Partial Centralization as a Remedy for Public-Sector Spillovers: Making Interjurisdictional Transportation a National Responsibility

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Abstract

This paper shows that the inefficiency of policy decentralization in the presence of spillovers of local public goods is partially solved with the partial centralization of transportation good. In particular, with partial centralization the citizens obtain the same level of public good benefit that with decentralization but with a lower level of taxes. Finally, we show several cases where the analysis of partial efficiency policies can lead to wrong conclusions.

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1 Introduction

One of the major tenets of the decentralization literature is that the local policy decentralization of local public good is optimal only without interjurisdictional spillovers (Oates, 1972). The reason is that the local government ignores the interjurisdictional spillovers of a policy on local public good; instead the national government is able to coordinate the policies to internalize the interjurisdictional spillovers. Therefore, a centralization of public-sector decisions is desirable. This argument, which is part of the famous decentralization theorem (reformulated by Besley and Coate (2003)), has been criticized by some papers analyzing particular type of policies (Brueckner, 2013; Feder and Katashi, 2015; Ogawa and Wildasin, 2009).

The aim of this paper is to understand if it is possible to solve the problem of interjurisdictional spillovers of generic local public goods with the centralization of transport policies. The main idea of the paper is that the transportation good affects the spillovers of local public goods. Indeed, a local public good (e.g. a museum, school or hospital) has two types of potential users: the citizens that live in the jurisdiction where the local public good is produced; and the citizens that live in another jurisdiction that moving from their jurisdiction can to take advantages of the local public good. For these last users the benefit derives for an increase of the local public good is measured with the spillovers and it depends also by the easiness to arrive at the jurisdiction with the local public good. Using the concept of partial (de)centralization (Shah, 2004; Brueckner, 2009) it is possible decentralize the public-sector decision of local public goods but centralize the public-sector decision of transportation good (or vice versa) to try to solve the decentralization failure with interjurisdictional spillovers.[1]

The result is that the interjurisdictional spillover problem is partially solved. Indeed, if the national government increases the level of transportation good, in one hand, it increases the level of spillovers and then it increases the level of citizens' utility; but, in the other hand, it moves the local public goods far to the optimum level and then it decreases the level of citizens' utility. This is a new trade-off that the national government has when it decides only transportation policy. Therefore, the problem of spillovers is not canceled but reduced thanks to the fact that, on one side, the national government considers both the advantages and disadvantages that a modification of spillovers implies and that, on other side, it can control the spillovers through the level of transport good between the jurisdictions.

If the choices of local public goods are taken at the national level then it is indifferent which government level decides on the transport layer. In this case there is not the problem of internalization of spillovers and then the centralization of transportation good loses its usefulness. However, if the choice of local public goods is taken at the local level then with centralization of the transport layer the welfare is higher than with decentralization of this policy. In this case, there are spillovers and thus the centralization allows a better coordination of public policies. Moreover, in this second case, we find

[1] In this paper we use the broader definition of partial decentralization in the literature (Devarajan et al. 2007). I.e. we define the partial decentralization as any institutional arrangement that leads local governments to bear only part of the fiscal and/or expenditure responsibilities for policy outcomes. However, to simplify the exposition it will be called partial centralization.

that, with the centralization of the transportation policy, the citizens obtain the same direct benefit that would occur from its decentralization (the public component of the welfare remains unchanged) but with a lower level of taxes that are paid from its decentralization (the private component of the welfare is higher with centralization).

More generally, the paper shows that when there is an interaction between different policies (i.e. policies on local public goods and on transportation good) then, not only the sum of the effects of each single policy diverges from the sum of the total effects of this policy, but also that the sum of the effects of all policies diverges to the sum of the total effects of all policies. In particular, we show two examples where, also if the welfare is the sum of the public and the private component, it is possible to find that a modification of all policies does not change the efficiency of the public component and it reduces the efficiency of the private component; but that the total efficiency increases.

Nevertheless, this is not the first paper that analysis the partial centralization with the transportation policy. Indeed, to the best of our knowledge, Van der Loo and Proost (2013) assume that there are two levels of government: a local level that does not consider the interjurisdictional spillovers but has local information; and a national level that considers the interjurisdictional spillovers but it has not local information. However, the national level of government could use a monetary national transfer to obtain the truthful local information. Note that with this last feature the paper is focused on the partial centralization, as described by Brueckner (2009). The results of the model are different depending on the type of spillovers: with air pollution, always exist a mechanism to incentive the local government to show the truthful local information; with traffic congestion, this mechanism exist only if there are both local and transit traffic and if this last is not too high. In addition, Russo (2013) assumes that there are two levels of non-coordinating governments where everyone controls only a tax that affects the transport layer, the city use the parking fees and the region use the toll road, then to reduce the problem of spillovers (arising from traffic congestion in the city) is better than the city controls both taxes. However, these two papers analysis the public-sector decision on transportation with the partial fiscal (de)centralization. Indeed, in these cases the partial centralization considers the taxation aspect of transportation policy but in this paper we focus on the expenditure aspect of transportation policy.[2]

[2]All the literature on partial (de)centralization is divided in two fields: on the one hand, the papers are focused on the tax (Brueckner, 2009; Peralta, 2011; Borge et al., 2014; Bellofatto and Besfamille, 2014); on the other hand, the papers are focused on the expenditure (Janeba and Wilson, 2011; Jametti and Joanis, 2011; Hatfield and Padrò i

As well as Russo (2014) there are other few papers that show how the problem of spillovers can be solved even in the case of decentralization of transport policies. In particular, De Borge and Proost (2013) analyse two possible compositions of jurisdictions: with decentralized state the governments must agree the policies with the others governments; and with centralized state the governments take the public-sector decision individually. They find that the decentralized state manages better the problem of traffic congestion (a case of interjurisdictional spillovers) than the centralized state. Indeed, in the De Borge and Proost (2013)'s model, the decentralized state internalize the decentralization problem on interjurisdictional spillovers through the interjurisdictional agreement (which does not happen if there are two separate jurisdictions). However, both De Borge and Proost (2013) and Russo (2014) use different definitions of centralization and decentralization in respect to the decentralization theorem.[3] The only paper that, like us, keeps exactly this definition but finds a different result is Brueckner (2013). In particular, he assumes that there are three zones connected only for a road (or a bridge) to which the government can force to pay a toll for all access. This leads to traffic congestion. The main result of the paper is that it is possible achieve the optimum level in two ways: the first one, most obvious, is with a centralization of transport politics, but it is necessary that the national government chooses the same level of congestion in all roads; the second one, more innovative, is with a decentralization of transport policies, but it is necessary that the local governments force to pay a toll for all access on the road and anything at the citizens of the own zone (provided that also the conditions of the self-financing theorem hold).

However, most of the papers say instead that to solve the problem of lack of internalization of spillovers is necessary the centralization of transportation policies. In particular, Bjørner (1996) shows that the problem of environmental spillovers of transport policies can be resolved with the centralization of these policies at a government level enough high to internalize interjurisdictional spillovers. More recently, Ferguson (2015) considers two levels of government that must decide the amount of transport in a country where the poor citizens live in the center and the rich citizens live in the suburbs (or vice versa). In the case of centralized policy, the citizens obtain a medium level of transportation in both zones; instead, in the case of decentralized policy, the citizens that live in the periphery obtain a high level

Miquel, 2012; Joanis, 2014; Flamand, 2014).

[3]There are other definitions of centralization and decentralization that diverge from the decentralization theorem. In particular, Xie and Levinson (2009) and De Borger and Proost (2013) assume that if the jurisdictions must be agree on the policy there is centralization; while if the jurisdictions must not be agree there is decentralization.

of transportation and the citizens that live in the center obtain a low level of transportation. As citizens have to travel often to the center then the decentralization creates more traffic congestion that centralization.

Finally, note that the literature on the transport policies is focused on this particular good because it has some specific characteristics and, among others, it has some kinds of spillovers (e.g. traffic congestion and smog) that are different in nature from each other good. In this paper, we affirm that among these features, it is possible to add the ability of affect the interjurisdictional spillovers of the local public goods. Indeed, the biggest difference with all other papers in the literature on transportation and decentralization (for a complete survey of the literature read De Borger and Proost, 2012; 2014) is that these want solve the problem of spillovers of transportation policies; instead this paper wants solve the problem of spillovers of public goods through local transportation policies.[4] In other words, while in this literature the transportation policies increase the problem of (own) spillovers, in this paper the transportation policies reduce the problem of the (other) spillovers.

The plan of the paper is as follows. Section 2 develops the model and derives the public-sector decisions for different type of states. Section 3 shows the main efficiency results. Section 4 offers some examples. Section 5 relaxes the assumption of symmetry of public-sector decisions, and Section 6 concludes.

2 The model

Consider a country formed by two identical jurisdictions, $j = 1, 2$, where benevolent national and local governments can concur to define the intensity both on two local public goods (one in each jurisdiction) and on the transportation system (between the two jurisdictions). Let $g_j \geq 0$ be the intensity of the local public good in jurisdiction j; $\tau \geq 0$ be the intensity of the transportation system in jurisdiction j to connect the two jurisdictions; and S be the intensity of inter-jurisdictional spillovers of the local public good. The only difference between the two levels of government is on the fact that the national government maximizes the welfare of both jurisdictions; and the local governments maximize the welfare of its own jurisdiction. Then, we implicitly assume that the national government leads to a better coordination

[4] Other papers analyze the relationship between transportation and private goods and, in particular, for the trade of goods between jurisdictions (Bond, 2006; Mun and Nakagawa, 2010) or for the tourism (Levinson, 2000).

of policies by a full internalization of spillovers.[5]

Like Besley and Coate (2003) and Lorz and Willmann (2013), we assume that the local public good in jurisdiction j increases the utility function for the citizens that live in jurisdiction j but also increases the utility function for the citizens that live in jurisdiction i (where $i \neq j$). In other words, we assume that a local public good in j has two types of potential users: the citizens that live in j, that get the benefits in full; and the citizens that live in i, that get the benefits only partially (because they do not live where the local public good is produced). The last portion is measured with the spillovers and depends also by the level of connection between the two jurisdictions. If the two jurisdictions are very well connected, then for the citizens that live in i is almost living in j; i.e. they obtain a high advantage to the production of a better level of the local public good in j. Vice versa, if the connection is poor then is very hard for the citizens that live in i to obtain an advantage to a better level of the local public good in j. Therefore we assume that the spillovers are positive but lower than one (the full benefit) and that they are a function of τ, i.e. $S(\tau) \in (0,1)$. Then, we reasonably assume that the spillovers effect of the local public good g_j on the jurisdiction i, $S(\tau)$, increases with the level of transportation, $S_\tau(\tau) > 0$, but in a decreasing way, $S_{\tau\tau}(\tau) \leq 0$; and that it is symmetric for the two jurisdictions.

In each jurisdiction, there is a continuum of citizens with total mass equal to 1. Citizens have the same income y. The utility of the representative citizen, who lives in jurisdiction j, is:

$$U_j = G(g_j + S(\tau) g_i) + x_j, \tag{1}$$

where $G(\cdot) \geq 0$ is the indirect utility function of the representative citizen in j receives from the consumption of the public goods; and $x_j \geq 0$ is the utility that s/he receives from the consumption of a bundle of private goods. To solve properly the model, we assume that $G'(\cdot) > 0$, $G''(\cdot) < 0$. Note that since the mass of citizens in jurisdiction j is 1, then (1) is also the welfare function of jurisdiction j. We assume that the citizens cannot change their citizenship, i.e. they cannot move permanently from their jurisdiction to the other one or, in other words, they use the transportation good only to take advantage of the local public good in the other jurisdictions.[6]

[5] Of course the hypothesis on the optimality of the centralization is simplistic; but it enables us to focus better on the problem that we analyze. Others papers use the same assumption (e.g. De Borger and Proost, 2014).

[6] This assumption is harmless for most of the paper. With two identical jurisdictions and the symmetry of governmental powers between the jurisdictions, the level of public goods, whether they are local public goods or shipping, is the same everywhere. The

The citizen budget constraint is:

$$x_j = y - t_j - \frac{T}{2}. \tag{2}$$

where y is the income; t_j is the local tax and T is the national tax. We assume that the citizens that live in jurisdiction j potentially pay two types of taxes: the local tax, that the citizens in j paid in full; and the national tax, that the local citizens split, for the same amount, with the citizens in i. Note that they do not have a direct transportation cost but only indirectly with the taxes. This derives on the fact that this model tries to explain a mechanism on the transportation decision that rarely is considered in the literature. The cost to produce a g amount of local public good in j is ag_j; and that the cost of producing a τ amount of transportation good in j is $b\tau$. So, the marginal costs a and b are the same in both jurisdictions; they are independent from the decisional level; and they are entirely financed by the non-distortionary national and/or local taxes.[7] In particular, we assume that the public budget constrains hold for each government.

National and/or local politicians are involved in day-to-day decisions concerning the provision of public goods, g and τ. The decision on the intensity of local public good, namely g, could be taken by the national government (g^C); or by the local governments (g^D). In the same way the decision on the intensity of transportation good, namely τ, could be taken by the national government (τ^C); or by the local governments (τ^D). Then we can have four combinations that correspond at four types of institutional forms: the centralized state where both decisions are taken by the national government (g^C, τ^C); the decentralized state where both decisions are taken by the local governments (g^D, τ^D); and two types of partial centralized state where one good is taken by the national government and the other one by the local governments. In particular we have partial centralized state of type I where the national government chooses the amount of local public good and the local governments choose the amount of transportation good (g^P, τ^P); and partial centralized of type II where the national government chooses the amount of transportation good and the local governments choose the amount of local

assumption follows that the citizens do not have incentives to move in to the other jurisdiction. However this assumption is relevant in Section 5 where we assume that the governmental powers are asymmetric.

[7]Assuming different cost functions between central and local choices is a way of explaining different performance of the central and the local governments (Lorz and Williams, 2005). In order to better identify other key determinants for the decentralization choice, we make the simplifying assumption that cost functions are identical in the two cases. This choice is also motivated by the fact that it is not easy to identify in which case we observe the larger expenses (Breton and Scott, 1978; Lockwood, 2000).

public good (g^p, τ^p). In the rest of the Section we will calculate the levels of public policies chosen in the four systems of government described.

2.1 Centralization

With a centralized state the decisions on public goods are taken by the national government. Therefore there is only a national tax that covers the public cost to produce both local public goods and shipping. In this case the public budget constraints are:

$$\begin{aligned} t_j &= 0; \\ T &= a\left(g_1 + g_2\right) + 2b\tau. \end{aligned}$$

Then the maximization problem for the national government is:

$$\max_{g_1, g_2, \tau} G\left(g_1 + S\left(\tau\right) g_2\right) + G\left(g_2 + S\left(\tau\right) g_1\right) + 2y - a\left(g_1 + g_2\right) - 2b\tau.$$

So, the FOCs are:

$$\begin{aligned} G'\left(g_1 + S\left(\tau\right) g_2\right) + G'\left(g_2 + S\left(\tau\right) g_1\right) S\left(\tau\right) &= a; \\ G'\left(g_2 + S\left(\tau\right) g_1\right) + G'\left(g_1 + S\left(\tau\right) g_2\right) S\left(\tau\right) &= a; \\ G'\left(g_1 + S\left(\tau\right) g_2\right) S_\tau\left(\tau\right) g_2 + G'\left(g_2 + S\left(\tau\right) g_1\right) S_\tau\left(\tau\right) g_1 &= 2b. \end{aligned}$$

By the first two equations we know that $g_1 = g_2 = g$. So the FOCs become:

$$G'\left(g\left(1 + S\left(\tau\right)\right)\right)\left(1 + S\left(\tau\right)\right) = a; \tag{3}$$

$$G'\left(g\left(1 + S\left(\tau\right)\right)\right) S_\tau\left(\tau\right) g = b. \tag{4}$$

We can rewrite (3) as:

$$G'\left(g\left(1 + S\left(\tau\right)\right)\right) = \frac{a}{1 + S\left(\tau\right)}; \tag{5}$$

and, putting (5) in (4), we obtain:

$$g = \frac{b}{a}\frac{1 + S\left(\tau\right)}{S_\tau\left(\tau\right)}.$$

By assumption, note that the policies (g, τ) are also the optimal policies for the whole country. Indeed, the national government fully internalizes the spillovers. The following Lemma synthesizes the results:

Lemma 1 *Let* $\left(g^C, \tau^C\right)$ *be the couple of policies in a centralized contest, calculated by solving the following system:*

$$\begin{cases} G'\left(\frac{b}{a}\frac{\left(1+S\left(\tau^C\right)\right)^2}{S_\tau\left(\tau^C\right)}\right) = \frac{a}{1+S\left(\tau^C\right)} \\ g^C = \frac{b}{a}\frac{1+S\left(\tau^C\right)}{S_\tau\left(\tau^C\right)} \end{cases}; \tag{6}$$

then the unique solution $\left(g^C, \tau^C\right)$ *is also the first-best solution.*

In other word the centralization solves the potential institutional inefficiency with a perfect coordination of policies.

2.2 Decentralization

With a decentralized state the decisions on public goods are taken by the local governments. Then there is only two local taxes, one in each jurisdiction, that cover the public cost to produce both local public goods and shipping. So, in this case, the public budget constraints are:

$$\begin{aligned} t_j &= ag_j + b\tau; \\ T &= 0. \end{aligned}$$

Therefore the maximization problem for the local government j is:

$$\max_{g_j, \tau} G\left(g_j + S\left(\tau\right) g_i\right) + y - ag_j - b\tau.$$

So, the FOCs for the jurisdiction j are:

$$G'\left(g_j + S\left(\tau\right) g_i\right) = a \tag{7}$$

$$G'\left(g_j + S\left(\tau\right) g_i\right) S_\tau\left(\tau\right) g_i = b. \tag{8}$$

Combining (7) and (8) we obtain:

$$g_i = \frac{b}{aS_\tau\left(\tau\right)}. \tag{9}$$

Note that the solution is the same for each jurisdiction ($g_j = g_i = g$). However, the two policies are different respect to the first-best solution; so, the decentralized solution is suboptimal because there are spillovers. Then the following Lemma synthesizes the results:

Lemma 2 *Let $\left(g^D, \tau^D\right)$ be the couple of policies in a decentralized contest, calculated by solving the following system:*

$$\begin{cases} G'\left(\frac{b}{a}\frac{1+S\left(\tau^D\right)}{S_\tau\left(\tau^D\right)}\right) = a \\ g^D = \frac{b}{aS_\tau\left(\tau^D\right)} \end{cases} ; \tag{10}$$

then the unique solution $\left(g^D, \tau^D\right)$ is inefficient.

Indeed, the local governments are unable to solve the potential institutional inefficiency. Using the partial centralization concept we can better understand why the decentralization is inefficient. In particular, we first assume that the local governments centralize only the transportation good decision $\left(g^P, \tau^P\right)$ and then only the public good decision $\left(g^p, \tau^p\right)$.

2.3 Partial Centralization of type I

With a partial centralized state of type I the local governments centralize only the transportation decision, τ. Then in this case the public budget constraints are:

$$\begin{aligned} t_j &= ag_j \\ T &= 2b\tau. \end{aligned}$$

We assume that before the national level government τ and after the local governments choose g_1 and g_2. So the maximization problem for the local government j is:

$$\max_{g_j} G\left(g_j + S\left(\tau\right) g_i\right) + y - ag_j - b\tau,$$

where τ is given by the central government decision. Then, in each jurisdiction j the problem is:

$$G'\left(g_j + S\left(\tau\right) g_i\right) = a. \tag{11}$$

Note that this is the same result of (7) with a decentralized state. In addition, by symmetry, $g_j = g_i = g$ and then $\left(1 + S\left(\tau\right)\right) dg + gS_\tau\left(\tau\right) d\tau = 0$. So:

$$g_\tau = \frac{dg}{d\tau} = -\frac{gS_\tau\left(\tau\right)}{1 + S\left(\tau\right)} < 0. \tag{12}$$

Mathematically, if τ increases then $S\left(\tau\right)$ increases ($S_\tau\left(\tau\right) > 0$); so, to obtain the same level of equation (11) that before, a, g decreases. It is interesting to observe that the same relationship also holds in the decentralized case. Intuitively, the relationship between g and τ is negative because with the decentralization there is a market failure caused by the spillovers that reduces the level of public good. In particular, if τ increases then the spillovers increase; but if $S(\tau)$ is larger than g then it is still more suboptimal; so if τ increases then g decreases. In other word, if τ is low then g is close to the optimal one, but if τ is high then g is far to the optimal one. In other words, if the national government increases the level of public transportation, in one hand, increases the level of spillovers and therefore increases the level of utility of citizens; however, in the other hand, it moves the local public goods far to the optimum level and therefore decreases the level of utility of citizens. This is the trade-off that the national government has in case that it decides only the level of transportation good.

Then the maximization problem in the first step (national level) is:

$$\max_{\tau} 2G\left(g(\tau)\left(1+S(\tau)\right)\right)+2y-2ag(\tau)-2b\tau.$$

So, the FOC is:

$$G'\left(g\left(1+S(\tau)\right)\right)\left(g_{\tau}\left(1+S(\tau)\right)+gS_{\tau}(\tau)\right)=ag_{\tau}+b.$$

Using (11) and (12) we obtain:

$$g=\frac{b}{a}\frac{1+S(\tau)}{S_{\tau}(\tau)}. \tag{13}$$

Finally, putting (13) in (11), we have:

$$G'\left(\frac{b}{a}\frac{\left(1+S(\tau)\right)^{2}}{S_{\tau}(\tau)}\right)=a.$$

The public policies are not optimal, but knowing that the partial centralization of type I is more efficient than the decentralization we can conclude that this is a second-best solution. Then, the following Lemma synthesizes the results:

Lemma 3 *Let $\left(g^{P},\tau^{P}\right)$ be the couple of policies in a partial centralized contest of type I, calculated by solving the following system:*

$$\begin{cases} G'\left(\frac{b}{a}\frac{\left(1+S\left(\tau^{P}\right)\right)^{2}}{S_{\tau}\left(\tau^{P}\right)}\right)=a \\ g^{P}=\frac{b}{a}\frac{1+S\left(\tau^{P}\right)}{S_{\tau}\left(\tau^{P}\right)} \end{cases}; \tag{14}$$

then the unique solution $\left(g^{P},\tau^{P}\right)$ is also the second-best solution.

However, with a partial centralization of type I we partially solve the problem by using the transportation good, τ, to affect the local government decisions on local public good, g.

2.4 Partial Centralization of type II

With a partial centralized state of type II, the local governments centralize only the local public goods decisions, g_1 and g_2. Then in this case the public budget constraints are:

$$\begin{aligned} t_j &= b\tau \\ T &= a\left(g_j + g_i\right). \end{aligned}$$

We assume that before the national government chooses g and after the local governments choose τ. Therefore the maximization problem in the second step is:

$$\max_{\tau} G\left(g_j + S\left(\tau\right) g_i\right) + y - \frac{a\left(g_j + g_i\right)}{2} - b\tau,$$

where g_j and g_i are given by the national government decision. Then:[8]

$$G'\left(g_j + S\left(\tau\right) g_i\right) = \frac{b}{g_i S_\tau\left(\tau\right)}. \tag{15}$$

Now the maximization problem in the first step is:

$$\max_{g_i, g_j} G\left(g_j + S\left(\tau\left(g_j, g_i\right)\right) g_i\right) + G\left(g_i + S\left(\tau\left(g_j, g_i\right)\right) g_j\right) + 2y - a\left(g_i + g_j\right) - 2b\tau\left(g_j, g_i\right).$$

For each jurisdiction j, the FOC is:

$$G'\left(g_j + S\left(\tau\right) g_i\right)\left(1 + g_i S_\tau\left(\tau\right)\tau_{g_j}\right) + G'\left(g_i + S\left(\tau\right) g_j\right)\left(S\left(\tau\right) + g_j S_\tau\left(\tau\right)\tau_{g_j}\right) = a + 2b\tau_{g_j}.$$

Then, by (15) we obtain, $\forall j, i = 1, 2$:

$$\frac{b}{g_i S_\tau\left(\tau\right)} + \frac{b}{g_j S_\tau\left(\tau\right)} S\left(\tau\right) = a.$$

Solving the two equations, we find that $g_i = g_j = g$. So, we have:

$$g = \frac{b\left(1 + S\left(\tau\right)\right)}{a S_\tau\left(\tau\right)}. \tag{16}$$

Therefore, putting (16) in (15), we obtain:

$$G'\left(\frac{b}{a}\frac{\left(1 + S\left(\tau\right)\right)^2}{S_\tau\left(\tau\right)}\right) = \frac{a}{1 + S\left(\tau\right)}. \tag{17}$$

[8] We use the total differentiation instrument; but now we do not find the first derivative of τ on g because g_j and g_i could be different. However, in the second step of the game, we know that $g_j = g_i = g$ and then we can find the first derivative τ on g. Therefore, we obtain that $\tau_g \lesseqgtr 0$.

Note that (15) and (17) are equal to (3) and (4). The intuition is that the central government chooses the optimal level of local public goods and thus it solves all problems of spillovers. So the choice of the transport layer occurs in a context devoid of institutional failures. It follows that the level of government that makes the decision is not relevant. Therefore, we find the same solution of the central case (i.e. $(g^p; \tau^p) = \left(g^C; \tau^C\right)$). The following Lemma synthesizes the results:

Lemma 4 *Let (g^p, τ^p) be the couple of policies in a partial centralized contest of type II, calculated by solving the following system:*

$$\begin{cases} G'\left(\frac{b}{a}\frac{(1+S(\tau^p))^2}{S_\tau(\tau^p)}\right) = \frac{a}{1+S(\tau^p)} \\ g^p = \frac{b}{a}\frac{1+S(\tau^p)}{S_\tau(\tau^p)} \end{cases}; \tag{18}$$

then the unique solution (g^p, τ^p) is also the first-best solution.

These results have two important implications: the first one is that as previously showed, the partial centralization could also be optimal if there are spillovers; the second one is that the effect of centralization of two goods is not equal to the sum of the two separate effects. This implies that the decentralization does not only coordinate the policies on public goods local jurisdictions, but also these policies with the shipping policy. More generally, we have showed that the decision of which policy must be centralized has important implications on welfare. In the Section 3, we will compare the four institutional systems.

3 Discussion

As we study different but interconnected policies (e.g. local public good and shipping), we can analyze the policies through at least two levels of efficiency. A level of efficiency of one policy considered individually; and a level of globally efficiency of all policies considered together. This difference is important in the model because we have an interaction between two public goods, g and τ. Indeed, we seldom study the institutional efficiency with a public good that affects a different public good.[9] However, in the real word this happened in a lot of cases and then we can use the following Definitions:

[9] The only attempts in this direction are limited to cases of public goods that complements or substitutes and their intermediate cases (e.g. Brueckner, 2009); or the analysis of a public good that is produced partially in the local level and partially in the national level (e.g. Joanis, 2014). Although all these papers are noteworthy, our paper follows a different path assuming that transport good affects the other goods through the spillovers.

Definition 5 *A single policy is more (less) efficient than another policy if it is closer to the optimal level of this policy.*

Definition 6 *A set of policies is globally more (less) efficient than another set of the same policies if it is closer to the optimal level of this set of policies.*

By Definition 5, in this model we have g^P being more (less) efficient than g^D if it is closer to the optimal level (i.e. $\left|g^C - g^P\right| > (<) \left|g^C - g^D\right|$); and τ^P is more (less) efficient than τ^D if it is closer to the optimal level (i.e. $\left|\tau^C - \tau^P\right| > (<) \left|\tau^C - \tau^D\right|$). In addition, by Definition 6, in this model we have that the set of policies $\left(g^P, \tau^P\right)$ being globally more (less) efficient than $\left(g^D, \tau^D\right)$ if it implies a larger utility function (i.e. $U\left(g^P, \tau^P\right) > (<) U\left(g^D, \tau^D\right)$). With these definitions, we can have a public good, e.g. τ, that is analyzed with the other policies, e.g. g, being globally more efficient; but if analyzed singularly it is apparently becomes less efficient. This is exactly what can happen in this model for τ^P.

We can start with the welfare analysis. The only institutional failure in the model is the spillovers between the two jurisdictions then only the national government considers it in its decisions. Therefore the centralized state fully solves the failure. Indeed, each decision is taken by internalizing the spillovers effect. In addition, the partial centralization of type II gives the same solution of the centralized state than both institutional systems choose the optimal policies. Vice versa, the decentralized state never internalizes the spillovers, then it is the lower possible welfare (in the case of benevolent governments). In between these two extreme solutions there is the partial centralization of type I where the government solves partially the spillovers problem with the transportation good. We can write the following Proposition:

Proposition 7 $U^D < U^P < U^C = U^p$.

In other words, the centralized policies $\left(g^C, \tau^C\right)$ are globally more efficient that the partial centralized decision of type I $\left(g^P, \tau^P\right)$. With the first couple of public goods the citizens have a higher level of public goods than the second couple of public goods. In the same way, the partial centralized decision of type I $\left(g^P, \tau^P\right)$ is globally more efficient that the decentralized decision $\left(g^D, \tau^D\right)$. Therefore we can conclude that the partial centralization could also be optimal if there are decentralized institutional failures and that the effect of centralization of two goods is larger than of the sum of the two separate effects. This last point has particularly interesting consequences. In one hand, if the partial centralized state centralizes τ then there are no welfare advantages; but if the decentralized state centralizes τ then there are welfare advantages. Indeed, $U^P - U^D > U^C - U^p$. In the other hand, if the partial centralized state centralizes g then there are some welfare advantages; but if the decentralized state centralizes g then there are more welfare advantages. Indeed, $U^p - U^D > U^C - U^P$. The following Corollary summarizes the result:

Corollary 8 *The effects of the centralization of τ or g depend on the previous institution. In particular, the contribution of the centralization of a new policy has a larger (positive) effect in the decentralized state in respect to the partial centralized state.*

We will now explore the efficiency of each single public good. To simplify the following discussion we will not consider the partial centralization of type II in the analysis. Indeed, the form of state is identical to the central state. Then the partial centralization of type I will be simply called partial centralization. We start with the transportation good τ. By the first equations in the systems (6), (10) and (14) we have $\tau^P < \tau^D$ and $\tau^P < \tau^C$. Unfortunately, we do not have any conclusions on the τ^D and τ^C relationship. So, we have the following Proposition:

Proposition 9 $\tau^P < \tau^D \lesseqgtr \tau^C$.

Therefore, we have two possibilities of either $\tau^P < \tau^D < \tau^C$ or $\tau^P < \tau^C < \tau^D$. Note that the level of transportation could be more efficient with decentralization in respect to partial decentralization and also if it is globally less efficient. This is particularly surprising because with this type of partial decentralization the public-sector decision on the transportation good is taken by the national level in this model always takes the optimal decision. The motivation of this result derives by the negative relationship between the two public goods. For increases on the level of local public goods, g, the national government reduces the level of transportation good, τ. Knowing that the decentralization implies sub-production of g, then the optimal choice of τ is lower than the choice taken at the inefficient local level; but in this way the national government could choose a level of τ apparently farther than the optimal level, τ^C.

Remembering that $S_\tau(\tau) > 0$ and $S_{\tau\tau}(\tau) \leq 0$ we have $S\left(\tau^P\right) < S\left(\tau^D\right) \lesseqgtr S\left(\tau^C\right)$ and $S_\tau\left(\tau^D\right) \lesseqgtr S_\tau\left(\tau^C\right) < S_\tau\left(\tau^P\right)$. So, $\frac{1+S\left(\tau^P\right)}{S_\tau\left(\tau^P\right)} < \frac{1+S\left(\tau^C\right)}{S_\tau\left(\tau^C\right)}$; and, by (9) and (13), $g^P < g^C$. In addition, remembering that (12) is the same for the decentralized and the partial centralized states and that $\tau^P < \tau^D$, we obtain $g^D < g^P$. The following Proposition combines the results:

Proposition 10 $g^D < g^P < g^C$.

Therefore, the partial centralization of g is always more efficient than the decentralization. This derives to the fact that with the centralization of the transportation good the national governments solves, almost partially, the problem of spillovers that implies underproduction of local public goods, as it decreases the level of spillovers. However, this could imply a less efficient level of transportation good (see Proposition 9).

Its could be interesting to study how the public goods decision affects both the public and the private component of utility function. We start with the public component, G. Using the first equation in (10) and (14) we can write that $G'\left(g^D\left(1+S\left(\tau^D\right)\right)\right) = G'\left(g^P\left(1+S\left(\tau^P\right)\right)\right)$ then we obtain that $G^D = G^P$. This is particularly interesting because we show that the central state has a higher level of public goods in respect to partial centralization (of type I) and decentralization. The level of inefficiency of the public good component is the same in these two forms of state. Then the advantage in a decentralized state to have a high level of τ is brought down by the lower level of g; and these two effects have the same amount in the public good component, G. In other words, the two previous effects are exactly balanced; and that the two forms of state are equally (in)efficient for the public component of the utility function. Finally, using the first equation in (6) and (10), $G'\left(g^D\left(1+S\left(\tau^D\right)\right)\right) > G'\left(g^C\left(1+S\left(\tau^C\right)\right)\right)$ then, by $G'' < 0$, we have that $g^D\left(1+S\left(\tau^D\right)\right) < g^C\left(1+S\left(\tau^C\right)\right)$; in other, by $G' > 0$, we obtain $G^D < G^C$. The following Proposition summarizes the results:

Proposition 11 $G^D = G^P < G^C$.

We have stated that with a decentralized state or a partial centralized state the states have the same level of public (in)efficiency. It could happen that in the partial centralized state both the public goods, g^P and τ^P, are (globally) more efficient but this does not emerge when analyzing the public component of utility function. It could happen that the transportation good, τ^P, is less efficient but that it also induce the same level of efficiency for the public good.

We will now analyze the private component of utility function, x. First, note that, by (12) and (13), the partial centralized state implies $g_\tau^P = -\frac{b}{a}$. More interesting is the fact that this form of state maximizes the private component of the utility function. Mathematically, $x_\tau\left(g_\tau\right) = -b - ag_\tau$ and $x_{\tau\tau}\left(g_{\tau\tau}\right) = -ag_{\tau\tau}$ then $x_\tau\left(g_\tau^P\right) = 0$ and $x_{\tau\tau}\left(g_{\tau\tau}^P\right) = -ag_{\tau\tau}^P < 0$.[10] So, x^P is

[10] Using (12) we know that $g_{\tau\tau} = -\frac{(1+S(\tau))(S_\tau(\tau)g_\tau + gS_{\tau\tau}(\tau)) - gS_\tau(\tau)^2}{(1+S(\tau))^2} > 0$ for each level of τ.

the maximum level of private good (i.e. $x^D < x^P$ and $x^C < x^P$). In other word, the level of taxes are lower with a partial centralization. However, by the fact that $\tau^D \lesseqgtr \tau^C$ we cannot conclude anything about the x^D and x^C relationship. Then we can write the following Proposition:

Proposition 12 $x^D \lesseqgtr x^C < x^P$.

The partial centralization (of type I) has a higher level of private good in respect to the decentralization. Note that this could be more efficient in some case but less efficient in other cases. It could happen that x^D is more efficient that x^P. This is particularly surprising because G^D and G^P have the same level of efficiency but $U^D < U^P$. Section 4 will show two different cases where this occur. Finally, with Propositions 11 and 12 we have the following Corollary:

Corollary 13 *If the local governments centralize the decision of transportation good then it partially solves the spillovers' problem ($g^D < g^P$). In addition, the total amount of public good affects in the same way the utility function of the citizen but with a lower level of taxation ($G^D = G^P$ and $x^D < x^P$).*

With the partial centralized state the local governments choose, independently of τ, a level of G. Then as the central government can only control τ, the only possible strategy is to minimize the taxes. This could be an additional explanation on the fact that the partial centralized states are more efficient than the decentralized states (Shah, 2004 and Devarajan et al., 2007). Finally, note that the national government in the partial centralized state potentially could cancel the spillovers' problem. If it chooses a level of transportation τ s.t. $S(\tau) = 0$ the problem of spillovers disappears. However, this is probably not the optimal decision to take because it is cancel the indirect effect that the local public good has on the other jurisdiction. Given this trade-off, the national government chooses τ^P.

4 Examples

4.1 Logarithmic function

Let $G(\cdot)$ be a logarithmic function. Then, the utility function is:

$$U_j = \ln(g_j + S(\tau) g_i) + x_j. \quad (19)$$

Knowing that in this case $G'(g_j + S(\tau) g_i) = \frac{1}{g_j + S(\tau) g_i}$, with some calculations, we can write the systems (6), (10) and (14) as follow:

$$\begin{cases} \frac{S_\tau(\tau^C)}{b(1+S(\tau^C))} = 1 \\ g^C = \frac{1}{a} \end{cases} ; \quad (20)$$

$$\begin{cases} \frac{S_\tau(\tau^D)}{b(1+S(\tau^D))} = 1 \\ g^D = \frac{1}{a(1+S(\tau^D))} \end{cases} ; \quad (21)$$

$$\begin{cases} \frac{S_\tau(\tau^P)}{b(1+S(\tau^P))^2} = 1 \\ g^P = \frac{1}{a(1+S(\tau^P))} \end{cases} . \quad (22)$$

By the first equation in (20) and (21) we know that $\tau^D = \tau^C$; in addition, by Proposition 9, we know that τ^P is always the lower level of transportation. Then, we have $\tau^P < \tau^D = \tau^C$. We know that in this case not only the level of transportation in a decentralized state is more efficient than in a partial centralized state but also that the decentralized decision is also the first-best solution.

Using Proposition 10 we know that $g^D < g^P < g^C$. The decision to have a less efficient transport level has a positive effect on local public goods. In addition, we know that this also produce an improved level of overall utility, U; but not the public component of the utility function, G. By Proposition 11, we know that $G^D = G^P < G^C$. In addition, knowing that τ^C and g^C are the higher level of the respective public good, then x^C is the lower private component level, x. Finally, by Proposition 12, we obtain $x^C < x^D < x^P$.

In other word, the decentralized state is more efficient than the partial centralization state for the private component of utility function. Adding this observation on the public component, that both forms of state have the same level of inefficiency ($G^D = G^P$), we can incorrectly conclude that the policies in the decentralized state are better that the policies in the partial centralized state. The public component is unchangeable so τ^P maximizes x to obtain the higher level of total utility function (given the local decision of g). This result is particularly interesting because the total utility function is a simple additive function of the two components G and x. The following Proposition synthesizes the results:

Proposition 14 *Assuming that $U = G + x$, where $G = \ln(g(1 + S(\tau)))$ and $x = y - a\tau - bg$. Then we have the following:*

- $\tau^P < \tau^D = \tau^C$;
- $g^D < g^P < g^C$;

- $G^D = G^P < G^C$;
- $x^C < x^D < x^P$;
- $U^D < U^P < U^C$.

If we compare the decentralized policies $\left(g^D, \tau^D\right)$ with the partial centralized policies $\left(g^P, \tau^P\right)$ we obtain the following Corollary:

Corollary 15 *In respect to the partial centralized policies, the decentralized policies has the:*

- *same level of G; and*
- *more efficient level of x; but*
- *less efficient level of U.*

We can conclude that the decentralized choice $\left(g^D, \tau^D\right)$ affects the public component of utility function, G, in the same level as the partial centralized choices $\left(g^P, \tau^P\right)$. In addition, we have $\left(g^D, \tau^D\right)$ affects the private component of utility function, G, in a more efficient than $\left(g^P, \tau^P\right)$. However, we have $\left(g^D, \tau^D\right)$ affects the total utility function, U, in a less efficient way than $\left(g^P, \tau^P\right)$. This is particularly interesting because the utility function is a sum of these two components $U = G + x$. The result derives from the fact that in G and in x we have two different policies that interact in a negative and complex way.

4.2 Exponential function

Let $G(\cdot)$ be an exponential function. Then, the utility function is:

$$U_j = \left(g_j + S(\tau)\, g_i\right)^{\frac{1}{\theta}} + x_j, \tag{23}$$

where $\theta > 1$. Knowing that in this case $G'\left(g_j + S\left(\tau\right)g_i\right) = \frac{1}{\theta}\left(g_j + S\left(\tau\right)g_i\right)^{\frac{1-\theta}{\theta}}$, with some calculation, we can write the systems (6), (10) and (14) as follow:

$$\begin{cases} \frac{1}{\theta}\left(\frac{b\left(1+S\left(\tau^C\right)\right)^2}{aS_\tau\left(\tau^C\right)}\right)^{\frac{1-\theta}{\theta}} = \frac{a}{1+S\left(\tau^C\right)} \\ g^C = \frac{b\left(1+S\left(\tau^C\right)\right)}{aS_\tau\left(\tau^C\right)} \end{cases}; \tag{24}$$

$$\begin{cases} \frac{1}{\theta}\left(\frac{b}{a}\frac{1+S\left(\tau^D\right)}{S_\tau\left(\tau^D\right)}\right)^{\frac{1-\theta}{\theta}} = a \\ g^D = \frac{b}{aS_\tau\left(\tau^D\right)} \end{cases}; \tag{25}$$

$$\begin{cases} \frac{1}{\theta}\left(\frac{b}{a}\frac{\left(1+S\left(\tau^P\right)\right)^2}{S_\tau\left(\tau^P\right)}\right)^{\frac{1-\theta}{\theta}} = a \\ g^P = \frac{b\left(1+S\left(\tau^P\right)\right)}{aS_\tau\left(\tau^P\right)} \end{cases}. \tag{26}$$

Then by the first equation in (24) and (25) we know that the following equations hold:

$$\begin{aligned} \left(\frac{1+S\left(\tau^D\right)}{S_\tau\left(\tau^D\right)}\right)^{\frac{1-\theta}{\theta}} &= a\theta\left(\frac{b}{a}\right)^{-\frac{1-\theta}{\theta}}; \\ \left(\frac{1+S\left(\tau^C\right)}{S_\tau\left(\tau^C\right)}\right)^{\frac{1-\theta}{\theta}}\left(1+S\left(\tau^C\right)\right)^{\frac{1}{\theta}} &= a\theta\left(\frac{b}{a}\right)^{-\frac{1-\theta}{\theta}}. \end{aligned}$$

We know that $\left(1+S\left(\tau^C\right)\right)^{\frac{1}{\theta}} > 1$ then we must have $\left(\frac{1+S\left(\tau^C\right)}{S_\tau\left(\tau^C\right)}\right)^{\frac{1-\theta}{\theta}} < \left(\frac{1+S\left(\tau^D\right)}{S_\tau\left(\tau^D\right)}\right)^{\frac{1-\theta}{\theta}}$. Calculating the first derivative we obtain that $\frac{d\left(\frac{1+S(\tau)}{S_\tau(\tau)}\right)}{d\tau} = \frac{S_\tau(\tau)^2-(1+S(\tau))S_{\tau\tau}(\tau)}{S_\tau(\tau)^2}$ (>0). Then, remembering that $\theta > 1$, we have $\tau^D < \tau^C$. Then by Proposition 9, we know that $\tau^P < \tau^D < \tau^C$. So, we know that in this case the level of transportation in a decentralized state is more efficient than in a partial centralized state.

Using Proposition 10 we know that $g^D < g^P < g^C$. Then, the decision to have a less efficient transport level has a positive effect on local public goods. In addition, we know that this also produce an improved level of overall utility, U; but not the public component of the utility function, G. By Proposition 11, we know that $G^D = G^P < G^C$. Like before we know that $x^C < x^D < x^P$. The following Proposition synthesizes the results:

Proposition 16 *Assuming that* $U = G + x$, *where* $G = \left(g\left(1+S\left(\tau\right)\right)\right)^{\frac{1}{\theta}}$ *and* $x = y - a\tau - bg$. *Then we have the following:*

- $\tau^P < \tau^D < \tau^C$;
- $g^D < g^P < g^C$;
- $G^D = G^P < G^C$;
- $x^C < x^D < x^P$;
- $U^D < U^P < U^C$.

In both examples we have found the same political implications. Indeed, the centralized state chooses a higher level of public goods but also a higher level of taxes. The decentralized state chooses a lower level of public good and taxation. Finally the partial central state choose the same level of public good than the decentralized state but at a cheaper cost for the citizens, and then with lower taxation. If we compare the decentralized policies (g^D, τ^D) with the partial centralized policies (g^P, τ^P) we obtain the following Corollary:

Corollary 17 *In respect to the partial centralized policies, then the decentralized policies has the:*

- *same level of* G*; and*
- *more efficient level of* x*; but*
- *less efficient level of* U*.*

To conclude the main outcome of these two examples is that when there are public goods that interacts, the only way to study the efficiency is in a global way. In other words, we can get incorrect results if we only consider the efficiency of a set of policies or their effects; this conclusion is also true if the single policy is apparently optimal.

5 Asymmetric partial centralization

Now we consider the possibility that the jurisdictions have an asymmetric level of centralization. In other words, we assume that a jurisdiction has less centralized power than the other one. This could happen due to political, economic or historic reasons but it is the typical case in a lot of partial centralized state. We assume that the local governments centralize the local public goods decision only for the jurisdiction 2, g_2. In this case the public budget constraints are:

$$\begin{aligned} t_1 &= ag_1 \\ t_2 &= 0 \\ T &= 2b\tau + ag_2. \end{aligned}$$

In one hand, the local government chooses the level of local public good of jurisdiction 1 and this is fully paid by the local tax, t. In the other hand, the national government chooses both the level of local public good of jurisdiction 2 and the transportation level; and this is paid in full by the national tax, T. Note that the two total taxes in each jurisdiction are different and in particular that $x_2^A > x_1^A$.

In the asymmetric situation the maximization problem in the second step (only for jurisdiction 1) is:

$$\max_{g_1} G\left(g_1 + S\left(\tau\right) g_2\right) + y - ag_1 - b\tau - \frac{a}{2} g_2,$$

where τ and g_2 are given by the national government decisions. Then the FOC is:

$$G'\left(g_1 + S\left(\tau\right) g_2\right) = a. \tag{27}$$

Therefore the maximization problem in the first step (national level) is:

$$\max_{g_2,\tau} G\left(g_1\left(\tau\right) + S\left(\tau\right) g_2\right) + u\left(g_2 + S\left(\tau\right) g_1\left(\tau\right)\right) + 2y - ag_1\left(\tau\right) - ag_2 - 2b\tau.$$

So, using (27), the FOCs are:

$$G'\left(g_2 + S\left(\tau\right) g_1\left(\tau\right)\right) = a\left(1 - S\left(\tau\right)\right), \tag{28}$$

$$G'\left(g_2 + S\left(\tau\right) g_1\right)\left(S_\tau\left(\tau\right) g_1 + S\left(\tau\right) g_{1\tau}\right) = 2b. \tag{29}$$

Then, putting (28) in (29) we obtain:

$$a\left(1 - S\left(\tau\right)\right)\left(S_\tau\left(\tau\right) g_1 + S\left(\tau\right) g_{1\tau}\right) = 2b.$$

Therefore the following Lemma summarizes the results:

Lemma 18 *Let $\left(g_1^A, g_2^A, \tau^A\right)$ be the set of policies in an asymmetric partial centralized contest, calculated by solving the following system:*

$$\left\{ \begin{array}{c} G'\left(g_1^A + S\left(\tau^A\right) g_2^A\right) = a \\ G'\left(g_2^A + S\left(\tau^A\right) g_1^A\right) = a\left(1 - S\left(\tau^A\right)\right) \\ a\left(1 - S\left(\tau^A\right)\right)\left(S_\tau\left(\tau^A\right) g_1^A + S\left(\tau\right) g_{1\tau}^A\right) = 2b \end{array} \right. .$$

Note that $\left(g_1^A, g_2^A, \tau^A\right)$ are the unique solutions of the system.

Before to compare the policies with the previous type of states we compare the allocations of public goods between the two jurisdictions in the asymmetric partial centralization state. By the first two equations we know that $G'\left(g_1^A + S\left(\tau^A\right) g_2^A\right) > G'\left(g_2^A + S\left(\tau^A\right) g_1^A\right)$; then using $G' < 0$ we obtain that $g_2^A > g_1^A$. In addition, knowing that τ^A is the same in each jurisdiction we have $G_2^A > G_1^A$. Remembering that $x_2^A > x_1^A$ we also know that $U_1^A > U_2^A$. The following Proposition synthesizes the results:

Proposition 19 *An asymmetric power between two identical jurisdictions modifies the level and the composition of the welfare. In particular, the jurisdiction with more local power obtains a lower level of g, G, x and U in respect to the other jurisdiction.*

The economics interpretation of this result is that if we have asymmetry then the level of τ is the same in both jurisdictions. This implies that the local public good in jurisdiction 1 is lower that the local pubic good in jurisdiction 2 because the local government does not solve the spillovers problem. So, the problem of underproduction of g_1 affects directly the jurisdiction 1 and indirectly the jurisdiction 2. However, by $S(\tau) < 1$ the direct effect is larger than the indirect effect. Therefore, the utility function of jurisdiction 1 is lower than the utility function of jurisdiction 2.

We will now compare this set of policies with the previous one. We define $U^A = \frac{U_1^A + U_2^A}{2}$, then by construction we know that $U^D < U^P < U_1^A < U^A < U_2^A < U^C$. With decentralization the governments do not consider the spillovers a problem for each policy; with a partial centralization the governments do not consider the spillovers as a problem for both local public goods; with an asymmetric partial centralization the governments do not consider the spillovers as a problem for one local public good; and with a centralization the government considers the spillovers as a problem for each politics.

Unfortunately we are not able to compare the three single public goods, g_1, g_2 and τ, in the different institutional forms. However, we can compare the public and private component of the utility function. We start with the public component, G. By (7) and (27) we know that $G'\left(g^D\left(1 + S\left(\tau^D\right)\right)\right) = G'\left(g_1^A + S\left(\tau^A\right) g_2^A\right)$ and then $G^D = G_1^A$. In addition, by the definition of average $\left(G^A = \frac{G_1^A + G_2^A}{2}\right)$ and by Propositions 9 and 19 we know that $G^D = G^P = G_1^A < G^A < G_2^A$. Moreover, we know that $U^D < U^P < U_1^A$ and so $x^D < x^P < x_1^A$. Then by Proposition 12 and 19 we know that $x^C < x_2^A$. Finally, knowing that $U_2^A < U^C$ we can conclude that $G_2^A < G^C$. The following Proposition synthesizes the results:

Proposition 20 *With an asymmetric partial centralization system we can conclude that:*

- $x^D \lesseqgtr x^C < x^P < x_1^A < x^A < x_2^A$;
- $G^D = G^P = G_1^A < G^A < G_2^A < G^C$;
- $U^D < U^P < U_1^A < U^A < U_2^A < U^C$;

where $x^A = \frac{x_1^A + x_2^A}{2}$, $G^A = \frac{G_1^A + G_2^A}{2}$, $U^A = \frac{U_1^A + U_2^A}{2}$.

In other words, with an asymmetric partial centralization the citizens have a better solution in respect to the partial centralization (of type I) because this form of state fully solves the underproduction of one local public good. This increase both the public component but also the private component of utility function (i.e. $x^P < x^A$ and $G^P < G^A$) then the utility function increases in two ways. Finally, note that both of there are present in the jurisdiction with less local power ($x^P < x_2^A$ and $G^P < G_2^A$) but only the second one (also with a lower impact) is present in the other jurisdiction ($x^P = x_1^A$ and $G^P < G_1^A$). Then this extension highlights once again that the effect of centralization of two public goods is not equal to the sum of the two partial centralization policies taken separately.

6 Conclusion

The paper introduces two novelties in the decentralized fiscal's debate. On one hand, it combines the analysis of the transportation expenditure with the analysis of the partial (de)centralization. On the other hand, it assumes that the transportation good affects the spillovers of local public goods. In the model, the choice of which level of government (local or national) will decide the transport layer on two potentially effects on the citizens' welfare: one is direct, with the modification of the spillovers; the other one is indirect, with the following modification of local public goods. The main results of the models are that the effects on centralization of transportation's policy depend on whether the local public goods are centralized or not; and that, like Brueckner (2013), the transportation policy could help to solve the spillovers problem. Furthermore, we show that only through a global analysis of the efficiency it is possible to get the correct political implications. In particular, analyzing the proximity by the optimal level for an individual policy or a subset of policies it is possible to get incorrect conclusions. This stems from the fact that the public policies could affect each other. This implies that the effectiveness of a public policy must be analyzed only by considering all the effects that it has on all other public policies.

The novelties of the paper allow having multiple extensions of the model and new issues in the fiscal decentralization's literature. We conclude the paper by citing a few. Typically the Oates' decentralized theorem (Oates, 1972; Besley and Coate, 2003) assumes that the level of spillovers is given. However, it is interesting to analyze what would happen to this basic theorem, if the spillovers are affected by the decision of the transport layer. In addition, our model does not assume any benefit from the decentralization of policy. The inclusion of this aspect would make the model more realistic and empirically testable. In particular, this could allow to better compare the model with the current literature on partial decentralization using a continuum of local public goods (Lorz and Willmann, 2005; Alderighi and Feder, 2014). Finally, the transportation good is often analyzed in the context of fiscal decentralization using the concept of "vote with their feet" (Tiebout, 1956; Brueckner, 2000 and 2004). The inclusion of a certain mobility of citizens, which depends on the level of transport between heterogeneous jurisdictions, could merge the Tiebout and Oates' arguments. Note that the tool to converge the two main research fields is the transportation good.

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