisdictions are identical ($\theta = 0$), harmonization to a weighted average of Nash tax rates would not be an actual policy intervention because the weighted average is simply equal to the uncoordinated rate set by all three jurisdictions. Second, harmonization to a weighted average of the Nash tax rates may not achieve the socially optimal tax rates. In particular, if tax competition results in inefficiently low tax rates, it is possible that the Nash tax rates of all jurisdictions are less than the socially optimal tax rates. Thus, there is no value of ω that can achieve that desired outcome. Further, if the socially optimal tax rates are differentiated across jurisdictions, then harmonization does not allow for any of this diversity in tax rates.

What are the effects of harmonization in the simple shifting model presented previously? Under the assumptions above, proving the effects of harmonization almost follows Kanbur and Keen (1993), but as will become apparent the results become more nuanced. Because harmonizing tax rates results in the elimination of tax differentials, no tax base shifting will occur after the policy is implemented. As a result, the tax bases of each jurisdiction are simply equal to their "closed" economy bases. Then, tax revenue in each jurisdiction is $\tau\Theta_i$ and is increasing in τ. Thus, each jurisdiction would achieve the most tax revenue by harmonizing to the highest possible tax rate. But, for various weights ω, the question remains as to if the harmonized amount of revenue is better than the Nash tax revenue. Evaluating $\tau\Theta_i$ using (10)—evaluated at 6—and comparing it with the uncoordinated revenues in (8) implies a cutoff rule in ω for which harmonization lowers or raises revenues.

For the two jurisdictions of a similar size, s and σ, the revenue under tax harmonization is greater than the revenue earned in the uncoordinated equilibrium if

$$\omega \quad \begin{matrix} > \\ < \end{matrix} \quad \frac{\theta-5}{5(\theta-2)} \quad \begin{matrix} \text{if } \theta \geq 0 \\ \text{if } \theta < 0 \end{matrix} \tag{11}$$

Critically, if these jurisdictions are smaller than the other ($\theta > 0$), then the weight on the higher tax jurisdiction a needs to be sufficiently large. Intuitively, if the harmonized rate is too low, then the smaller jurisdictions lose by foregoing revenue from activity shifted into their jurisdiction and gain little additional revenue from their home base of economic activity. Only if the added revenue from their home base outweigh the losses of revenue from foregoing the inward shifted economic activity do they gain. If s and σ are the larger ($\theta < 0$) jurisdictions, the weight on the other smaller jurisdiction needs to be sufficiently low. Intuitively, a high-tax jurisdiction can always gain from harmonization to its own tax rate: it gains revenue from economic activity previously shifted out of the jurisdiction while maintaining its same tax rate.

Now turning to jurisdiction a, the asymmetric jurisdiction requires

$$\omega \begin{array}{ccc} > & \frac{3\theta}{5(\theta+1)} & \text{if}\theta \geq 0 \\ < & & \text{if}\theta < 0 \end{array} . \tag{12}$$

in order for harmonization to revenue dominate the uncoordinated equilibrium. Critically, the second branch makes it clear that if the asymmetric jurisdiction is the smaller one ($\theta < 0$), there exist no (positive) weights that will result in tax coordination improving the revenue of the jurisdiction. However, if the asymmetric jurisdiction is the larger one ($\theta > 0$), then ω must be sufficiently large for the jurisdiction to benefit from harmonization. In other words, tax harmonization that is too close to the lower uncoordinated Nash tax rate, T^U, will harm the larger country because it loses revenue from its previously loyal base that is not fully compensated by a reduction in shifting.

Combining this evidence, if $\theta < 0$, harmonization will not be able to find a political consensus on purely revenue grounds. But if $\theta > 0$, all jurisdictions will agree to harmonize *if* the harmonized rate is sufficiently high. In particular, it is clear that (11) is always larger than (12) for all relevant values of θ. Thus, (11) determines the minimum feasible weight for which revenue will improve in all jurisdictions—using the language of Kanbur and Keen (1993), a "Pareto" improving policy. For example, if $\theta = 0.50$, we have that the weight must exceed $\omega = 0.60$. At the same time, if the weight is too low rather than too high, then both jurisdictions may lose tax revenue. For example, $\omega = 0$ will result in the low-tax jurisdiction keeping the same rate, but losing activity shifted into its jurisdiction, while the high-tax jurisdiction will apply a much lower rate to its home base. Thus, despite the existence of Pareto improving harmonization policies, all jurisdictions might fear harmonization if they worry the harmonized weight is too low.

Proposition 1. *In a world with two small jurisdictions and one large jurisdiction, tax harmonization will improve tax revenues in all jurisdictions if harmonization if the weight on the larger jurisdiction is sufficiently high, but if that weight is too low, both jurisdictions will lose revenue. If instead, there are two large jurisdictions and one small jurisdiction, tax harmonization will surely harm the smaller jurisdiction and will only benefit the larger jurisdictions if the weight on the smaller jurisdiction is sufficiently low.*

The proposition stands in contrast to the stark result in Kanbur and Keen (1993). In their model of only two countries, tax harmonization to any tax rate between the

Nash tax rates will *always* harm the small country and may harm the large country if harmonization is to a rate that is too low. Intuitively this occurs because revenue in the small jurisdiction (using small/large letters now to distinguish quantities for the small/large jurisdiction) in the uncoordinated Nash equilibrium is $r(t^U, T^U)$. Under a harmonized equilibrium, at the harmonized rate where revenue would be its highest, revenue is $r(T^U, T^U)$. But in Kanbur and Keen (1993), a simple revealed preference argument rules out this yielding higher revenue: the small jurisdiction did not choose T^U as its Nash tax rate when the big jurisdiction choose T^U; thus harmonization must make it worse off. In my model, harmonization may improve the outcomes of smaller jurisdictions if there are multiple of them. The intuition is clear. When there are now three jurisdictions, the Nash revenues in the small jurisdictions are $R_s(T^U, T_a^U, T^U)$. Why is harmonization to the higher tax rate revenue improving in this case? Notice with $\omega = 1$, the harmonized tax revenue in the smaller jurisdiction is $R_s(T_a^U, T_a^U, T_a^U)$. Unlike the case of two jurisdictions, a revealed preference argument no longer applies because harmonization changes rates for multiple jurisdictions. In particular, the harmonized rate forces all other small jurisdictions to also raise their rates, leaving the possibility that each one is now better off. The presence of multiple jurisdictions implies that jurisdictions compete with more competitors (Hoyt 1991). The increase in the number of competitors heightens tax competition and the extent of tax base externalities in the uncoordinated equilibrium. As a result, small jurisdictions may gain revenues because harmonization mitigates this fiercer form of tax competition.

Under complete harmonization, the tax rate is imposed by a supranational institution or by a federal government to its states. In other words, harmonization is not modeled as a result of a grand coalition from which exit could occur, but rather a result of a mandate. Thus, I do not consider the possibility that jurisdictions will explicitly defect in this section; coalition formation will be considered subsequently. But the above proposition indicates which jurisdictions would politically support harmonization from a tax revenue perspective.

4.2 Minimum Tax Rates

Minimum tax rates differ from harmonization because they only bind for jurisdictions setting taxes below the imposed minimum rate.[15] As a result, a minimum forces low-tax jurisdictions to raise their rates, but unlike harmonization, does not require high-tax jurisdictions to lower their rates. I consider the interesting case where the minimum tax rate binds for some jurisdictions but not for others. In other words, the minimum tax

[15]See Konrad (2009) for a case with a non-binding minimum tax rate.

rate is given by (10) with weight $\omega \in (0,1]$ given to the asymmetric equilibrium.

4.2.1 Minimum Tax Rate Binds for Multiple Jurisdictions

First, consider the case where $\theta > 0$ so that the asymmetric jurisdiction is the larger of the three. In this case, the symmetric jurisdictions, s and σ, will be forced to set a minimum tax rate τ. The larger jurisdiction is not constrained by this tax rate, and given its best response function slopes upward, will find it in its interest to raise its tax rate. In this case, its best response becomes:

$$T_a \;=\; \tfrac{1}{4}\delta(1+\theta) + \tfrac{1}{2}\tau \;, \tag{13}$$

which also is the equilibrium tax rate, T_a^M, as a function of the exogenous parameters

In this case, the minimum tax rate increases revenues of both jurisdictions. The proof of the effect of the minimum tax rate on revenues follows Nielsen (2001). Tax revenues in the smaller jurisdictions are then $(\tau\delta(5-\theta) - 2\tau^2)/4\delta$, which are concave in the minimum tax rate. If the minimum were set to T^U, revenues would clearly be unchanged. But at this point, the derivative with respect to τ is positive, as it is for all possible values of τ. If on the other hand, the minimum were set to T_a^U, the jurisdiction clearly collects higher tax revenues than the uncoordinated equilibrium, so the same must be true for all intermediate values of τ. As for the bigger jurisdiction, its tax revenue is $(\delta(1+\theta)+2\tau)^2/8\delta$, which are clearly higher than R_a^U for all value of $\omega > 0$.

4.2.2 Minimum Tax Rate Binds for a Single Jurisdiction

Second, consider the case where $\theta < 0$ so that the asymmetric jurisdiction, a, is the smaller of the three and thus sets the lower rate in the uncoordinated equilibrium. Then, the jurisdictions for which the minimum tax rate does not bind ($i = s, \sigma$) can adjust their tax rates in response. Evaluating the best response functions (5) at the minimum tax rate and solving for the new equilibrium tax rates, denoting it with a superscript M, yields

$$T_s^M = T_\sigma^M = \frac{1}{3}(1 - \frac{\theta}{2}) + \frac{1}{3}\tau. \tag{14}$$

In this case, the minimum tax rate may harm some jurisdictions while benefiting others. As for these bigger jurisdictions, tax revenues are $(\delta(\theta-2) - 2\tau)^2/18\delta$, which are clearly higher than R^U for all value of $\omega > 0$. Thus, again, the minimum tax helps the jurisdictions that set higher tax rates than the uncoordinated tax equilibrium. Matters are more complex for the lower-tax jurisdiction for which the minimum tax rate binds. Tax revenues are $\tau(\delta(5+2\theta) - 4\tau^2)/3\delta$, which are concave in the minimum tax rate. At the lowest possible value of the minimum tax rate, the jurisdiction is clearly unaffected, but the derivative of revenues with respect to the minimum tax rate is positive. However, at the highest possible value of the minimum tax rate, revenue may yield higher or lower revenue than the unconstrained case. In particular, at its highest possible value, the minimum tax rate regime will yield higher revenues if

$$-\frac{1}{50}\delta(8\theta+5)\theta > 0 \Longleftrightarrow \theta > -\frac{5}{8}. \tag{15}$$

Obviously, a similar value can be solved for involving intermediate weights ω. Keeping in mind that $\theta < 0$ in this case, the prior expression says the minimum tax rate will only be revenue improving if the size asymmetries between jurisdictions are sufficiently small. Otherwise, the jurisdiction would have been better off in the uncoordinated equilibrium, where its much smaller size allowed it to aggressively undercut the larger jurisdictions and obtain a large amount of economic activity shifted into the jurisdiction. But, if size asymmetries are sufficiently small, the minimum tax rate raises revenues on its own tax base in a manner that offsets any loss from shifting.

Proposition 2. *In a world with two small jurisdictions and one large jurisdiction, a binding minimum tax rate will improve tax revenues in all jurisdictions regardless of the level of the minimum tax rate. If instead, there are two large jurisdictions and one small jurisdiction, a binding minimum tax rate will improve tax revenues in all jurisdictions if the size differences between the jurisdictions are sufficiently small.*

Unlike tax harmonization, strategic responses still occur with a minimum tax rate. In the new Nash equilibrium, the small jurisdiction sets the minimum tax rate, still undercutting the large jurisdiction. But, the higher tax rate that it sets then allows the larger jurisdiction to strategically respond. As shown above, the minimum tax rate can raise revenue for the smaller jurisdiction. Even though the small jurisdiction will gain revenue from being forced to raise its tax rate, it would not have raised the tax on its own because doing so would induce the large jurisdiction to respond.

In contrast to harmonization, ignoring the case where size differences are very large, revenue is higher in both jurisdictions! All jurisdictions now set higher tax rates, but the increase is greater in the small jurisdiction—the effect on the large jurisdiction's tax is dampened by the slope of best response function. Thus, inter-jurisdictional tax differentials fall. Because the minimum tax rate reduces tax differentials, revenue therefore certainly increase in the larger jurisdictions. But similar to harmonization, the effect on the small jurisdiction is initially unclear: revenue is gained from taxing the loyal base as a higher rate, but lost through diminished tax shifting into the jurisdiction. The former effect can be shown to dominate under most conditions because the minimum tax rate mitigates tax competition. This is a remarkably strong result! It establishes a clear dominance of the minimum-tax strategy over that of harmonization. Harmonizing to any tax rate between the unconstrained Nash equilibrium will likely harm the small jurisdiction and may also harm the large jurisdiction, but imposing that same rate as a minimum will be to the benefit of all.

4.3 Forced Cooperation: Partial Harmonization

As an alternative to complete harmonization, a central government could "force" two regions to cooperate with each other and set a common tax rate. I label this coordination as partial harmonization, meaning that the tax rates of a subset of jurisdiction are harmonized. With partial harmonization, the government could force either the two symmetric jurisdictions to cooperate or may force the asymmetric jurisdiction to cooperate with one of the symmetric jurisdictions.

4.3.1 Cooperation Among Symmetric Jurisdictions

Initially, assume that cooperation is forced upon the two symmetric jurisdictions, similar to the setup of Konrad and Schjelderup (1999). Jurisdictions s and σ then set a common tax rate denoted $T_{s\sigma}$ and raise common (total) revenue of $R_{s\sigma}$. This coalition then chooses its tax rate $T_{s\sigma}$ in a Nash game with jurisdiction a. The tax revenue function for the coordinated jurisdiction and the uncoordinated jurisdiction are

$$\begin{array}{rcl} R_{s\sigma} & = & 2-\theta-\frac{2(T_{s\sigma}-T_a)}{\delta} \\ R_a & = & 1+\theta-\frac{2(T_a-T_{s\sigma})}{\delta} \end{array}, \tag{16}$$

where the tax base in the coordinated jurisdictions is twice their closed border sizes plus a shifting term. Critically, the shifting term appears twice in the revenue functions. The reason for this is that the cost of shifting is jurisdiction-pair specific, and I assume this pair-specific shifting remains after the coalition forms.Tax coordination does not eliminate the two jurisdictions, but rather just forces them to set a common tax rate. Thus, there is a shifting rule that determines the amount of shifting between s and a along with another rule that determines shifting between σ and a. Given the common tax rate, the same cutoff rule hold for both pairs. Its useful to think of this in the commodity tax setting: coordinating tax rates still implies the cooperative still has two borders from which is loses cross-border shoppers.[16] However, there is no shifting between s and σ as the tax rate is harmonized.

[16] As an alternative example, firms in s and σ still have incentives to shift profits to a with the same cost function.

Differentiating the revenue functions and solving obtains the Nash tax rates, superscripted by C for cooperation, with the forced coalition in parenthesis:

$$\begin{array}{rcl} T_{s\sigma}^{C(s\sigma)} & = & \frac{1}{6}\delta(5-\theta) \\ T_{a}^{C(s\sigma)} & = & \frac{1}{6}\delta(4+\theta) \end{array}, \tag{17}$$

implying a tax differential between the cooperative and the non-cooperating jurisdiction of

$$T_{s\sigma}^{C(s\sigma)} - T_{a}^{C(s\sigma)} = \frac{1}{3}\delta(\frac{1}{2}-\theta). \tag{18}$$

From this difference between the cooperating jurisdiction and the non-cooperating jurisidction, notice that if the cooperating jurisdictions are sufficiently similarly sized as the other jurisdiction ($0 < \theta < 1/2$) or initially larger than the other jurisdiction ($\theta < 0$), the cooperative will set a higher tax rate than the non-cooperating jurisdiction. But if the jurisdiction outside the cooperative is sufficiently large ($\theta > 1/2$), the non-cooperating jurisdiction will set a higher tax rate. Intuitively, joining two larger jurisdictions will make them even larger in their common base. And if these jurisdictions are not too small initially, their combined size will still be larger than the other jurisdiction. Then, starting from equal tax rates, the cooperative will perceive a smaller elasticity and markup its tax rate. However, if the jurisdictions are initially very small, their combined tax base will not exceed that of the larger jurisdiction, and they will still perceive the larger elasticity and set the lower tax rate.

Next, despite this ambiguity in the tax differential, it is easy to show that for all values of θ, taxes in the cooperative and the noncooperative are higher than the uncoordinated equilibrium: $T_{s\sigma}^{C(s\sigma)} > T^U$ and $T_a^{C(s\sigma)} > T_a^U$. Partial harmonization allows the cooperating jurisdictions to set higher tax rates; because taxes are strategic complements, the outside member also raises her tax rate.

What about tax revenues? Although tax rates are rising in all jurisdictions, the tax differential will generally change in response to cooperation. As a result, the equilibrium tax bases of the jurisdictions change relative to the non-cooperative equilibrium. As a result, some jurisdictions will see a reduction in inward shifting of activity. This possibly negative effect is offset by less intense tax competition, due to a smaller number of competing jurisdictions, and higher tax rates on the loyal base. Despite the possibility of counteracting effects, it is also easy to show that in the presence of equally splitting tax revenues within the cooperative, $R_{s\sigma}^{C(s\sigma)}/2 > R^U$.[17] The cooperative sets a higher tax rate and tax competition between the two jurisdictions is eliminated, both raising

[17] In this case, because both jurisdictions are equally sized, it is reasonable to believe that tax revenues are split equally among them. Equal splitting would be identical to splitting tax revenues proportional to the equilibrium bases in this case.

revenues. The same holds true for the non-cooperating jurisdiction, $R_a^{C(s\sigma)} > R_a^U$: it sets a higher tax rate and benefits from less intense tax competition. This result is consistent with Hoyt (1991) who shows that tax competition becomes less intense the smaller the number of jurisdictions, which raises tax rates. Thus, these channels dominate any loss of shifting into initially the low-tax jurisdiction.

4.3.2 Cooperation Among Asymmetric Jurisdictions

Next, assume partial harmonization involves a coalition of two jurisdictions that differ in size. Without loss of generality consider the possibility that jurisdictions a and σ cooperate, but jurisdiction s does not. Then, the tax base in the absence of shifting in the cooperative is $2 + \theta/2$ while it is $1 - \theta/2$ in the non-cooperating jurisdiction. As in (16), there are similar cutoff rules for shifting that enter into the tax base. Solving for the Nash equilibrium in tax rates yields:

$$\begin{array}{rcl} T_s^{C(a\sigma)} & = & \frac{1}{6}\delta(4 - \frac{1}{2}\theta) \\ T_{a\sigma}^{C(a\sigma)} & = & \frac{1}{6}\delta(5 + \frac{1}{2}\theta) \end{array}, \tag{19}$$

implying a tax differential of

$$T_{a\sigma}^{C(a\sigma)} - T_s^{C(a\sigma)} = \frac{1}{6}\delta(\theta + 1) > 0. \tag{20}$$

Critically, unlike the prior case, notice the tax differential is always positive. This indicates that when two jurisdictions that differ in size cooperate, the tax rate in the cooperative is surely to be higher than the other jurisdiction. This result follows because $2 + \theta/2$ is always larger than $1 - \theta/2$ so that, starting from equal taxes, the cooperative always perceives the smaller elasticity and raises its tax rate. Simply put, the cooperative will always have a size advantage relative to the other jurisdiction. Notice this even holds true if the asymmetric jurisdiction is the smallest: combining one large jurisdiction with a very small one still means the cooperative is largest.

Given the above statement, then it is clear that the equilibrium tax rates of the cooperating jurisdictions are always higher than those in the uncoordinated Nash equilibrium ($T_{a\sigma}^{C(a\sigma)} > T_a^U$; $T_{a\sigma}^{C(a\sigma)} > T_\sigma^U$). For the jurisdiction external to the cooperative, it can be verified that its tax rate also rises relative to the uncoordinated case. Intuitively, tax competition is dampened, which places upward pressure on its tax rate. Revenues in the non-cooperating jurisdiction unambiguously increase as well, as tax rates are higher and tax competition dampened ($R_s^{C(a\sigma)} > R_s^U$).

In this case, cooperating jurisdictions differ in size. Thus, comparing tax revenues of jurisdictions within the cooperative to their uncoordinated values requires further assumptions about how revenues are split among the jurisdictions in the cooperative. In a comprehensive model, the split of tax revenues would be modeled via a formal bargaining process such as Nash bargaining (Nash 1950). However, in this paper I take two stylized approaches, leaving more formal analysis for future research. This simple approach might be justified as an exogenous rule determined by the federal government that governs how revenues are split in coalitions.

One simple possibility is that revenues are equally divided within the cooperative, while an alternative possibility is that revenues are allocated proportional to the declared tax bases within each jurisdiction. Under equal splitting, if θ is sufficiently negative, then revenues will fall in jurisdiction σ relative to the noncooperative equilibrium; otherwise, revenues increase. The opposite is true for the jurisdiction a: if θ is sufficiently large (and positive), revenues will fall for this jurisdiction relative to the noncooperative equilibrium.[18] Intuitively, equal splitting of revenues advantages the small jurisdiction at the expense of the large jurisdiction. On the other hand, if tax revenues are allocated proportional to their tax bases in each local jurisdiction, then if θ is of an intermediate value, tax revenues will rise in both jurisdictions relative to the noncooperative case ($R_{a\sigma}^{C(a\sigma)} > R_a^U$; $R_{a\sigma}^{C(a\sigma)} > R_\sigma^U$).[19] Intuitively, the larger jurisdiction benefits from less tax competition even though two gives up some of its size advantage, while the smaller jurisdiction of the two gives up its ability to undercut.

Proposition 3. *Regardless of the two jurisdictions cooperating, partial harmonization raises tax rates in all jurisdictions relative to the uncoordinated Nash equilibrium. If two symmetric jurisdictions cooperate, tax revenues also rise in all jurisdictions. But, if two jurisdictions of different sizes are forced to cooperate, while revenues unambiguously increase in the noncooperating jurisdiction, revenues may rise or fall in the cooperating jurisdictions. If revenues are allocated proportional to the coordinated equilibrium tax bases or equally shared, then there exist scenarios where revenues increase in both cooperating jurisdictions relative to the noncooperative setting.*

There proposition has some similarities to Konrad and Schjelderup (1999). In their model, all jurisdictions are symmetric. They then show that if a subset of jurisdictions coordinate on a tax rate marginally higher than the uncoordinated equilibrium and if taxes are strategic complements, the utility of each jurisdiction (both inside and outside of the jurisdiction) increases. Further, in the coordinated Nash equilibrium, they show the coordinating jurisdictions receive higher utility. These results have parallels to the result

[18] The precise condition for revenue to increase in jurisdiction a requires $-263\theta^2 - 940\theta + 700 > 0$ or θ needs to be smaller than approximately 0.63. For jurisdiction σ to increase its revenue requires $-47\theta^2 - 1220\theta - 700 > 0$ or θ needs to be larger than approximately -0.56.

[19] The precise condition for revenue to increase in jurisdiction a requires $\theta > -10/19$. For jurisdiction σ, it requires $\theta < 10/17$.

above, showing that revenues rise relative to the uncoordinated equilibrium. However, the asymmetry of jurisdictions present in my model, but not in theirs, allows for a richer array of outcomes for the individual jurisdictions, showing that the precise coalition of jurisdictions matters.

4.4 Voluntary Cooperation: Partial Harmonization

The prior section considered forced cooperation, but in many countries, intermunicipal cooperation or the signing of tax treaties is voluntary. In these cases, jurisdictions have flexibility to determine with whom to cooperate with. As a result, the decision to cooperate—and with whom—is endogenous to the tax competition game. As a result, coalition formation becomes a necessary part of the game, similar to the setup of Burbidge et al. (1997).

In stage one, jurisdictions decide with whom to cooperate, if anyone. The rules are as follows. There is no pre-play or pre-communication in this model.[20] Each of the three jurisdictions decides who to cooperate with by declaring a possible partner. Each jurisdiction has three strategies that they may declare. For example, jurisdiction s may play σ, a, or s, where the first two strategies denote possible coalition partners and the last strategy indicates an intent to go-it-alone. If two of the jurisdictions jurisdiction play a strategy that results in both wanting to be in the same coalition, then that coalition is formed regardless of the third player's strategy. If no two jurisdictions declare each other, the jurisdictions then act in uncoordinated game. In stage two, taxes are set in a Nash game. The game is solved backwards and simply requires comparing tax revenues under the different combinations of coalitions to solve for the equilibrium coalition.

When thinking about coalition formation, the equilibrium concept is important. For purposes of this paper, I use the standard Nash equilibrium concept. This concept is intuitive, but likely a weak equilibrium concept for a noncooperative game of this form. To see this, note that in a Nash equilibrium, each jurisdiction takes as given the strategies of the other players. Thus, the Nash game does not consider mutually beneficial deviations by possible for coalitions of players. For coalition games, it would instead be reasonable for players to discuss their strategy in a pre-play stage, though without making a binding commitment. In this case, it must be that any agreement is self-enforcing. The Nash concept is a necessary requirement for any agreement to be self-enforcing, but it is not sufficient. Given this, Bernheim, Peleg and Whinston (1987*a*) and Bernheim, Peleg and Whinston (1987*b*) define a coalition-proof Nash equilibrium, which are the Pareto efficient strategies that are self-enforcing—if no coalition of players, given a fixed action

[20]See Konrad and Thum (2021) for a model of tax coordination with negotiations.

of its complement, can agree to deviate such that all members of the coalition are better off. While such an equilibrium concept is more realistic, it is more demanding, and given the overview purpose of this article, I focus on the weaker Nash concept. The Nash concept sheds light on the possible set of equilibrium, ruling out some possibilities, even if it is less realistic than the coalition-proof Nash equilibrium. An alternative to the Nash coalition-proof Nash concepts would be a strong Nash equilibrium (Aumann 1959), but such an equilibrium often does not exist.

The Nash equilibrium concept is applied by considering all possible combinations of declarations of strategies (σ, a, or s) by all three jurisdictions (σ, a, or s). The Nash equilibrium is obtained by taking as given the other two player's declarations and determining whether or not there exists a unilateral revenue deviation by one jurisdiction. It does not require I check coordinated deviations by two jurisdictions. Keep in mind that the Nash concept has been applied to solve for all tax rates, but the Nash equilibrium solved for here can be viewed as a two-stage coordinated Nash equilibrium which differs from the single-stage uncoordinated Nash equilibrium above.

I proceed by both considering the scenario where taxes are distributed proportional to the size of the equilibrium tax base in each jurisdiction and, alternatively, the case where tax revenues are split equally. Furthermore, for simplicity, I also assume that there cannot be a grand coalition that would form or that the federal government exogenously prohibits such a coalition, in which case, the tax base would be completely captive and taxes and revenues would be excessively high. In a model of welfare maximization, allowing for the grand coalition would be important. But, even then, there are plausible explanations to rule out a grand coalition. One possibility at the national level is that it is nearly impossible to implement tax coordination across all countries in the world. An obvious example is an EU versus US story, where coordination powers are stronger in the region (EU) than among European and North American countries. Another possible justification at the local level is that municipal cooperation across state borders is challenging due to institutional differences in the rules governing local policy-making. Even beyond those institutional arguments, there are economic reasons to believe that larger coalitions with more members may entail substantial costs that may outweigh the gains of coordination (Alesina and Spolaore 2005).

When two symmetric jurisdictions cooperate and revenues are split proportionally according to the tax bases, then equilibrium revenues, denoted with a superscript C for cooperation, under voluntary partial cooperation are

$$\begin{array}{rcl} \tilde{R}_s^{C(s\sigma)} = \tilde{R}_\sigma^{C(s\sigma)} = & = & \frac{1}{36}\delta(\theta-5)^2 \\ \tilde{R}_a^{C(s\sigma)} & = & \frac{1}{18}\delta(\theta+4)^2 \end{array} \tag{21}$$

where the subscript denotes the jurisdiction receiving the revenue and the term in parenthesis of the superscript is the coalition. The tilde denotes that the allocation rule is proportional to the tax base. But when two asymmetric jurisdiction cooperated, revenues under cooperation are

$$\begin{array}{rcl} \tilde{R}_s^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta-8)^2 \\ \tilde{R}_a^{C(a\sigma)} & = & \frac{5}{72}\delta(\theta+10)(1+\theta) \\ \tilde{R}_\sigma^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta+10)(5-4\theta) \end{array} . \tag{22}$$

Equilibrium revenues for the coalition between as can be derived similarly by flipping the revenues for jurisdiction s and σ. When the splitting rule is governed by equal splitting, tax revenue in each jurisdiction is one-half the coalition's tax revenue, with formal expressions given in Appendix A.5.

Then, pairwise revenue comparisons of each regime indicates that the preferred strategies for each jurisdiction depend on the value of θ. The revenue hierarchy for each jurisdiction, conditional on a value of θ, can then be used to construct the Nash payoff matrices. These matrices in Appendix A.5 allow me to solve for the Nash equilibrium coalitions.

As discussed above, the Nash concept is relatively weak so multiple equilibrium often exist, so I only focus only on equilibrium where a coalition will form, ignoring those where the game reduces to its uncoordinated form.

Proposition 4. *Regardless of if tax revenues are split proportional to the jurisdiction's tax bases or equally split, a coalition between the one of the symmetric jurisdictions and the asymmetric jurisdiction is only an equilibrium if the size asymmetries are of intermediate values. On the other hand, regardless of if tax revenues are split proportional to the tax bases or equally split, a coalition between both symmetric jurisdictions is an equilibrium for all size differentials.*

The proposition states that if tax revenues are split proportional to the tax base, then, a partnering with one of the other two jurisdiction will only arise if θ is sufficiently close to zero. If θ is too far away from zero, then as and $a\sigma$ can never arise in equilibrium. Intuitively, if the asymmetric jurisdiction is too small ($\theta \to -1$), it prefers to deviate to be alone: when a very small jurisdiction is alone, it can set a low tax rate but attract a very large tax base due to shifting into the jurisdiction. If the asymmetric jurisdiction is too large ($\theta \to 1$), then the symmetric jurisdictions either prefer their own coalition or the uncoordinated game because, with base-splitting, their very small size means they only receive a negligible amount of the coalition's tax revenue.

On the other hand, a coalition between symmetric members will arise for all values of θ. Intuitively, when $\theta > 0$, two smaller jurisdictions join in size together. However, the smaller jurisdictions have no incentive to deviate to be with the large jurisdiction—in fact, they wish the other small jurisdiction were in a coalition with a. Any deviation to be with a thus results in very low payoffs for the jurisdiction deviating because the base is allocated proportional to relative equilibrium sizes. If $\theta < 0$, the equilibrium with a coalition among symmetric jurisdictions arises only if player a wants to go-it alone, in which case the coalition of s and σ is better than the uncoordinated equilibrium. However, if a does not play a, then the coalition of symmetric jurisdictions cannot emerge when $\theta < 0$

With equal splitting, $s\sigma$ is similarly a Nash equilibrium for all values of θ, as equal splitting is identical to base splitting if the members are symmetric. But, matters are more nuanced for coalition as or $a\sigma$. Again, like base splitting, a partnering with one of the other two jurisdictions will only arise if θ is in an intermediate range. Intuitively, if the asymmetric jurisdiction is too small ($\theta \to -1$), forming a coalition with a always yields the lowest payoff for the larger symmetric jurisdiction, as the gains from combining only result in a slightly higher tax rate, but require the larger jurisdiction to give up a substantial amount of revenue to the smaller. If the asymmetric jurisdiction is too large ($\theta \to 1$), then that jurisdiction prefers to go it alone rather than be in a coalition where it has to share a large share of its revenues with the much smaller.

The results in this proposition have some parallels to Burbidge et al. (1997). That paper shows that if there are two jurisdictions, the grand coalition is the equilibrium. However, the authors show that if there are more than two jurisdictions, then, a coalition structure other than the grand coalition is the unique equilibrium. Given the complexity of the model, the authors prove this result using an example: two states that are symmetric and large in size will form a coalition. Unfortunately, the authors do not characterize all potential equilibrium coalitions for different parameter constellations, highlighting the value in the simplicity of the model that I have proposed.

A richer model than mine might consider additional cases, such as three entirely asymmetric jurisdictions. Under the completely asymmetric case, one could answer questions such as: does a central planner prefer joining the two largest jurisdictions to joining the two smallest jurisdictions? In particular, a central planner's preferred coalition may differ from the endogenously chosen coalition among the the jurisdictions, possibly creating a conflict of interest between the central government and decentralized governments. But this simple model, even with a Nash equilibrium concept, suggests that a wide range of coalitions may be possible—but that there are also many parameter constellations for which some coalitions will not emerge. Critically, a key message is that if jurisdictions are sufficiently asymmetric, it is never in the interest of those asymmetric jurisdictions to form a coalition.[21]

Finally, a key simplification in this model is that when a coalition forms, all tax authority is ceded to the coalition. In practice, intermunicipal cooperation coexists with its members maintaining some municipal tax autonomy. The cohabitation of taxes bases by the municipality and the the cooperative creates incentives that can make tax rates too high (Keen and Kotsogiannis 2002; Keen and Kotsogiannis 2004). Whether this force moves the equilibrium closer toward the optimal solution or whether it moves it too far past the optimal is an empirical question. This "vertical" channel is not in the model, but worthy of future study.

4.5 Sourcing Rules

As an alternative to minimum tax rates, tax harmonization, or cooperation, governments may change whether taxes are based on a source or residence principle. In the context of commodity taxes, this would be the origin versus the destination principle (Lockwood 1993; Lockwood 2001). If goods are taxed at origin, then revenue accrues to the jurisdiction where the sale occurs. If goods are taxed at destination, then revenue accrues to the jurisdiction where the consumer lives. Of course, the corporate tax and the capital tax literatures also has a long history discussing the difference between source based and residential based capital taxes (Auerbach and Devereux 2018). More generally, the taxation of cross-border labor income requires clear sourcing rules, as the rise of telework now could result in states taxing remote workers either in the state where the firm is located or in the state where the worker resides (Agrawal and Brueckner 2023).

In the above model, jurisdictions tax mobile factors in the jurisdiction where the economic activity is "shifted to" but could just as easily be tax the activity in the location where the activity is "shifted from." Suppose that governments change the souring rule to tax it where the activity is shifted from. In this case, tax revenue then becomes:

$$R_i = \quad T_i B_i = \quad T_i \Theta_i \quad . \tag{23}$$

Then, because this simple model assumes Leviathan governments and features no other behavioral responses, the tax base becomes perfectly inelastic, allowing governments to set tax rates that are as high as possible. As the maximization becomes equivelent to (9), all tax rates are thus set to T^*. In the case of consumption taxes, this would be the tax rates such that the government extracts all of the surplus from the consumers of the taxed commodities. While such a model is a bit extreme, it provides some useful

[21]See Fleurbaey, Kanbur and Snower (2022) for a discussion of moral motives in the competitive context along with issue of cooperation.

intuition.

Proposition 5. *Equilibrium tax rates will be higher under the sourcing rule where taxes are levied on the more inelastic base.*

To gain some intuition, it is useful to consider the example of cross-border workers and personal income taxes. The typical U.S. state levies a (personal) income on all income earned within the state, a source-based tax.[22] However, some U.S. states have entered into reciprocity agreements, which turn their income tax systems into residence-based taxes, with no taxation of nonresident earnings, but taxing resident income resulting from cross-border commuting. Thus, reciprocity agreements are a form of a tax treaty that shifts the state personal income tax away from a source-based taxed toward a residence-based tax (Coomes and Hoyt 2008; Agrawal and Hoyt 2018; Rohlin, Rosenthal and Ross 2014). The results above suggest that reciprocity can reduce tax competition if firms and employment are more elastic then residential locations. Rork and Wagner (2012) write "states may have less incentive to engage in income tax competition with neighboring states, as nonresident workers no longer contribute to the tax base." Intuitively, sourcing rules change the elasticity of the tax base. As a Leviathan government follows a simple Ramsey rule when setting its Nash tax rates, sourcing rules that lower the elasticity will raise tax rates.

Finally, consider an extreme case. If residential decisions are completely immobile, but the employment location can easily be shifted across borders, then switching to tax to the residential location from employment location entirely eliminates tax competition. In practice, this is too extreme, but it suggests that there are intermediate cases.

In the context of capital income taxation, standard models again predict that taxes should be levied on the more immobile factors. The optimal rate of a source-based capital income tax is zero in a small open economy. Auerbach and Devereux (2018) elegantly state the intuition: "Imposing a positive tax rate raises the required rate of return, reducing the domestic capital stock and causing deadweight loss. The incidence of the tax is on immobile domestic residents—who could be taxed directly without creating the deadweight loss." With capital mobility and cross-country tax differentials, capital taxes either distort international savings (when residence-based) or international production (when source-based). The international version of the production efficiency theorem states that, in the absence of pure profits, and with a full set of taxes, only residence-based taxes are used and source-based taxes are zero in the optimum. This is true not only in a small open economy, but also for a set of symmetric countries that are all "large"

[22]In the U.S., matters are slightly more complex, as the state of residence also may tax the income. To avoid double taxation, tax credits are provided.

(Eggert and Haufler 1999).[23]

4.6 Other Mechanisms

Of course, there are many other tools—especially in fiscal federations—that allow governments to potentially limit tax competition. These policies might involve outright bans of local taxes on particular bases, might involve restrictions on the rates jurisdictions are able to set (e.g., only integers), or place limits on the rate of growth of particular taxes. Other possible restrictions may include tax and expenditure limitations, intergovernmental grants, and tax enforcement. While I omit formal modeling of these policies, I discuss a few issues briefly here.

Intergovernmental grants have long been used to equalize tax bases across jurisdictions. However, they also have an important effect on fiscal competition as discussed by Köthenbürger (2002). In particular, he shows that in a small open economy, tax base equalization yields the efficient tax rates by helping to internalize fiscal externalities.

Further, the discussion on the role of sourcing rules raises the possibility that governments could use enforcement tools to mitigate tax competition. If shifting behavior could be eliminated via perfect enforcement rather than a change of sourcing rules, then the optimal tax rates would still be derived from maximizing (23). However, if enforcement is not done by the higher level governments, then it is possible that enforcement policies also become strategic choice variables (Stöwhase and Traxler 2005). Perhaps competing in tax rates is too politically obvious, in which case governments might not change the statutory rate and instead lower the effective tax rate via more lax enforcement. In Stöwhase and Traxler (2005), the enforcement decisions interact with the fiscal equalization rules in place. These authors show that without regional transfers, fiscal competition leads to audit rates which are inefficiently low for revenue-maximizing governments.

Although the paper considers interjurisdictional cooperation, another possible way to reduce the number of jurisdictions are via municipal mergers and annexations. These municipal mergers differ from the cooperation above because following a merger, a jurisdiction surrenders the entirety of its tax and spending policy to the merged jurisdiction. With intermunicipal cooperation, however, local governments may maintain autonomy over some policies, with others ceded to the cooperative. Thus, absent federal requirements to do so, mergers and annexations may be politically more challenging, perhaps not happening simply because municipalities could not agree on the merged municipality's name. Perhaps this explains why such mergers have been infrequent in the US (Epple

[23]See also Gordon (1986), Bucovetsky and Wilson (1991), and Keen and Piekkola (1997).

and Romer 1989), though other countries have forced mergers in an effort to reduce the number of jurisdictions. Further, mergers are often more about exploiting economies of scale in the provision of public services rather than tax harmonization.

Finally what is the role of preferential tax regimes where jurisdictions provide advantaged tax treatment to some firms, individuals or factors? These preferential regimes are often seen as a wasteful form of tax competition. But Keen (2001) shows that, preferential regimes may allow jurisdictions to confine their most aggressive tax competition to particular parts of the tax system, and therefore, banning them may actually worsen tax competition. Of course, counterarguments exist. The issue of preferential regimes has recently gained attention in the context of bidding for firms, where states create preferential policies to attract a large firm to the state (Black and Hoyt 1989; Slattery 2021; Slattery and Zidar 2020).

5 Comparing Revenues Across Policies

While the above analysis indicates that there are a vast array of policy mechanisms that can improve tax revenues of all jurisdictions relative to the uncoordinated case, an important question is which of the policies improves total tax revenues the most? The answer to this question then sheds light on which policy would be preferred from a "social" or federal planners perspective. Of course, in a model of Leviathan governments, there are some philosophical questions that need addressing. In particular, certain assumptions are necessary to conclude that the socially optimal policy would be the one that maximizes tax revenues of all region. Under one view, revenue-maximizing governments have a traditional welfarist interpretation if residents place a very high marginal valuation on the public good financed by the tax revenues (Kanbur and Keen 1993). In this setting, the policy that increases tax revenues the most would be better. Under an alternative view, revenue-maximizing governments can be viewed from a public choice perspective as governments that seek to extract surplus from residents. In this latter setting, tax coordination may fuel the Leviathan and, as such, tax competition yielding lower tax rates and revenues would be preferred—if the social planner were not a Leviathan—as an attempt to tame the Leviathan (Brülhart and Jametti 2019). For purposes of this paper, I take a simple view that both the local and social planners maximize tax revenue, and thus evaluating the policies on the basis of which one yields higher tax revenues.

5.1 Aggregate Tax Revenues

To provide a systematic comparison across policies, tax revenues can be summed over all three jurisdictions under each regime. This combined revenue can then be used by the social planner to determine which policy yields the most total revenue. It is clear from the above analysis that appropriately enforcing taxes via appropriate sourcing rules and tax auditing achieves the highest tax revenues. Thus, given this partially derives from several of the assumptions of the model, such as inelastic demand, my focus is on comparing across all the other policies.

I proceed by summing tax revenues for all three jurisdictions. In the case of the uncoordinated Nash strategy, denoting combined revenues with the subscript total, we have:

$$R^U_{total} = \delta(\frac{3}{2} + \frac{3}{25}\theta^2). \tag{24}$$

Under the policy of tax harmonization, tax revenues depend on the weights given to the low-tax or high-tax jurisdiction. Then total tax revenues are

$$R^H_{total} = \delta(\frac{3}{2} + \frac{9\omega - 3}{10}\theta) \tag{25}$$

which is clearly increasing in ω if $\theta > 0$ and decreasing in ω if $\theta < 0$.

Under a minimum tax rate, the weights also matter. Total tax revenues are now piecewise in θ:

$$R^M_{total} = \begin{cases} \delta(\frac{3}{2} + \frac{3\omega\theta}{4} + \frac{3(8+2\omega-3\omega^2)\theta^2}{200} & \theta \geq 0 \\ \delta(\frac{3}{2} + \frac{(\omega-1)\theta}{2} + \frac{(4\omega^2-6\omega-4)\theta^2}{50} & \theta < 0 \end{cases} \tag{26}$$

With partial harmonization via coalitions, total revenue if as or $a\sigma$ cooperate is

$$R^{C(as)}_{total} = R^{C(a\sigma)}_{total} = \delta(\frac{\theta^2 + 2\theta + 82}{36}), \tag{27}$$

while if $s\sigma$ is the coalition, then

$$R^{C(s\sigma)}_{total} = \delta(\frac{2\theta^2 - 2\theta + 41}{18}). \tag{28}$$

5.2 Which Regime Revenue Dominates?

Figure 1 shows the level of total revenue for each policy for all values of θ. Given some policies depend on the parameter ω, I depict graphs where this weight takes on a low, medium, and intermediate value.

First, compare the minimum tax rate and harmonization. Then differencing total revenues R^M_{total} and R^H_{total}, it is easy to see that the minimum tax rate always delivers higher tax revenues for a given value ω.[24] The intuition is clear: harmonizing, even to the highest possible tax rate, constrains the tax rate of the bigger jurisdiction. However, setting the same rate as the minimum allows the bigger jurisdiction to raise its tax rate above and beyond the minimum. Although this results in tax base shifting, some of the tax base is taxed at a higher rate under the minimum and the shifted base is taxed at a rate no lower that what would have been harmonized to.

Further, it is also easy to show that the minimum tax rate dominates the uncoordinated equilibrium. These results, combed with the possible existence of Pareto improvements discussed above, mean that there is ample reason to prefer minimum tax rates over harmonization to an identical tax rate.

Next, consider the case of partial harmonization. It can easily be verified that the total tax revenue from either coalition exceeds the total tax revenue from the uncoordinated equilibrium, as is evident from the figure. But which coalition yields more tax revenues? Comparing the two coalitions from a total revenue perspective, we have that

$$R_{total}^{C(as)} - R_{total}^{C(s\sigma)} = \frac{(2-\theta)\theta\delta}{12} \tag{29}$$

such that $R_{total}^{C(as)} > R_{total}^{C(s\sigma)}$ if $\theta > 0$ and $R_{total}^{C(as)} < R_{total}^{C(s\sigma)}$ if $\theta < 0$.

Given we know the minimum tax rate dominates harmonization, I can then compare partial harmonization with the minimum rate. Does the coalition yield more revenue that the minimum tax rate? First consider the coalition as or $a\sigma$. Then, equation (27) minus (26) is always positive for both branches of (26) regardless of the value of $\omega \in [0, 1]$. The same is true for coalition $s\sigma$ with one minor exception: the minimum tax rate regime dominates if ω is close to one and θ is close to 1.[25] Thus, the revenue-preferred solution from a central planner's perspective is coalition $a\sigma$ or as if $\theta > 0$ and coalition $s\sigma$ if $\theta < 0$. These coalition arrangements dominate all other possible policy responses for most parameter values. Intuitively, for most parameter constellations, the coalition of jurisdictions allows them to raise their tax rates above the minimum tax rate, even if the minimum tax rate is set to its highest possible value. Then the combined bases of those jurisdictions are taxed at a higher tax rate. Because taxes are strategic complements, the tax rate in the jurisdiction outside the coalition is also slightly higher, resulting in revenue gains.

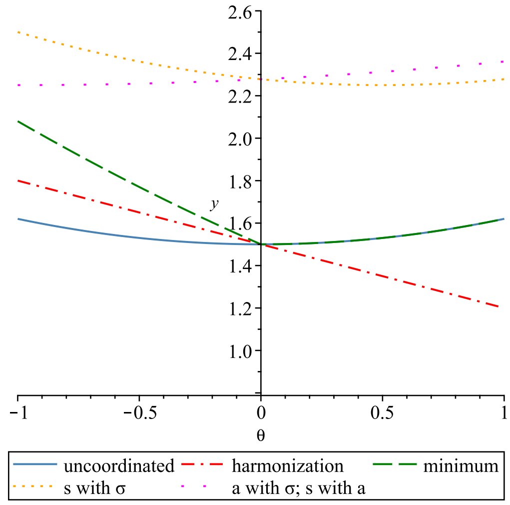
Proposition 6. *A minimum tax rate revenue-dominates harmonization to the same tax rate, A minimum tax rate regime also revenue-dominates total revenues in the uncoordinated equilibrium. However, there always exists a coalition under partial harmonization*

[24]If $\theta = 0$, the two regimes are equivalent to each other and to the uncoordinated equilibrium.

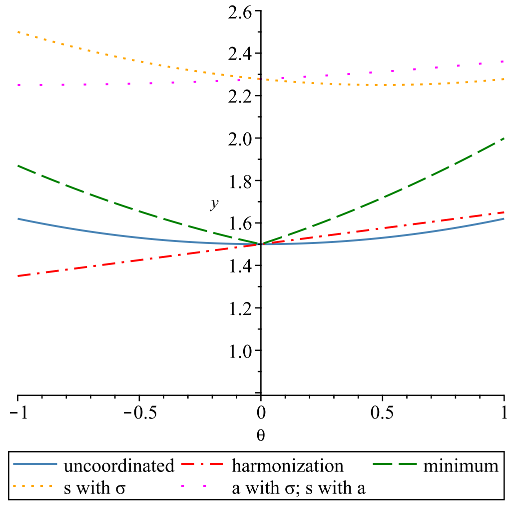
[25]The precise condition for the minimum tax regime to yield more revenue is $(9\theta\omega + 2\theta - 10)(9\theta\omega - 8\theta - 140) > 0$, which for $\omega = 1$ implies $\theta > 10/11$.

Figure 1: Total (Combined) Revenue of All Jurisdictions

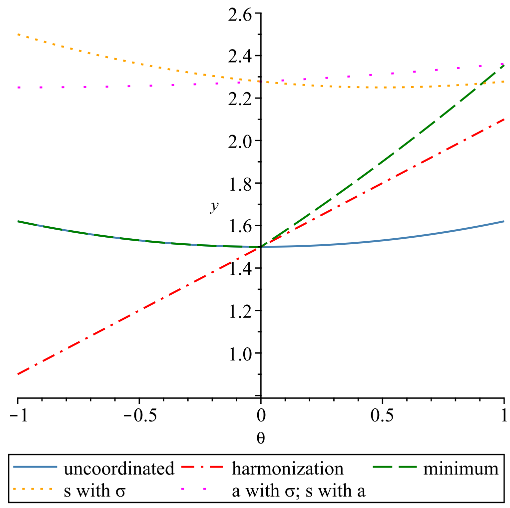
(a) Case: $\omega = 0$



(b) Case: $\omega = .5$



(c) Case: $\omega = 1$



This figure shows total (combined) revenue as a function of θ. As the harmonized tax revenues and minimum tax revenues are a function of the weight ω, I display revenues for three different values of ω across the panels.

where total revenues dominate the total revenues from minimum tax regime. When the asymmetric jurisdiction is the larger, the revenue preferred outcome is a coalition between one of the symmetric jurisdictions and the asymmetric jurisdiction; when the asymmetric jurisdiction is the smaller, the revenue preferred outcome is the coalitions with two symmetric jurisdictions.

However, if $\theta > 0$ and ω is sufficiently close to one, the minimum tax regime will dominate coalition $s\sigma$ even if it does not dominate coalitions $a\sigma$ or as. Would coalition $a\sigma$ or as emerge in equilibrium? Recall that under voluntary coalition formation, coalition $a\sigma$ or as are only a Nash equilibrium if θ is not too close to one. Thus, unless the federal government forces cooperation, there exist a range of values large values θ where ω is sufficiently high such that the minimum tax regime revenue dominates any feasible voluntary coalition from the federal government's perspective. This result shows a tension between imposing coalitions on subnational governments versus letting those coalitions arise versus their own free will. Obviously the central government prefers forcing a coalition on the subnational jurisdictions to implementing the minimum tax rate for these extreme parameter values. That said, this range of θ and ω only arises for very extreme values.

As emphasized earlier in the paper, the proposition raises an interesting paradigm. Minimum tax rates clearly dominate complete harmonization both from a Pareto principle for each jurisdiction and from a total revenue principle. Intuitively, the minimum tax rate allows high tax jurisdictions to raise their tax rates, while harmonization does not. But, minimum tax rate proposals usually seek to set the minimum somewhere between the noncooperative taxes, thus imposing a maximum value for the lowest possible tax rate. This is especially noticeable when $\theta = 0$, because both harmonization and the minimum tax rate regime are equivalent to each other and to the uncoordinated equilibrium: if all jurisdictions set the same rate and the policy requires coordination is to a rate in between, that policy cannot mitigate tax competition forces! Of course, the model presented here is static. In the long run, the federal government or supra-national institutions may decide to change the harmonized rate. Perhaps, with time, they may increase it without regard to the historical uncoordinated tax rates.

Partial harmonization via a coalition, however, does not constrain the members of the coalition to set a tax rate less than or equal to the maximum noncooperative tax rate. Indeed, there are clearly cases where the coalition raises their tax rate above that Nash value, thus allowing the other jurisdiction to also raise its tax rate. Partial coordination thus mitigates tax competition by reducing the number of competitors, but does not impose any restriction on the resulting taxes. Thus, minimum taxes and harmonization suffer from an important fallacy: if taxes are too low due to tax competition, any policy intervention that relies on the Nash tax rates is relying on taxes that are too low. Partial harmonization, by still allowing autonomous choice over taxes, allows for a reduction of competitors but potentially lets all jurisdictions set taxes above the noncoordinated tax rates.

Interestingly, harmonization never revenue-dominates partial harmonization. The reason is that harmonization puts the most stringent restrictions on all jurisdictions to be constrained to set tax rates between the uncoordinated values. While a minimum tax rate only raises the lower tax jurisdiction rate in this range, it allows the higher tax jurisdiction to raise its rate above the equilibrium. Partial harmonization places no explicit restriction on jurisdictions to be between the equilibrium.

6 Empirical Evidence

In this section, I selectively review some empirical evidence on tax coordination. I focus on two strands of the literature: first, counterfactual exercises concerning minimum tax rates and harmonization and second, empirical evidence on partial harmonization resulting from intermunicipal cooperation.

6.1 Minimum Tax Rates Versus Harmonization

As noted above, in many circumstances, there is a clear dominance of minimum tax rates over tax harmonization. Perhaps this—and the political challenges of harmonization across sovereign international countries—explains why recent policy efforts on reforming the international tax structure have focused on the global minimum tax rather than tax harmonization. But in federalist systems, central governments could consider passage of either minimum tax rates or tax harmonization. Despite this, the empirical evidence on harmonization and minimum tax rates remains limited.

Fajgelbaum et al. (2019) study the spatial distortions of tax dispersion and consider counterfactual exercises that reduce the dispersion in tax rates across jurisdictions. Using a more general welfare function that revenue maximization, eliminating tax dispersion could have ambiguous effects on tax revenues. The authors find that reducing tax dispersion across U.S. states raises welfare. Their model does not incorporate tax competition forces explicitly, so adding endogenous policy determination to a model like theirs represents a promising avenue for future research.

In one recent example that links closely to the prior theory, Agrawal, Foremny and Martínez-Toledano (2022) study the mobility to regional wealth taxes within Spain. Tax-induced migration and mobility is a shifting behavior that can results in interjurisdictional fiscal externalities. A unique feature of the Spanish setting is that only the region of Madrid—the largest region within Spain—set a zero tax rate on wealth; all other regions within Spain set reasonably similar positive tax rates to each other. As a result, most all migration was from high-tax regions to Madrid. After estimating the elasticity of wealth tax mobility, the authors then conduct counterfactual simulations of various tax coordination policies. Given Madrid is a relatively large region, representing approximately 15% of the entire population of Spain, it makes sense to think about the effects in the context of the model above where Madrid is a single large region.[26] From the theory above, harmonization would need to be to a sufficiently high tax rate while a minimum tax rate may benefit all regions.

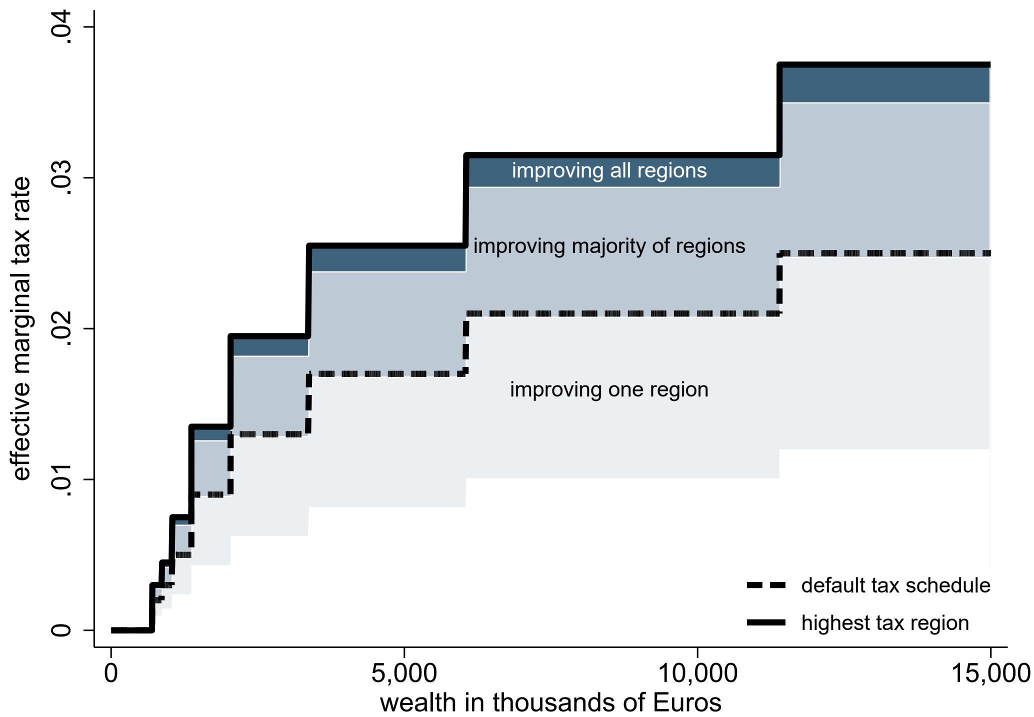
The authors first estimate the elasticity of the number of wealth tax filers to regional wealth tax rates: Madrid's lower tax rate increases the number of wealth tax filers there by about 8%, which is a decline in the number of filers in other regions by about 2%. To shed light on the theoretical issues discussed above, the authors then consider various tax harmonization schemes. To do this, they exploit the fact that tax harmonization removes tax differentials, thus eliminating tax-induced migration. Then for each tax rate in between that of the lowest tax region and the highest tax region, Agrawal, Foremny and Martínez-Toledano (2022) count the number of regions that see increases in tax revenue from harmonization. As with the theory above, abstracting from taxable wealth responses, there are two effects. Harmonization raises regional tax revenue by reducing migration to Madrid. But, if the harmonized rate is to a rate lower than the uncoordinated tax rate, revenues mechanically fall due to the lower rate on the infra-marginal tax base. Simulating the these revenue effects using the causal estimates to obtain the revenue gains from reduced mobility, the authors show that when harmonization is to a low rate only a few regions are improved. For tax harmonization to benefit all regions, the tax rate needs to be sufficiently close to the maximum decentralized region. Figure 2 shows the result. Consistent with the theoretical propositions above, Agrawal, Foremny and Martínez-Toledano (2022) provides new empirical evidence documenting that harmonization needs to be to a sufficiently high rate to benefit all regions, highlighting the political difficulty of finding a consensus for harmonization.

Then, the authors compare tax harmonization to minimum tax rates.[27] Counterfactual simulations are a bit more challenging because the authors cannot explicitly model tax competition and do not know if eliminating a tax haven will result in mo-

[26]Obviously there are other larger regions in Spain, so this is a simplification. Further, clearly, Madrid is not revenue maximizing wealth tax revenues by setting a zero tax rate. An alternative might be that more wealth individuals in Madrid drives up personal income tax revenues, but even under such a story, it appears Madrid is not a Leviathan government.

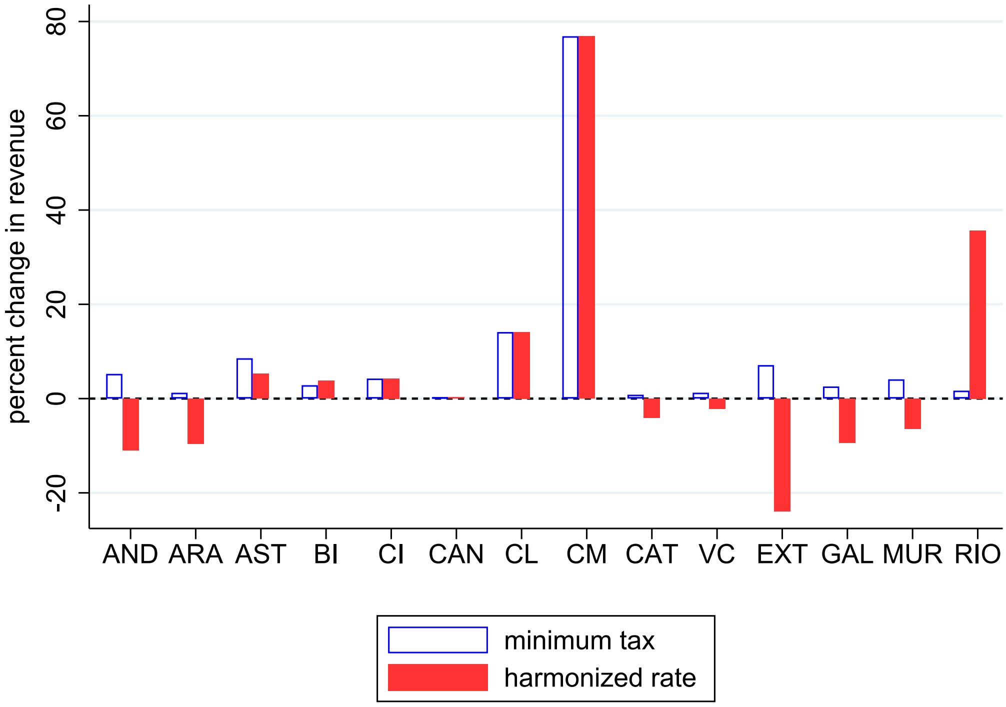
[27]See Keen, Liu and Pallan (2022) for simulations related to the global minimum tax.

Figure 2: How Many Regions Increase Tax Revenue from Harmonization to Different Rates?



This figure shows the number of regions benefiting from various harmonized wealth tax schedules in Spain. The solid dotted line is the recommended default schedule proposed by the national government, while the solid black line is the tax schedule of the highest tax rate. The lower bound of each shaded area represents one region, a majority of regions, and all regionswhich that would benefit from that harmonization to that tax rate. To construct this, the figure looks at only wealth tax revenue, but Agrawal, Foremny and Martínez-Toledano (2022) also consider spillovers to other tax based, such as capital income tax revenue.

Figure 3: Tax Harmonization versus Minimum Tax Rates



This figure shows the percent change in tax revenues for each region for a minimum tax rate and harmonization to the same rate (the recommended national default schedule). All changes here are for wealth tax revenues only. Agrawal, Foremny and Martínez-Toledano (2022) also consider spillovers to other tax based, such as capital income tax revenue.

bility occurring to the region setting the minimum tax rate. Nonetheless, assuming a partial equilibrium analysis and that after the minimum tax rate is adopted it is to a rate sufficiently high that it eliminates most shifting responses, allows the authors to make some progress. Figure 3 shows the revenue changes under two different scenarios: (1) a minimum tax regime with the minimum tax rate set at the national default schedule (dashed line on the prior figure) and (2) tax harmonization to the same rate.

Critically, under the (strong) assumption of the minimum tax rate eliminating shifting, the minimum rate and harmonization affect jurisdictions previously below the new rate in the same manner. If these minimum tax rate jurisdictions would still benefit from some inflows of wealthy tax payers from higher tax regions, then the minimum tax rate scheme might lead to higher revenues for them than harmonization. However, for jurisdictions with uncoordinated rates above the default schedule, harmonization lowers tax revenues, while the minimum tax rate raises revenues. This is because the minimum reduces shifting but does not force the jurisdiction to raise the rate. This effect might be mitigated if there were some revenue losses to jurisdictions adopting the minimum, but might also be amplified if the jurisdictions responded by raising their tax rates by raising theirs substantially. Given the assumptions, the precise estimates should not be the focus, but rater the emphasis is on the heterogeneity of responses by policy and region. These simulations clearly indicate the dominance of the minimum tax rate regime from a political economy perspective: minimum tax rates can raise revenues everywhere, while harmonization cannot.

6.2 Intermunicipal Cooperation

France has a very long history of intermunicipal cooperation. This dates back to syndicates which were formally codified in the 22nd March 1890 Law, allowing jurisdictions to form cooperatives to provide necessary public services among municipalities (clean water, sewage treatment, waste collection, etc.), but without taxing authority. More formal cooperation leading to the Establishments for Intermunicipal Cooperation (EIMC) arose in French laws of 1966, 1970, 1992, and 1999. EIMCs are an example of (voluntary) cooperation among municipalities of one's choosing—in fact, it was not even until 2010 that municipalities were required to join an EIMC. EIMCs can be viewed as another level in the fiscal federalism hierarchy with municipal delegation of particular revenue and expenditure instruments, including taxing power, to the EIMC. But many fiscal instruments remain under municipal control. Despite rich data on local public finance in France, it is difficult to study the effect of joining a EIMC empirically: prior to 2010, municipalities select into EIMCs and they select with whom to cooperate. Fiscal policies are then determined in an open economy setting, with fiscal competition persisting at the municipal level and also co-determined with the EIMC's fiscal policies.

After forming an EIMC, some tax policies remain under control of the municipality. Given the theory above, partial harmonization seem to be unambiguously beneficial. But, as noted above, the presence of a new tier of government with vertical tax externlaities creates other forces. The question then is whether joining an EIMC actually mitigates or amplifies strategic tax competition. On the one hand, an EIMC may reduce strategic tax competition as members of the cooperative share common policy goals on at least some dimensions. Moreover, any leakage of the tax base shrinks not only the tax base of the municipality, but also the cooperative, implying that any tax induced-shifting outside of the EIMC imposes a "double harm" to the municipality. As a result, competition with towns outside the cooperative may be more fierce. On the other hand, competition within a cooperative may be more intense with with respect to remaining municipal tax instruments. This offsetting effect might arise if the tax base is locally mobile within the set of similarly situated municipalities. Either way, the formation of EIMCs implies that the strategic responses to "peer" municipalities within the same EIMC may be different than with municipalities outside of the EIMC. This heterogeneity is not usually modeled in standard tests of the existence of strategic interactions.

Traditional tax competition researchers often estimate a strategic reaction function regressing a jurisdiction's tax rate on the spatial average of competitor tax rates (Brueckner 2003; Brueckner and Saavedra 2001):

$$\mathbf{T} = \rho \mathbf{W} \mathbf{T} + \mathbf{X}\beta + \boldsymbol{\varepsilon} \tag{30}$$

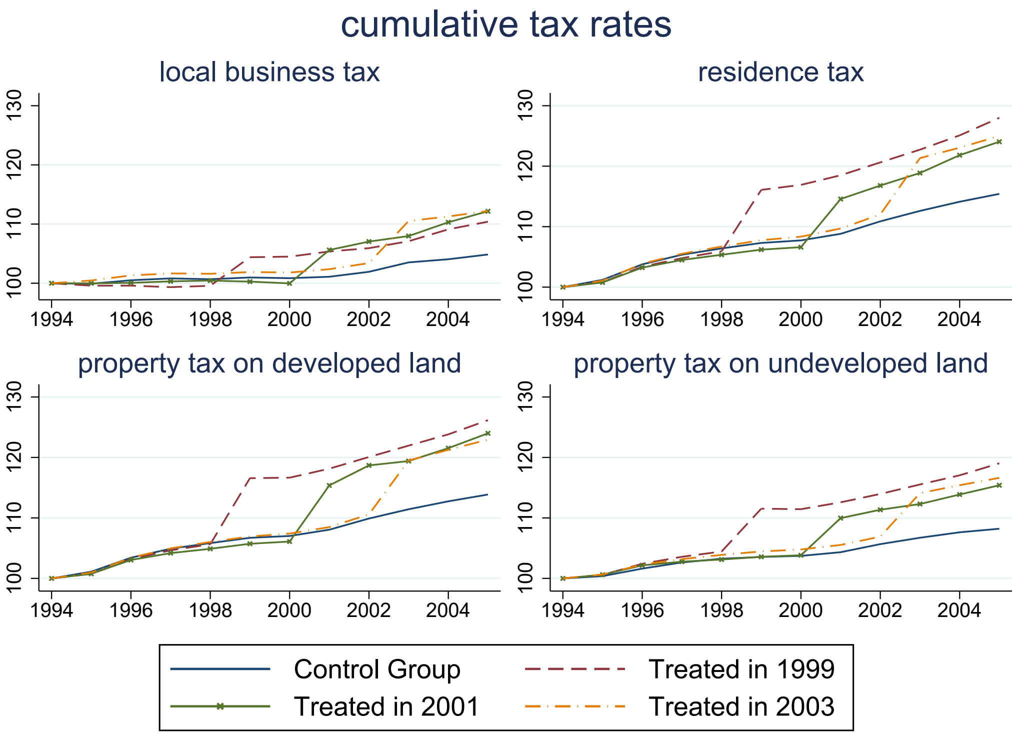
where $\mathbf{T}$ is a vector of tax rates for municipalities over time, $\mathbf{W}$ is a block-diagonal weights matrix identifying competitor municipalities, and $\mathbf{X}$ are any covariates and fixed effects. Then, the coefficient ρ is the slope of the strategic reaction function. In words, it says if the weighted average of competitor tax rates rise by one unit, then the own-jurisdiction tax rate changes by ρ units. If taxes are strategic complements—where reaction functions slope upward—then ρ is positive. If taxes are strategic substitutes—where reaction functions slope downward—then ρ is negative. A zero sloped reaction function implies the lack of strategic interactions—but does not imply there is not tax competition at work. In particular, if jurisdictions are small and there are infinitely many of them, jurisdictions compete à la perfect competition, but not strategically. Even if jurisdictions are not strategic, a tax change in any one jurisdiction still imposes an interjurisdictional fiscal externality on the rest of the world. A reaction function such as (30) assumes that there is no heterogeneity in how jurisdictions compete. The question then is whether intermunicipal cooperation changes the extent of strategic reactions.

Agrawal, Brueillé and Gallo (2021) study whether EIMCs dampen tax competition among towns within the cooperative relative to towns external to the EIMC. To do this, (30) is modified to allow for different slopes for both groups:

$$\mathbf{T} = \rho^{EIMC} \mathbf{W}^{\mathbf{EIMC}} \mathbf{T} + \rho^{OUT} \mathbf{W}^{\mathbf{OUT}} \mathbf{T} + \mathbf{X}\beta + \boldsymbol{\varepsilon} \tag{31}$$

where $\mathbf{W}^{\mathbf{EIMC}}$ is the weight matrix for municipalities inside the EIMC and $\mathbf{W}^{\mathbf{OUT}}$ is the weight matrix for those outside. Then, if ρ^{EIMC} is significantly different from ρ^{OUT}, the strategic responses to each sub-groups of towns are different. In addition to standard endogeneity of nearby jurisdiction tax rates, the spatial weight matrices are also endogenous because the decision of whom to cooperate is a choice. The authors use new methods to address these concerns. The authors estimate $\rho^{EIMC} < \rho^{OUT}$, with the difference between the coefficients statistically significant. The differential pattern of strategic responses suggests that municipalities react less intensely to change by municipalities in the same EIMC than they do to municipalities outside of the EIMC. Intermunicipal cooperation thus dampens strategic tax competition among municipalities. In the context

Figure 4: The Effect of Intermunicipal Cooperation on Total Tax Rates



This figure a modified figure from Breuillé, Duran-Vigneron and Samson (2018) and shows the effect of joining an EIMC on total tax rates. Treated groups are towns joining an EIMC in a year, while the comparison groups is towns that do not join an EIMC.

of the theoretical model above, there is no tax competition within an EIMC, so this empirical evidence suggests that even allowing jurisdictions within a coalition to maintain some tax autonomy can still have beneficial effects.

Although the strategic responses are dampened by tax cooperation, the reaction function slope does not translate into a welfare metric (Agrawal, Hoyt and Wilson 2022), and the prior results cannot be translated into the efficiency effects of cooperation. To shed some light on this, Breuillé, Duran-Vigneron and Samson (2018) exploit a difference-in-difference design to identify the effect of cooperation on the total (EIMC plus municipal) tax rate of local jurisdictions. The authors compare tax rates in the treatment group: (municipalities that form an EIMC) with a comparison group (municipalities that do not form a EIMC in their sample). This allows the authors to test if the economies to scale of public good provision resulting from cooperation allow jurisdictions to reduce costs and cut taxes or if the effects on tax competition discussed above may arise, allowing them to raise taxes. If economies of scale were at work, this would suggest costs would fall and tax rates would thus fall to balance the budget. On the other hand, if tax competition becomes less intense, one might expect tax rates to rise. The authors find, as in Figure 4, that total tax rates rise.

The results suggest that economies of scale are not the dominant force resulting from intermunicipal cooperation. While the authors cannot causally identify EIMCs dampening tax competition as the mechanism by which tax rates rise, this combined with the evidence on reaction function slopes in Agrawal, Brueillé and Gallo (2021) is consistent with it. The intuition follows Hoyt (1991), who shows that reducing competition by reducing the number of jurisdictions in a metropolis increases both tax rates and welfare.

Cooperating can be costly for municipalities, as they lose autonomy over local policies, reducing their ability to tailor policies to local preferences and protect local interests. Tricaud (2021) provides evidence on this by exploiting a 2010 reform in France that required holdout municipalities to join an EIMC. She classified municipalities that were forced to join an EIMC as treatment municipalities and then compares them to municipalities that joined an EIMC voluntarily previously. She focuses on two costs to municipalities. First, EIMCs decide where and how much building can be allowed in each member municipality. New development can be costly for some municipalities that have been using local housing regulations to prevent outsiders from coming in—not in my backyard (NIMBYism). Second, decisions over the location of public services can benefit some municipalities while harming others. EIMCs may concentrate resources for new facilities in high-density areas. As a result, low-density municipalities might end up with fewer facilities, increasing the distance to public services for their residents. Tricaud (2021) finds that after a municipality is forced to join an EIMC, the number of building permits increases in these towns relative to the comparison group. This evidence is consistent with municipalities not joining an EIMC in order to prevent development in the "backyard" of residents. With respect to the second cost, she finds that the number of daycare slots falls in rural municipalities, while it increases in urban municipalities. This suggests that joining an EIMC moves public services further away from smaller municipalities. Thus, cooperation can be costly for some municipalities in a way not captured by the purely tax-driven model above.

Overall, the empirical evidence on intermunicipal cooperation suggests that it has been successful at limiting the parasitic effects of tax competition. While this comes at some cost, which might be born by some municipalities more so than others, EIMCs may be a way to mitigate competitive tax competition while still allowing for Tiebout sorting benefits across EIMCs.

7 Directions for Future Research

Policy responses to tax competition are becoming increasingly common, but we there are many open questions that remain.

First, while there are many individual studies of *specific* policies to limit competition, like the goal of this chapter, more work is needed to compare across various forms of cooperation, such as minimum tax rates versus harmonization versus partial harmonization. When doing so, it is useful to know both the effect on taxes and spending levels including the mobility of businesses/factors/individuals, but also any costs imposed on municipalities. Simple theory, like the one presented above, could be helpful by nesting different forms of cooperation in a single model, providing information on parameters needed to conduct counterfactual exercises that provide information on welfare. It would be useful to make explicit comparisons regarding welfare across various policy responses so that governments can determine how to respond to heightened tax competition.

Second, the literature on federal or state interventions in local policy matters (Agrawal, Hoyt and Wilson 2022) is much more well-developed than the literature with respect to voluntary forms of cooperation, such as intermunicipal cooperation and bilateral tax treaties. An important empirical challenge here is that both the decision to engage in cooperation—and with whom to cooperate—is endogenous because it is selected by the municipality. The data challenges of studying such forms of cooperation are numerous, especially in countries where local data are not tracked nationally, and where special districts often have vague fiscal authorities. Moreover, information on bilateral tax treaties are often not centralized, and understanding how the treaties work in practice often involve legal interpretations.

Third, when thinking about the effect of policy responses to tax competition, it is tempting to only look at tax rates as the outcome. However, more emphasis on the effect of cooperation and coordination on interjurisdictional fiscal externalities and public spending is necessary. As the inefficiencies resulting from tax competition are driven by fiscal externalities, and cannot be inferred by the slope of the reaction function per se, estimating the effect on fiscal externalities is critical for understanding whether taxes are too high or too low and whether the implemented policy responses move the equilibrium closest to the efficient level. A challenge is that is difficult to measure fiscal externalities when governments are small. While the effect on world may be large, the effect any one other jurisdiction it may be small. An alternative would be, perhaps, to estimate the fiscal externality of any one jurisdiction on the aggregation of all other municipalities in the federal system. These fiscal externalities are important because they have implications for the level of public services within the economy.

Fourth, there are many understudied limitations on fiscal instruments by state authorities. Although a large literature focuses on TELs and minimum tax rates in federal systems, some big picture restrictions—including the outright ban of local taxes by the state or constitutional prohibitions—remain understudied. For example, do outcomes differ when localities cannot levy local sales taxes but can levy municipal income taxes? When they cannot levy local income taxes but can levy local sales taxes? Are there restrictions on progressivity that may also influence whether or how governments cannot compete? Related to the literature on preferential tax rates above, a progressive income tax allows localities to have multiple policy levers (a rate for high income individuals and a rate for low income households) that potentially influences the nature of competition. But flat taxes lack this flexibility (Keen 2001). Can preferential tax regimes be beneficial?

Fifth, sourcing rules and the remittance rules (Slemrod 2019) that enforce where taxes are due are important. This is well known in the capital tax and corporate tax literature, but personal income tax treaties such as reciprocity agreements and sourcing rules concerning consumption taxes are less well studied. Taxing rights over income and consumption are becoming increasingly controversial, especially with the dramatic increase in teleworkers and e-commerce. Telework allows individuals and firms to be located in different states; e-commerce allows individuals to consume goods from all over the world. How this "globalization" of labor and consumption increases tax competition may depend upon the sourcing rules in place that define the location of taxation.

Sixth, what political challenges do cooperation and coordination face? Ultimately, any policy responses to tax competition need to be passed by governing bodies. At the international setting, this requires the agreement of many countries. Within federal systems, such reforms might come about voluntarily by agreement of municipalities or may be imposed by federal or state level authorities. In the latter case, any policy reform forcing municipalities to cooperate requires a consensus in the state legislative bodies, made up with representatives who may be sensitive to their local—rather than state—interest. Thus, understanding obstacles adopting cooperation/coordination, including the political economy of adoption, are critical to increasing its usage. These political considerations might be especially important if the model were dynamic, such that governments were playing a repeated game.

Finally, the model developed in this paper is stylized: it uses a single tax instrument, assumes Leviathan rather than welfare maximizing governments, has no role for public services, assumes a Nash equilibrium concept, assumes jurisdictions have market power that gives rise to strategic interactions, and does not have three fully asymmetric jurisdictions. Expanding on these simplifications represent a useful path for research. In practice, governments have access to multiple taxes; there is a budget constraint and governments offer a package deal of local services. This combination of taxes and services raises issues as to whether governments compete in taxes or expenditures (Wildasin 1988). Whether governments compete in taxes or expenditures is similar to the difference between Cornout and Bertrand competition, and just like firms cannot compete in both prices and quantities, governments pick one strategic variable with the other adjusting residually. Matters become more complex where there are multiple taxes and expenditure program. If governments then have the choice to cooperate or coordinate some, but not all of these, we need to understand what government choose to cooperate over. In other words, how do governments chose to limit the instruments with the most intense competition? More generally, the model assumes a Nash game, but the prior literature indicates the results of a minimum tax may vary in a Stackelberg (Wang 1999) or repeated game setting. The Nash concept with coalition formation also faces limitations, and future work might utilize a coalition-proof Nash equilibrium. Researchers might also endogenize the splitting rules for coalitions using a Nash bargaining concept, or explicitly model the possibility of side-payments.

Further, jurisdictions in the model above have some market power that gives rise to strategic interactions, but localities are small and any one locality likely cannot affect the world rate of return. Thus, it would be reasonable to focus on models of atomistic competition—where governments compete in the purest form of competition—perfect competition. In such models, jurisdictions would not interact strategically but tax competition forces still introduce inefficiencies: although the fiscal externality on any one jurisdiction caused but another small jurisdiction raising its tax rate is negligible, the fiscal externality on the system of jurisdictions is not.

How does cooperation impact competition and economic outcomes in an increasingly complex world? Many generalizations of the model in this paper abound, but I hope the framework sketched above is useful for researchers considering the welfare effects of policy responses to interjurisdictional competition.

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A Appendices

A.1 Derivation: Nash Equilibrium

The revenue functions are given by

$$\begin{array}{rcl} R_s & = & T_s\left(1-\frac{\theta}{2}-\frac{T_s-T_a}{\delta}-\frac{T_s-T_\sigma}{\delta}\right) \\ R_\sigma & = & T_\sigma\left(1-\frac{\theta}{2}-\frac{T_\sigma-T_a}{\delta}-\frac{T_\sigma-T_s}{\delta}\right) \\ R_a & = & T_a\left(1+\theta-\frac{T_a-T_s}{\delta}-\frac{T_a-T_\sigma}{\delta}\right) \end{array} . \tag{A.1}$$

Differentiating and solving the system of first order conditions presented in the main text yields the Nash equilibrium.

A.2 Derivation: Harmonization

For the two jurisdiction of a similar size, the revenue under tax harmonization is greater than the revenue earned in the uncoordinated equilibrium if

$$\left[(1-\omega)T^U+\omega T_a^U\right]\left(1-\frac{\theta}{2}\right)-R^U>0. \tag{A.2}$$

Evaluating at the uncoordinated Nash values and simplifying yields

$$-\frac{3}{100}\theta\delta(5\theta\omega-\theta-10\omega+5)>0, \tag{A.3}$$

which implies the equation in the text, (11).

For the asymmetric jurisdiction a, the revenue under tax harmonization is greater than the revenue earned in the uncoordinated equilibrium if

$$\left[(1-\omega)T^U+\omega T_a^U\right](1+\theta)-R_a^U>0. \tag{A.4}$$

Evaluating at the uncoordinated Nash values and simplifying yields

$$\frac{3}{50}\theta\delta(5\theta\omega-3\theta+5\omega)>0, \tag{A.5}$$

which implies the equation in the text, (12).

A.3 Derivation: Minimum Tax Rates

First consider the case where $\theta > 0$. In this case, the minimum tax rate exceeds T^U but is below T_a^U. Then, the best response of the higher tax jurisdiction will be

$$T_a = \frac{1}{4}\delta(1+\theta) + \frac{1}{4}T_s + \frac{1}{4}T_\sigma = \frac{1}{4}\delta(1+\theta) + \frac{1}{2}\tau. \tag{A.6}$$

For the small jurisdictions, tax revenues—evaluated at $T_s = T_\sigma = \tau$ and $T_a = \frac{1}{4}\delta(1+\theta) + \frac{1}{2}\tau$—are given by:

$$R_s^M = R_\sigma^M = \frac{\tau(5\delta - 2\tau - \delta\theta)}{4\delta}, \tag{A.7}$$

where the superscript M denotes the minimum tax regime. The derivative with respect to τ is

$$\frac{(5-\theta)\delta - 4\tau}{4\delta}, \tag{A.8}$$

which evaluated at $\tau = T^U$ yields

$$-\frac{3}{20}\theta + \frac{3}{4} > 0. \tag{A.9}$$

This means revenue is increasing as the small jurisdictions are forced to raise the tax rate marginally. Evaluated at the maximum value for which the minimum rate does not bind for both jurisdictions, $\tau = T_a^U$, also yields

$$-\frac{9}{20}\theta + \frac{3}{4} > 0. \tag{A.10}$$

Thus, tax revenue of the smaller jurisdiction is always increasing in τ.

As for the bigger jurisdiction, its tax revenue—evaluated at $T_s = T_\sigma = \tau$ and $T_a = \frac{1}{4}\delta(1+\theta) + \frac{1}{2}\tau$—is

$$R_a^M = \frac{(\delta(1+\theta) + 2\tau)^2}{8\delta}. \tag{A.11}$$

Then (A.11) minus R_a^U yields:

$$\frac{(9\delta\theta + 15\delta + 10\tau)(\delta\theta - 5\delta + 10\tau)}{200\delta}, \tag{A.12}$$

which is strictly increasing in τ and when evaluated at $\tau = T^U$, is equal to zero. Thus, revenue is increasing for all values of ω.

Next, consider the case where $\theta < 0$. In this case, $T_s^U = T_\sigma^U > \tau$. Evaluating the best response functions (5) at the minimum tax rate yields

$$\begin{array}{rcl} T_s & = & \frac{1}{4}\delta(1-\frac{1}{2}\theta)+\frac{1}{4}\tau+\frac{1}{4}T_\sigma \\ T_\sigma & = & \frac{1}{4}\delta(1-\frac{1}{2}\theta)+\frac{1}{4}\tau+\frac{1}{4}T_s \end{array}. \tag{A.13}$$

Solving for the new equilibrium yields

$$T_s = T_\sigma = \frac{1}{3}(1-\frac{\theta}{2})+\frac{1}{3}\tau. \tag{A.14}$$

As for the bigger jurisdictions, tax revenues are

$$R_s^M = R_\sigma^M = \frac{(\delta(\theta-2)-2\tau)^2}{18\delta}. \tag{A.15}$$

Then (A.15) minus R^U yields:

$$\frac{(2\delta\theta+5\delta-10\tau)(8\delta\theta-25\delta-10\tau)}{450\delta}, \tag{A.16}$$

which is strictly increasing in τ and when evaluated at $\tau = T_a^U$, is equal to zero. Thus, revenue is increasing for all values of $\omega > 0$.

For the jurisdiction for which the minimum tax rate binds, tax revenues are

$$R_a^M = \frac{\tau(\delta(5+2\theta)-4\tau^2)}{3\delta}, \tag{A.17}$$

which is concave in the minimum tax rate. At the lowest possible value of the minimum tax rate, the jurisdiction is clearly unaffected but the derivative of revenues with respect to the minimum tax rate:

$$\frac{(2\theta+5)-8\tau}{3\delta}, \tag{A.18}$$

is positive for values of τ at its lowest value. However, at the highest possible value of the minimum tax rate, T^U, the difference in revenues with the uncoordinated case is

$$\frac{(2\delta\theta+5\delta-10\tau)(20\tau-6\delta\theta-15\delta)}{150\delta} = \frac{-\theta\delta(8\theta+5)}{50\delta}. \tag{A.19}$$

This is positive if

$$-\frac{1}{50}\delta(8\theta+5)\theta > 0 \Longleftrightarrow \theta > -\frac{5}{8}. \tag{A.20}$$

A.4 Derivation: Forced Cooperation

Initially, assume that cooperation forces the two symmetric jurisdictions to cooperate. Then, the tax revenue functions are given by (16) yielding the Nash tax rates in the text.

The tax differential is

$$T_a^{C(s\sigma)} - T_{s\sigma}^{C(s\sigma)} = \frac{1}{3}\delta(\theta - \frac{1}{2}), \tag{A.21}$$

which is positive for $\theta < 1/2$. To sign the pattern of taxes relative to the uncoordinated equilibirum, note that

$$\begin{array}{rcl} T_{s\sigma}^{C(s\sigma)} - T^U & = & \frac{1}{15}\delta(5-\theta) > 0 \\ T_a^{C(s\sigma)} - T_a^U & = & \frac{1}{30}\delta(5-\theta) > 0 \end{array}. \tag{A.22}$$

With respect to tax revenues, equilibrium revenues of the coalitions are:

$$\begin{array}{rcl} R_{s\sigma}^{C(s\sigma)} & = & \frac{1}{18}\delta(\theta-5)^2 \\ R_a^{C(s\sigma)} & = & \frac{1}{18}\delta(\theta+4)^2 \end{array}. \tag{A.23}$$

To sign the pattern of tax revenues in individual jurisdictions, one must determine how revenues are allocated within the cooperative. Given both jurisdictions are of equal size, a reasonable assumption is equal splitting. Then, differencing coordinated and uncoordinated revenues (after dividing the cooperative's revenue by two) yields:

$$\begin{array}{rcl} \frac{R_{s\sigma}^{C(s\sigma)}}{2} - R^U & = & \frac{7}{900}\delta(\theta-5)^2 > 0 \\ R_a^{C(s\sigma)} - R_a^U & = & \frac{1}{450}\delta(5-\theta)(11\theta+35) > 0 \end{array}, \tag{A.24}$$

Thus, cooperation yields higher tax revenues in both jurisdictions. With symmetric jurisdictions equally split revenues are the same as if split proportional to the bases.

Next, without loss of generality consider the possibility that jurisdictions a and σ cooperate, but jurisdiction s does not. Then tax revenues are:

$$\begin{array}{rcl} R_s & = & T_s\left[1 - \frac{\theta}{2} - \frac{2(T_s - T_{a\sigma})}{\delta}\right] \\ R_{a\sigma} & = & T_{a\sigma}\left[2 + \frac{\theta}{2} - \frac{2(T_{a\sigma} - T_s)}{\delta}\right] \end{array} \tag{A.25}$$

and the equilibrium tax rates are given in the text. This implies a tax differential of

$$T_s^{C(a\sigma)} - T_{a\sigma}^{C(a\sigma)} = -\frac{1}{6}\delta(\theta+1) < 0. \tag{A.26}$$

The equilibrium tax rates can be compared with the noncooperative equilibrium, noting that, in this case, because the members of the cooperative differ in size, three pairwise comparisons are necessary:

$$\begin{array}{rcl} T_s^{C(a\sigma)} - T_s^U & = & \frac{1}{6}\delta(1+\frac{1}{10}\theta) > 0 \\ T_{a\sigma}^{C(a\sigma)} - T_a^U & = & \frac{1}{3}\delta(1-\frac{7}{20}\theta) > 0 \\ T_{a\sigma}^{C(a\sigma)} - T_\sigma^U & = & \frac{1}{3}\delta(1+\frac{11}{20}\theta) > 0 \end{array}. \tag{A.27}$$

Turning to tax revenues, equilibrium tax revenues are given by

$$\begin{array}{rcl} R_s^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta-8)^2 \\ R_{a\sigma}^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta+10)^2 \end{array} \tag{A.28}$$

and the non-cooperating jurisdiction sees an increase in revenues:

$$R_s^{C(a\sigma)} - R_s^U = \frac{1}{1800}\delta(\theta+10)(70-11\theta) > 0 \tag{A.29}$$

Comparing tax revenues within the cooperative requires further assumptions about how revenues are split among the jurisdictions in the cooperative. With equal splitting in the cooperative, then the difference in tax revenues becomes:

$$\begin{array}{rcl} \frac{R_{a\sigma}^{C(a\sigma)}}{2} - R_a^U & = & \frac{1}{3600}\delta(700-940\theta-263\theta^2) \\ \frac{R_{a\sigma}^{C(a\sigma)}}{2} - R_\sigma^U & = & \frac{1}{3600}\delta(700+1220\theta-47\theta^2) \end{array} . \tag{A.30}$$

The expression $\frac{R_{a\sigma}^C}{2} - R_\sigma^U$ is positive if $700+1220\theta-47\theta^2 > 0$, which is true if $\frac{610}{47} - \frac{450}{47}\sqrt{2} < \theta$. The expression $\frac{R_{a\sigma}^{C(a\sigma)}}{2} - R_a^U$ is positive if $700 - 940\theta - 263\theta^2 > 0$, which is true if $-\frac{470}{263} + \frac{450}{47}\sqrt{2} > \theta$.

An alternative proposal allocates revenues proportional to the equilibrium tax bases in each local jurisdiction. Letting the tilde denote revenues after base splitting, this means revenues will be allocated according to

$$\begin{array}{rcl} \tilde{R}_a^{C(a\sigma)} & = & T_{a\sigma}^{C(a\sigma)}\left[1+\theta-\frac{(T_{a\sigma}^{C(a\sigma)}-T_s^{C(a\sigma)})}{\delta}\right] \\ \tilde{R}_\sigma^{C(a\sigma)} & = & T_{a\sigma}^{C(a\sigma)}\left[1-\frac{\theta}{2}-\frac{(T_{a\sigma}^{C(a\sigma)}-T_s^{C(a\sigma)})}{\delta}\right] \end{array} \tag{A.31}$$

where each jurisdiction has the same amount shifting activity because they face the same tax differential and where the first terms in brackets are the asymmetric sizes of the jurisdiction in the absence of shifting. Evaluating (A.31) at the coordinated Nash tax rates, and subtracting revenues in the uncoordinated regime yields:

$$\begin{array}{rcl} \tilde{R}_a^{C(a\sigma)} - R_a^U & = & \frac{1}{1800}\delta(35-\theta)(19\theta+10) \\ \tilde{R}_\sigma^{C(a\sigma)} - R_\sigma^U & = & \frac{1}{1800}\delta(10-17\theta)(8\theta+35) \end{array} , \tag{A.32}$$

where I use a single jurisdiction subscript of a member in the coalition to denote split revenues in contrast to using both jurisdictions' subscripts to indicate combined revenues. The first expression is positive if $(35-\theta)(19\theta+10) > 0$ which is true if $\theta > -10/19$. The second expression is positive if $(10-17\theta)(8\theta+35) > 0$, which is true if $\theta < 10/17$.

A.5 Derivation: Voluntary Cooperation

First, consider the case where tax revenues are split proportional to the tax bases in equilibrium. In the case where two symmetric jurisdictions cooperate, this amounts to equal splitting of revenues, where a single jurisdiction in the subscript, indicates the revenue of a single member of the cooperative in the superscript:

$$\begin{array}{rcl} \tilde{R}_s^{C(s\sigma)} = \tilde{R}_\sigma^{C(s\sigma)} & = & \frac{1}{36}\delta(\theta-5)^2 \\ R_a^{C(s\sigma)} & = & \frac{1}{18}\delta(\theta+4)^2 \end{array} . \tag{A.33}$$

But when two asymmetric jurisdiction cooperated, taking the case $a\sigma$ as representative, revenues under cooperation are

$$\begin{array}{rcl} R_s^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta-8)^2 \\ R_a^{C(a\sigma)} & = & \frac{5}{72}\delta(\theta+10)(1+\theta) \\ R_\sigma^{C(a\sigma)} & = & \frac{1}{72}\delta(\theta+10)(5-4\theta) \end{array} . \tag{A.34}$$

Revenues in the case as can be similarly derived.

Under equal splitting, revenues in the asymmetric case need to be replaced with $R_a^{C(a\sigma)} = R_{a\sigma}^C/2$ and $R_\sigma^{C(a\sigma)} = R_{a\sigma}^C/2$. With equal splitting, there is no tilde, and it is known to be the jurisdiction revenue rather than the coalition revenue because of the single jurisdiction in the subscript. Under the symmetric coalition, equal splitting and base splitting yield the same revenues.

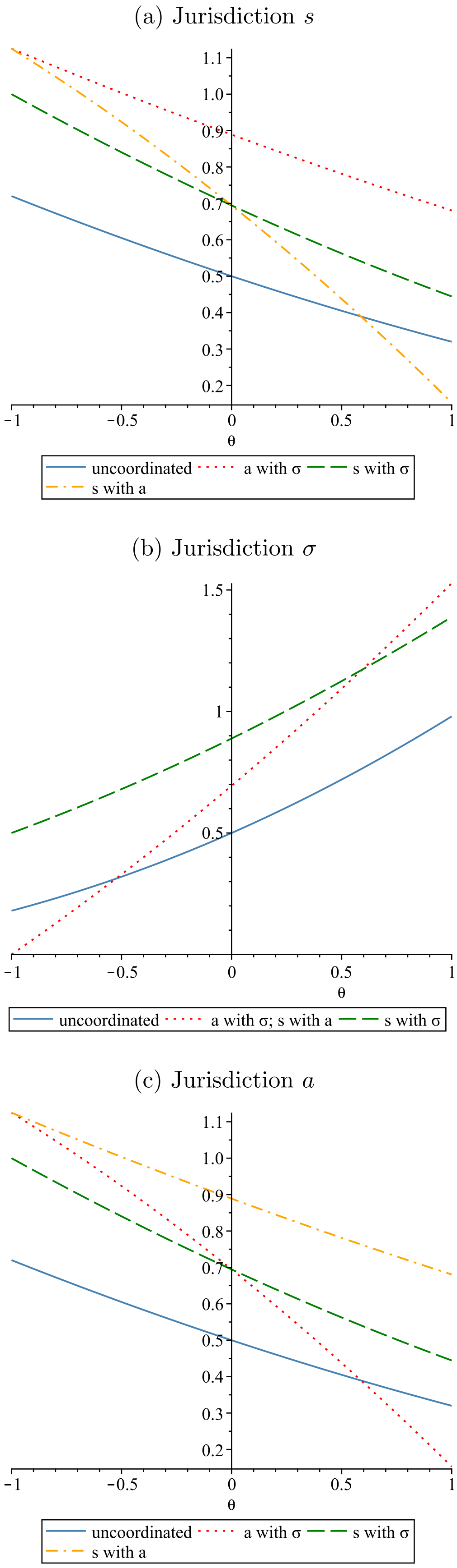
Table A.1: Jurisdiction Payoffs by Coalition

	Jurisdiction			
Coalition	s	a	σ	ID
Nash	$\frac{1}{50}\delta(\theta-5)^2$	$\frac{1}{50}\delta(2\theta+5)^2$	$\frac{1}{50}\delta(\theta-5)^2$	A
$s\sigma$	$\frac{1}{36}\delta(\theta-5)^2$	$\frac{1}{18}\delta(\theta+4)^2$	$\frac{1}{36}\delta(\theta-5)^2$	B
as (base splitting)	$\frac{1}{72}\delta(\theta+10)(5-4\theta)$	$\frac{5}{72}\delta(\theta+10)(\theta+1)$	$\frac{1}{72}\delta(\theta-8)^2$	$\tilde{C}$
as (= splitting)	$\frac{1}{144}\delta(\theta+10)^2$	$\frac{1}{144}\delta(\theta+10)^2$	$\frac{1}{72}\delta(\theta-8)^2$	C
$a\sigma$ (base splitting)	$\frac{1}{72}\delta(\theta-8)^2$	$\frac{5}{72}\delta(\theta+10)(\theta+1)$	$\frac{1}{72}\delta(\theta+10)(5-4\theta)$	$\tilde{D}$
$a\sigma$ (= splitting)	$\frac{1}{72}\delta(\theta-8)^2$	$\frac{1}{144}\delta(\theta+10)^2$	$\frac{1}{144}\delta(\theta+10)^2$	D

Rows indicate the coalition and the splitting rule. Columns are the jurisdictions. The cells are equilibrium tax revenues.

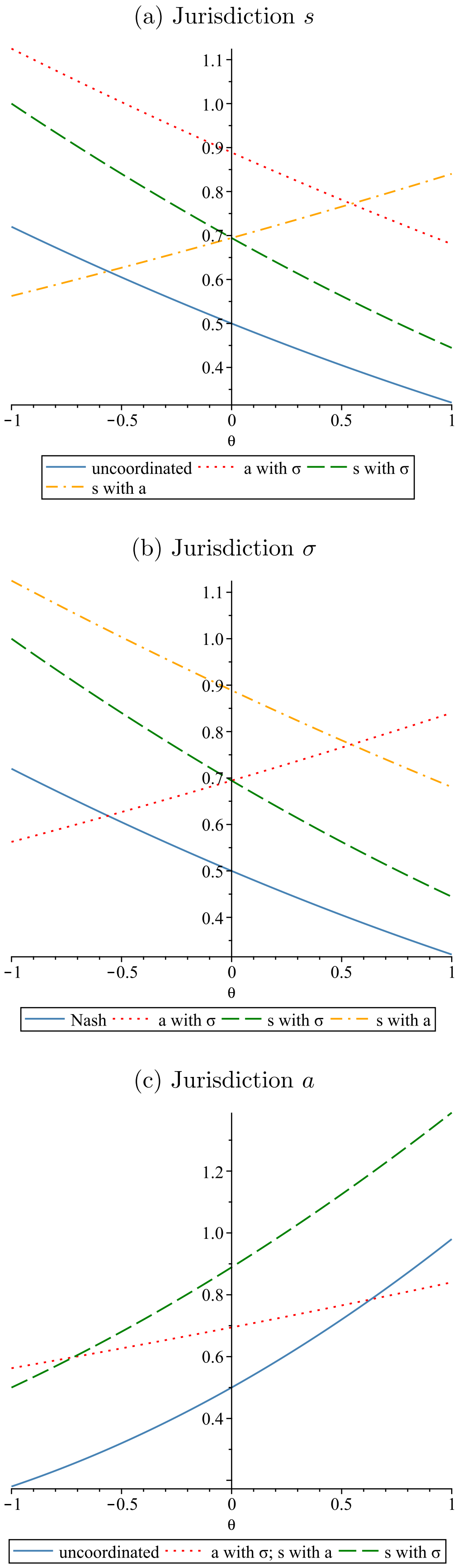
Having ruled out a grand coalition by assumption, it suffices to compare all unilateral deviations from a coalition. To facilitate this, I construct a matrix given in Table A.1 where rows are all possible coalitions and columns give the payoff for the jurisdictions. The matrix shows all payoffs for each time of splitting rule. However, the splitting rules are exogenously determined and thus, jurisdiction need to consider only deviations to regimes with the same splitting rules.

Figure A.1: Payoffs for Each Jurisdiction with Base Splitting



This figure shows the payoffs (revenue) for each jurisdiction for all possible coalitions by values of θ. Within coalitions tax revenues are split proportional to the tax bases.

Figure A.2: Payoffs for Each Jurisdiction with Equal Splitting



This figure shows the payoffs (revenue) for each jurisdiction for all possible coaliations by values of θ. Within coalitions tax revenues are split equally within the coalition.

In order to visualize these payoffs for all values of θ, I normalize $\delta = 1$ (or equivalently divide by δ) and then plot the payoff functions separately for base splitting (Figure A.1) and equal splitting (Figure A.2).

While these figures visualize which strategies dominate each other, to determine the equilibrium I must check for all unilateral deviations taking as given and fixed the other player strategies. As noted in the text, the Nash equilibrium in a coalition game is likely too weak a concept, but for simplicity, I use this equilibrium concept. To determine the Nash equilibria, I write the payoff matrices in the following tables. Player s plays rows as strategies, player σ plays columns as strategies, and player a plays boxes as strategies. Each strategy is the player you wish to pattern with. For example, if player s plays σ they are declaring their intent to form a coalition with σ; if player s plays s they are declaring their intent to go-it-alone. If any two players declare each other, then that coalition forms and they receive the revenue payoffs for that coalition. Note that under the rules of this game, if s plays σ, σ plays s and a plays a, then $s\sigma$ emerges as a coalition. But what if instead of a playing a, it plays s? Under the assumptions I have made, since both s and σ still agree, the payoffs remain unchanged as $s\sigma$ still emerges as a coalition. Finally, consider the case where s plays σ, σ plays σ and a plays σ. With these strategies, no two jurisdictions wish to form a coalition together. As a result, the payoffs default to the unccordinated Nash game (e.g., as if s plays s, σ plays σ and a plays a). Of course, alternative rules governing the game could be specified.

Table A.2 shows the payoff matrices for base splitting, while Table A.3 shows the payoffs for equal splitting. Note that the payoffs given in Figure A.1 and Figure A.2 are clearly a function of θ. However, conditional on a given value of θ, the payoff of each player can be ranked from 1 (lowest) to 4 (highest). In the payoff matrices, I use this rank rather than the precise revenue amount. Finally, the rankings differ on the basis of θ. Thus, I calculate the value of θ where any payoff curve intersects another curve, and then construct a different payoff matrix for each unique range of θ.

The Nash equilibria are then obtained by checking for unilateral profitable deviations. The best responses to the other player strategies are highlighted in bold font. Then the equilibria are denoted in underline. Note that the equilibria are conditional on the values of θ. More generally, some equilibria can only arise if the other player uses a given strategy while others may arise regardless of the non-members strategy, which clearly is a result of the assumption regarding no pre-play or communication. Tables A.4 and A.5 summarize these results along with when they arise. The use of other, likely stronger, equilibrium concepts is discussed in the main text of the paper.

Table A.2: Base Splitting Game: Nash Equilibria

(a) Case: $\theta \leq -\frac{10}{19}$

Player a: Strategy σ

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**3**	**2**,2,4	**4**,**3**,1
s	**1**,1,**3**	1,1,**3**	**4**,**3**,1
a	**1**,1,**3**	1,1,**3**	**4**,**3**,1

Player a: Strategy s

Player s Strategy	Player σ: σ	s	a
σ	1,1,**3**	2,**2**,4	1,1,**3**
s	1,1,**3**	1,**1**,**3**	1,1,**3**
a	**3**,**4**,1	**3**,**4**,1	**3**,**4**,1

Player a: Strategy a

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**3**	$\underline{\mathbf{2,2,4}}$	**1**,1,**3**
s	$\underline{\mathbf{1,1,3}}$	1,1,**3**	**1**,**1**,**3**
a	**1**,**1**,**3**	1,**1**,**3**	$\underline{\mathbf{1,1,3}}$

(b) Case: $-\frac{10}{19} < \theta \leq 0$

Player a: Strategy σ

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**1**	**2**,2,4	$\underline{\mathbf{4,3,3}}$
s	**1**,1,**1**	1,1,**1**	$\underline{\mathbf{4,3,3}}$
a	**1**,1,1	1,1,1	$\underline{\mathbf{4,3,3}}$

Player a: Strategy s

Player s Strategy	Player σ: σ	s	a
σ	1,1,**1**	2,**2**,4	1,1,1
s	1,**1**,**1**	1,**1**,1	1,**1**,1
a	$\underline{\mathbf{3,4,3}}$	$\underline{\mathbf{3,4,3}}$	$\underline{\mathbf{3,4,3}}$

Player a: Strategy a

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**1**	$\underline{\mathbf{2,2,4}}$	**1**,1,1
s	$\underline{\mathbf{1,1,1}}$	1,**1**,**1**	**1**,**1**,1
a	**1**,**1**,1	1,**1**,1	**1**,**1**,1

(c) Case: $0 < \theta \leq \frac{10}{17}$

Player a: Strategy σ

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**1**	$\underline{\mathbf{3,3,4}}$	4,2,3
s	**1**,1,**1**	1,1,**1**	$\underline{\mathbf{4,2,3}}$
a	**1**,1,1	1,1,1	$\underline{\mathbf{4,2,3}}$

Player a: Strategy s

Player s Strategy	Player σ: σ	s	a
σ	1,1,**1**	$\underline{\mathbf{3,3,4}}$	1,1,1
s	1,**1**,**1**	1,**1**,**1**	1,**1**,1
a	$\underline{\mathbf{2,4,3}}$	2,**4**,**3**	$\underline{\mathbf{2,4,3}}$

Player a: Strategy a

Player s Strategy	Player σ: σ	s	a
σ	**1**,1,**1**	$\underline{\mathbf{3,3,4}}$	**1**,1,1
s	$\underline{\mathbf{1,1,1}}$	1,**1**,**1**	**1**,**1**,1
a	**1**,**1**,1	1,**1**,1	**1**,**1**,1

(d) Case: $-\frac{23}{2} + \frac{3\sqrt{65}}{2} < \theta \leq \frac{10}{17}$

Player a: Strategy σ

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	$\underline{\mathbf{3,3,4}}$	4,1,**3**
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	4,1,**3**
a	**2**,**2**,1	2,**2**,1	4,1,**3**

Player a: Strategy s

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	**3**,3,4	**2**,2,1
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	**2**,**2**,1
a	1,**4**,**3**	1,**4**,**3**	1,**4**,**3**

Player a: Strategy a

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	$\underline{\mathbf{3,3,4}}$	**2**,2,1
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	**2**,**2**,1
a	**2**,**2**,1	2,**2**,1	**2**,**2**,1

(e) Case: $\frac{10}{17} < \theta$

Player a: Strategy σ

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	$\underline{\mathbf{3,3,3}}$	4,1,**4**
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	4,1,**4**
a	**2**,**2**,1	2,**2**,1	4,1,**4**

Player a: Strategy s

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	$\underline{\mathbf{3,3,3}}$	**2**,2,1
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	**2**,**2**,1
a	1,**4**,**4**	1,**4**,**4**	1,**4**,**4**

Player a: Strategy a

Player s Strategy	Player σ: σ	s	a
σ	**2**,2,**1**	$\underline{\mathbf{3,3,3}}$	**2**,2,1
s	$\underline{\mathbf{2,2,1}}$	2,**2**,**1**	**2**,**2**,1
a	**2**,**2**,1	2,**2**,1	**2**,**2**,1

Each table denotes the payoff matrix for the three jurisdictions in that range of θ. Player s plays rows, player σ plays columns and player a plays boxes. The numerical values are the rank of revenue for the jurisdiction, with four denoting the most revenue. Best responses are in bold and Nash equilibria are underlined.

Table A.3: Equal Splitting Game: Nash Equilibria

(a) Case: $\theta \leq -\frac{22}{7} + \frac{12\sqrt{2}}{7}$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	2,2,1	3,3,3	4,1,4	2,2,1	3,3,3	2,2,1	2,2,1	3,3,3	2,2,1
	s	2,2,1	2,2,1	4,1,4	2,2,1	2,2,1	2,2,1	2,2,1	2,2,1	2,2,1
	a	2,2,1	2,2,1	4,1,4	1,4,4	1,4,4	1,4,4	2,2,1	2,2,1	2,2,1

(b) Case: $-\frac{22}{7} + \frac{12\sqrt{2}}{7} < \theta \leq \frac{610}{47} - \frac{450\sqrt{2}}{47}$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	2,2,1	3,3,4	4,1,3	2,2,1	3,3,4	2,2,1	2,2,1	3,3,4	2,2,1
	s	2,2,1	2,2,1	4,1,3	2,2,1	2,2,1	2,2,1	2,2,1	2,2,1	2,2,1
	a	2,2,1	2,2,1	4,1,3	1,4,3	1,4,3	1,4,3	2,2,1	2,2,1	2,2,1

(c) Case: $\frac{610}{47} - \frac{450\sqrt{2}}{47} < \theta \leq 0$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	1,1,1	3,3,4	4,2,3	1,1,1	3,3,4	1,1,1	1,1,1	3,3,4	1,1,1
	s	1,1,1	1,1,1	4,2,3	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1
	a	1,1,1	1,1,1	4,2,3	2,4,3	2,4,3	2,4,3	1,1,1	1,1,1	1,1,1

(d) Case: $0 < \theta \leq 26 - 18\sqrt{2}$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	1,1,1	2,2,4	4,3,3	1,1,1	2,2,4	1,1,1	1,1,1	2,2,4	1,1,1
	s	1,1,1	1,1,1	4,3,3	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1
	a	1,1,1	1,1,1	4,3,3	3,4,3	3,4,3	3,4,3	1,1,1	1,1,1	1,1,1

(e) Case: $26 - 18\sqrt{2} < \theta \leq -\frac{470}{263} + \frac{450\sqrt{2}}{263}$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	1,1,1	2,2,4	3,4,3	1,1,1	2,2,4	1,1,1	1,1,1	2,2,4	1,1,1
	s	1,1,1	1,1,1	3,4,3	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1	1,1,1
	a	1,1,1	1,1,1	3,4,3	4,3,3	4,3,3	4,3,3	1,1,1	1,1,1	1,1,1

(f) Case: $-\frac{470}{263} + \frac{450\sqrt{2}}{263} < \theta$

		Player a: Strategy σ			Player a: Strategy s			Player a: Strategy a		
		Player σ			Player σ			Player σ		
	Strategy	σ	s	a	σ	s	a	σ	s	a
Player s	σ	1,1,3	2,2,4	3,4,1	1,1,3	2,2,4	1,1,3	1,1,3	2,2,4	1,1,3
	s	1,1,3	1,1,3	3,4,1	1,1,3	1,1,3	1,1,3	1,1,3	1,1,3	1,1,3
	a	1,1,3	1,1,3	3,4,1	4,3,1	4,3,1	4,3,1	1,1,3	1,1,3	1,1,3

Each table denotes the payoff matrix for the three jurisdictions in that range of θ. Player s plays rows, player σ plays columns and player a plays boxes. The numerical values are the rank of revenue for the jurisdiction, with four denoting the most revenue. Best responses are in bold and Nash equilibria are underlined.

Table A.4: Nash Equilibria with Base Splitting

Range of θ	Nash Coalition	Other Player's Strategy	Asymmetric Coalition
$\theta \leq -\frac{10}{19}$	$s\sigma$	a	
$-\frac{10}{19} < \theta \leq 0$	$s\sigma$	a	
	$a\sigma$	a, s, σ	Y
	as	a, s, σ	Y
$0 < \theta \leq \frac{10}{17}$	$a\sigma$	σ	Y
	as	s	Y
	$s\sigma$	a, s, σ	
$-\frac{23}{2} + \frac{3\sqrt{65}}{2} < \theta \leq \frac{10}{17}$	$s\sigma$	a, σ	
$\frac{10}{17} < \theta$	$s\sigma$	a, s, σ	

The splitting rule governing the results in this table is equal splitting. This table lists the Nash equilibria coalitions for the complete range of θ. The uncoordinated equilibrium is omitted from the table. The first column is the range of θ. The second column lists the equilibrium coalition. And the third column lists the strategy the non-coalition member must play for that coalition to be a Nash equilibrium. For example, in the first row $s\sigma$ is a Nash coalition if θ is sufficiently small, but this equilibrium only arises if the non-member of the coalition (a) plays strategy a. If a were to play any other strategy, the coalition members have incentive to deviate. The equilibrium coalitions that arise between asymmetric jurisdictions are marked with a "Y" in the final column and are highlighted in red.

Table A.5: Nash Equilibria with Equal Splitting

Range of θ	Nash Coalition	Other Player's Strategy	Asymmetric Coalition
$\theta \leq -\frac{22}{7} + \frac{12\sqrt{2}}{7}$	$s\sigma$	a, s, σ	
$-\frac{22}{7} + \frac{12\sqrt{2}}{7} < \theta \leq \frac{610}{47} - \frac{450\sqrt{2}}{47}$	$s\sigma$	a, s, σ	
$\frac{610}{47} - \frac{450\sqrt{2}}{47} < \theta \leq 0$	$s\sigma$	a, s, σ	
	$a\sigma$	a, s	Y
	as	a, σ	Y
$0 < \theta \leq 26 - 18\sqrt{2}$	$a\sigma$	a, s, σ	Y
	as	a, s, σ	Y
	$s\sigma$	a	
$26 - 18\sqrt{2} < \theta \leq -\frac{470}{263} + \frac{450\sqrt{2}}{263}$	$a\sigma$	a, s, σ	Y
	as	a, s, σ	Y
	$s\sigma$	a	
$-\frac{470}{263} + \frac{450\sqrt{2}}{263} < \theta$	$s\sigma$	a	

The splitting rule governing the results in this table is equal splitting. This table lists the Nash equilibria coalitions for the complete range of θ. The uncoordinated equilibrium is omitted from the table. The first column is the range of θ. The second column lists the equilibrium coalition. And the third column lists the strategy the non-coalition member must play for that coalition to be a Nash equilibrium. For example, in the last row $s\sigma$ is a Nash coalition if θ is sufficiently large, but this equilibrium only arises if the non-member of the coalition (a) plays strategy a. If a were to play any other strategy, the coalition members have incentive to deviate. The equilibrium coalitions that arise between asymmetric jurisdictions are marked with a "Y" in the final column and are highlighted in red.

A.6 Derivation: Sourcing Rules

If taxes can be effectively sourced such that the tax base cannot be shifted to engage in tax arbitrage, the revenue functions become

$$R_i = \; T_i B_i = \; T_i \Theta_i \; . \tag{A.35}$$

As this does not depend on the tax rate, a Leviathan will set taxes to extract all the surplus.

A.7 Derivation: Total Revenue Dominance

Recall the sum of revenues across all three jurisdictions for each scenario are given in the text and restated here:

$$R^U_{total} = \delta(\frac{3}{2} + \frac{3}{25}\theta^2) \tag{A.36}$$

$$R^H_{total} = \delta(\frac{3}{2} + \frac{9\omega - 3}{10}\theta) \tag{A.37}$$

$$R^M_{total} = \begin{cases} \delta(\frac{3}{2} + \frac{3\omega\theta}{4} + \frac{3(8+2\omega-3\omega^2)\theta^2}{200} & \theta > 0 \\ \delta(\frac{3}{2} + \frac{(\omega-1)\theta}{2} + \frac{(4\omega^2-6\omega-4)\theta^2}{50} & \theta < 0 \end{cases} \tag{A.38}$$

$$R^{C(as)}_{total} = R^{C(a\sigma)}_{total} = \delta(\frac{\theta^2 + 2\theta + 82}{36}) \tag{A.39}$$

and

$$R^{C(s\sigma)}_{total} = \delta(\frac{2\theta^2 - 2\theta + 41}{18}). \tag{A.40}$$

To show that $R^M_{total} \geq R^H_{total}$ note that

$$R^M_{total} - R^H_{total} = \begin{cases} -\frac{2\theta\delta(\omega+\frac{1}{2})(5+\theta\omega-2\theta)}{25} & \theta > 0 \\ -\frac{3\theta\delta(3\theta\omega+4\theta+10)(\omega-2)}{200} & \theta < 0 \end{cases} \tag{A.41}$$

and equals zero when $\theta = 0$. However, the derivative of this difference with respect to θ is increasing if $\theta > 0$ but is decreasing if $\theta < 0$. Thus, $R^M_{total} - R^H_{total} \geq 0$ for all values of θ. Conducting a similar exercise, yields $R^M_{total} - R^H_{total} \geq 0$.

As noted in the text,

$$R^{C(as)}_{total} - R^{C(s\sigma)}_{total} = \frac{(2-\theta)\theta\delta}{12}, \tag{A.42}$$

such that $R^{C(as)}_{total} > R^{C(s\sigma)}_{total}$ if $\theta > 0$ and $R^{C(as)}_{total} < R^{C(s\sigma)}_{total}$ if $\theta < 0$.

Comparing total revenues under each coalition game with the revenues under tax harmonization, it is easy to show that $R^{C(as)}_{total} > R^{H}_{total}$ and $R^{C(s\sigma)}_{total} > R^{H}_{total}$ for all parameter constellations.

Finally, I compare the minimum tax rate regime with the coalition regime. Initially, focus on the case where $\theta < 0$. I first check the relationship with the coalitions that yields the lowest revenue for $\theta < 0$:

$$R^{C(as)}_{total} - R^{M}_{total} = \frac{(72\theta^2\omega^2 - 108\theta^2\omega - 47\theta^2 - 450\omega\theta + 500\theta + 700)\delta}{900}, \tag{A.43}$$

and it can be verified that this is positive in the relevant ranges. Given this is positive for the coalition yielding the lower revenues, it is also positive for the other coalition.

Then, repeating this exercise for $\theta > 0$, yields

$$R^{C(as)}_{total} - R^{M}_{total} = \frac{(81\theta^2\omega^2 - 54\theta^2\omega - 166\theta^2 - 1350\omega\theta + 100\theta + 1400)\delta}{900}, \tag{A.44}$$

and the derivative of this expression is decreasing in ω. Given the above expression evaluated at $\theta = 0$ is positive and the derivative with respect to ω is negative, if R^{M}_{total} is larger, it will be the case for $\omega = 1$. Evaluating yields $R^{C(as)}_{total} - R^{M}_{total} > 0$ for all $0 < \theta < 1$.

Turning to the coalition yielding the lower revenues:

$$R^{C(s\sigma)}_{total} - R^{M}_{total} = \frac{(9\theta\omega + 2\theta - 10)(9\theta\omega - 8\theta - 140)\delta}{1800}, \tag{A.45}$$

and the derivative is decreasing in ω. Again, given the above expression evaluated at $\theta = 0$ is positive and the derivative with respect to ω, if R^{M}_{total} is larger, it will be the case for $\omega = 1$. Evaluating yields $R^{C(s\sigma)}_{total} - R^{M}_{total} = \frac{(11\theta-10)(\theta-140)\delta}{1800}$,which is positive if $\theta < 10/11$.