ESSAYS ON THE INSTITUTIONAL DETERMINANTS OF PUBLIC EXPENDITURE

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Chapter 1

Introduction

1.1 Public Expenditure and the Institutional Setting of the Public Sector

What is the role of the public sector? According to Richard Musgrave (1959), it includes macroeconomic stabilization, income redistribution, and resource allocation. To realize these objectives, the state levies taxes and provides goods and services for individuals and firms. Oates (1972) already observed that *institutional factors* such as the federal structure of a state play a huge role in this context. E.g. if the federal government, a supranational organization (for instance the EU), or a strong private sector try to influence the decision process at the regional level, this may well determine the amount and quality of the goods and services provided. Thus, the distribution of decision power among different political institutions or the size of the public sector itself is likely to affect the composition of public expenditure. Until now, these links are still not completely understood. It is the aim of this thesis to cast some more light on the impact of the institutional setup of the public sector on its expenditure decisions.

Two institutional features are of particular interest to us: fiscal federalism and privatization. First, it is well known that the distribution of power among different tiers of government, that is *fiscal federalism*, may affect the spending decisions of the government. While there exists a huge literature on fiscal federalism with two tiers of government, the implications of more complex federal structures for the level and composition of public spending is still an open issue. For instance, the EU can be interpreted as a governmental structure with at least three tiers of government: regional and national governments as well as the EU itself. In this case it is no longer clear, how the different tiers of governments will behave and which level of public investment is actually realized. One important aspect here is that the federal structure does not only affect the level, but also the composition of public spending and investment. Second, *privatization* is another important institutional aspect, which might affect public spending: If a public firm is privatized, it is likely to change from a mostly social towards a more profit oriented objective. This may lead to changes in the demand for public services and goods and thereby the spending decisions of the government.

This thesis is organized as follows: The remainder of this chapter discusses the basic findings of the thesis and its policy implications in a broader context. Chapter 2 investigates how redistribution in more complex federal systems affects regional public investment. Chapter 3 provides an empirical analysis of what determines the composition of public investment in Europe, with fiscal decentralization being of special interest. Finally, Chapter 4, provides a theoretical framework to better understand how privatization may affect public spending and in particular redistribution. Note that all four Chapters can be read independently.

1.2 Fiscal Federalism and Public Expenditure

There is a huge literature on the determinants and implications of fiscal federalism. One of its basic questions is how to distribute spending and tax autonomy between the regional and the central governments. Oates (1972) developed a comprehensive framework to analyze the potential advantages and drawbacks of a centralized system. On the one hand, decentralization assures that decisions are made as close as possible to where people actually live. This facilitates the adjustment of the provision of public goods to the heterogeneous preferences of voters. This is what the famous "Decentralization Theorem" dating back to Oates (1972) basically says. On the other hand, externalities of different kinds may affect public expenditure (see e.g. Keen and Marchand (1998)). E.g. regions may compete in tax rates to attract firms or in public goods to attract human capital. In this case, inefficiencies arise due to strategic behavior of regional governments. A strong central government is then needed to set the proper incentives in order to implement the optimal provision of public goods at the local level. In practical terms both issues - response to local preference as well as externalities - are relevant. Most countries therefore opt for kind of a "in-between" solution - that is a federal system where decisions are taken partly by local and partly by federal institutions. However, the degree of fiscal federalism may also affect the level and composition of public spending and in particular of public investment as we will see below.

In Chapter 2, we try to understand the incentive effects generated by (de-)centralization in more complex federal systems. Indeed, federal systems are often more sophisticated than commonly assumed: In many cases, at least three tiers of government are involved in federal decision making. For instance in Germany or the US, there exist central, state, and local governments, implying a rather complex structure of the federal system in place. The EU itself is also organized beyond at least three tiers of government, though the EU as the highest tier disposes of only limited autonomy. This chapter is to better understand how the distribution of power among higher tiers of governments affects the investment decisions taken at the regional level. Based on Dahlby (1996), we set up a model with three tiers of government, to analyze federal redistribution in the presence of fiscal externalities. Our analysis identifies an additional qualitative disincentive effect, particularly for intermediate governments: They behave strategically in order to attract additional redistribution funds from outside, while still employing corrective policies towards their own regions. Our results also suggest that differently from the US, the federal system of the EU may lead to inefficiently low regional investment. This holds, because by construction the EU does not dispose over sufficient autonomy to thwart regional and national under-investment tendencies.

Chapter 3 provides an empirical investigation of the impact of decentralization not only on the level, but also on the composition of public investment. Though, public investment is an important variable in economics, its nature, drivers, and impact are still not completely understood. Most notably, there is often confusion about what it is in the first place. Perhaps the most prominent example of this type of confusion is the customary synonymous use of "public investment" and "infrastructure investment" in much of economic literature. Our data show, however, that there is a great deal of infrastructure investment that is not public, and there is a great deal of public investment that is not infrastructure investment. While it is well-known that many roads and municipal swimming pools are publicly funded and provided, both economic theory and empirical analyses have hardly distinguished between them. Keen and Marchand (1997) are among the first to think about what affects the composition of public spending. Based on their theoretical findings, we concentrate on public investment, only. The analysis yields some interesting insights, most notably that fiscal decentralization boosts economically productive public investment, notably infrastructure, while economically less productive public investment, such as recreational facilities, remains unchanged. While not readily reconcilable with the traditional theory of fiscal federalism, these findings can be interpreted in terms of the literature on fiscal competition, with not only tax rates but also the quality of public expenditure (in particular infrastructure) weighing in firms' location decisions.

1.3 Privatization and Public Expenditure

Since privatization - by definition - affects the structure of the public sector it will most likely also have an impact on its spending decisions. First of all, privatization shifts the objective of firms from welfare maximization towards more profit orientation. Persons employed in a public firm may then be exposed to a lower risk of becoming unemployed than private employees. Until now, however, little is known about how privatization affects other sectors of government activity (Sheshinski et al. (2003)), in particular as regards the level and composition of public expenditure. For instance, a change in the demand for public goods may lead to an increase of public funds (higher taxation) or an adjustment of the composition of public spending, (e.g. public investment vs. social spending). Thus, in order to properly assess the benefits of privatization, it is essential to understand its implications for public expenditure.

Chapter 4 provides a framework to investigate how privatization might affect public social spending. Based on Kanbur (1981), the model includes two sectors, a private and a public, with the risk of becoming unemployed being higher in the private sector. An exogenously given increase of privatization then leads to a higher expected rate of unemployment as well as higher productivity of workers. Since it is the privatization policy of the government that generates additional risks, it is likely that voters will require it to bear the cost involved. The public sector will increase its social spending in order to satisfy the changing demand for public goods. We investigate how privatization affects the per capita unemployment transfers as well as overall redistribution if transfers are financed only through the profits of the public firms or through public profits and a lump-sum tax. Our results suggest that overall redistribution increase with privatization under rather mild assumptions, while per capita transfers decrease if redistribution is financed only through profits of public firms. On the other hand, if the government disposes over lump-sum taxes as additional tool to finance redistribution, both overall and per capita redistribution increase with privatization. Moreover, if it is costly to raise tax funds, it is no longer clear whether privatization leads to overall efficiency gains: Higher redistribution is accompanied by a higher need to raise costly tax funds, which outbalances at least some of the benefits from privatization.

1.4 Policy Implications

Public spending is an important driver of the overall economic performance. As our results suggest, there is a link between institutional characteristics - with our main focus being on decentralization and privatization - and the level and composition of public expenditure. This allows for interesting policy conclusions:

First, supra-national or federal cooperation may not only lead to efficiency gains, but also generate additional disincentive effects at different levels of government. As Chapter 2 suggests, political decision processes in more complex federal systems cause additional strategic behavior of political representatives. This is particularly true for intermediate levels of government, which then try to exploit the central (or supranational) government in order to benefit their own jurisdictions. One should therefore bear in mind that supranational cooperation leads to a higher complexity and additional distortions within the system, which stand against its benefits (e.g. efficiency gains from free trade).

Second, in more complex federal structures, it is important to transfer sufficient autonomy towards the highest tier of government. Our findings have wide-ranging implications, especially for the European Union: If too little power is delegated to the highest tier of government, there is no way to evade the additional disincentive effects arising through the more complex federal structure. Thus, the additional externality in our setting requires more centralization. As the example of the EU shows, especially in transition or reform periods, this may be difficult to achieve. One possible solution to the problem is to delegate tax autonomy towards the EU to finance the required investment grants for the regions.

Third, institutional reforms - in particular decentralization - affect not only the level, but also the composition of public investment. This has wide-ranging implications for the economic performance and the provision of public goods at the local level. We find that decentralization leads to externalities, which distort the composition of public investment towards more infrastructure. Thus, against the common intuition, central governments should pay attention that their regions do not over-invest in order to attract private firms. This is an interesting result, in particular since most governments run comprehensive grant programs to boost regional investment.

Fourth, privatization is another important factor to understand the composition of public spending and the role of the state in general. While privatization implies less state intervention in one respect (less influence in firm's decisions) it entails higher government activity in other respects (more redistribution). This shift in government engagement generates additional indirect distortions: On the one hand, the additional need for public funds to finance redistribution may generate a social cost - e.g. through the excess burden of taxation. On the other hand, higher social spending may also be financed through a reduction in other types of public spending (e.g. public investment). In both cases, additional distortions arise, which at least partly outbalance the benefits of privatization. Thus, in order to correctly assess the benefits of a privatization reform, it is crucial to understand its potential indirect effects on the tax and expenditure policies of the government.

Note that one should be careful in deriving specific policy recommendations from these conclusions. Both theoretical and empirical findings are based on assumptions, which may not hold under real conditions. For instance, the three tiered federal structure in Chapter 1 assumes a benevolent government and complete information - assumptions which may not hold in real political decision processes. Furthermore, the empirical analysis in Chapter 3 by construction does not distinguish between the spending decisions made by different tiers of government. Thus, it is not straightforward to see, which implications these results have for a specific regional or federal government. Additional research would be highly valuable in this context.

Chapter 2

Fiscal Externalities in a Three-Tier Structure of Government

2.1 Introduction

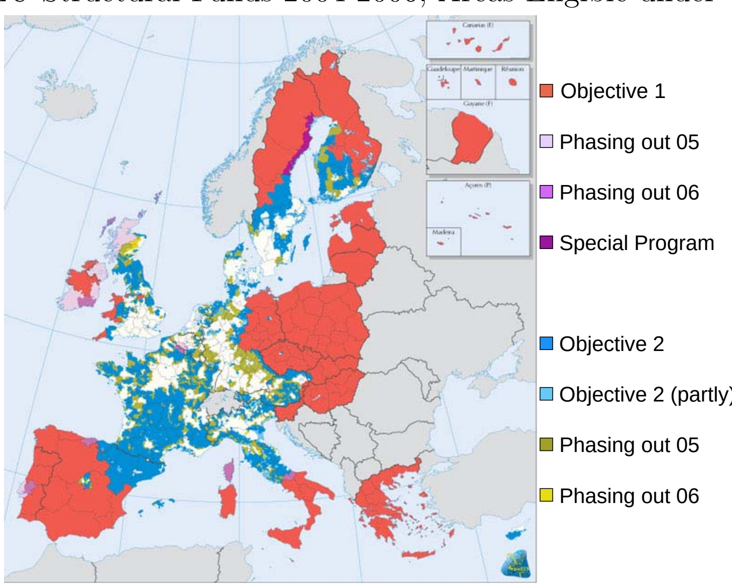
In contrast to the common assumption in the literature on fiscal federalism, more than two tiers of government are involved in most federal decision-making. E.g. regions in the US finance expenditure by about 20 percent through federal transfers and by 35 percent through state grants. On the other hand, local governments in the EU receive more than 70 percent of their grants from national governments, while the EU itself only plays a minor role in the provision of regional funds.[1] This implies that the role of the intermediate government is much stronger in Europe than in the US. We argue that such differences in the allocation of power between the two highest tiers of government crucially determine the behavior at each level of government. In this context, the role of the middle-level governments is of particular interest: They employ corrective policies vis-a-vis their regions, while still engaging in strategic interaction with the highest level of government.

In order to understand the complexity of such federal systems, we focus on federal re-

[1]Portugal is one important exception. Its regions receive about 19 percent of grants from international organizations. See Ford (1999) and Bergvall (2006) for further details.

distribution with fiscal externalities of public investment. Regional redistribution may generate a need for additional investment grants. This argument holds if federal redistribution exerts fiscal externalities leading to strategic behavior and under-investment by all regions (e.g. see Dahlby (1996)). However, with three tiers of government, not only the level of federal redistribution matters, but also the allocation of redistribution power between the two highest levels of government. This becomes particularly evident within the EU. There, middle-level and high-level authorities may have different objectives for federal redistribution and the use of corrective matching grants. Further, differently from the US, the highest level of government in the EU does not dispose over tax autonomy. For this reason it provides conditional transfers for investment only towards poor regions as shown in Figure (2.1). Thereby, the EU wants to achieve two aims at the same time: On the one hand, it redistributes from rich to poor regions. On the other hand, it still aims at implementing optimal regional investment. All this suggests that the analysis of fiscal externalities in more complex federal structures can be expected to become increasingly important in the future.

Figure 2.1: EU Structural Funds 2004-2006, Areas Eligible under Objective 1 and 2



Source: European Union (2006).

This paper investigates federal redistribution with three tiers of governments when regional investment generates fiscal externalities. Within this setting we try to understand the impact of fiscal externalities on investment targets and corrective policies at different tiers of government. Our findings suggest that a transfer of redistribution power towards the highest level of government generates an additional, qualitative incentive effect for middle level governments: They want their own regions to under-invest in order to attract additional redistribution funds from outside regions.

Within this setting, we also analyze the role of tax autonomy to finance corrective policies at the two highest levels of government. Three cases are distinguished: First, both high level and middle level governments finance corrective matching grants with region type specific taxation. This tax schedule allows concentrating on the pure disincentive effects arising from redistribution. Since the middle level government wants its regions to strategically under-invest in order to attract additional redistribution funds, only the highest level of government provides conditional transfers. Second, we assume a general lump sum tax to finance corrective matching grants. In this case, the tax regime generates an additional, indirect redistribution effect. Thus, middle level governments balance the positive effect from taxation with the negative effect of redistribution resulting in a higher investment target. In this case, both high level and middle level governments provide conditional transfers to implement first best investment at the regional level. Third, corresponding to the federal structure of the EU, we assume that only middle level governments dispose over tax autonomy to finance matching grants. In this case, the high level government can provide investment incentives to its regions only if it imposes investment restrictions on its equalization transfers. Thus, if redistribution funds available at the EU-level are low, this may lead to inefficiently low investment by both rich and poor regions.

The paper proceeds as follows. Section 2.2 gives a short literature overview. Section 2.3 presents the basic model with two tiers of government. Section 2.4 extends this setting to a three-tiered federal system with mutual redistribution by the two highest levels of governments. After characterizing the impact of mutual redistribution on the investment targets at all three tiers of government, Section 2.4.1 determines matching grant policies adopted by the two higher levels of governments with type specific taxation. This setting is generalized in Section 2.4.2 where we allow for general lump sum taxes to finance matching transfers. Section 2.4.3 investigates the case where only the middle-level government can levy taxes. Section 2.5 concludes.

2.2 Literature Review

The analysis of intergovernmental grants and federal redistribution is well established in economic theory. A good overview is provided by Johnson (1988) proposing a general theory of redistribution. He also refers to problems arising from spillovers and factor mobility. However, he does not explicitly address strategic disincentives generated within the redistribution system itself. More recently, Persson and Tabellini (1996) present a general framework of redistribution and taxation. Oates (1972) provided an analytical framework justifying conditional grants. He proved optimality of matching grants to account for spillover effects of public goods beyond regional borders.

More than one decade later, Inman (1988) doubted whether the widespread use of conditional grants can only be justified by traditional efficiency and spillover arguments. His findings motivated further research to explain conditional grants as a common policy instrument, for instance, by introducing information asymmetries, fiscal externalities, and conditional grants in redistribution systems. E.g. Huber and Runkel (2006) assume information asymmetries among national and regional governments to show that conditional block grants or capped matching grants may be required to implement a second best solution. As Dahlby (1996) shows, federal redistribution generates fiscal externalities leading to under-investment by all regions. Regional governments account for the positive income effect of their investment resulting in less federal transfers in the future. This argument is empirically supported by the study of Matheson (2005). He finds that federal redistribution does discourage regional investment in Russia. Also, Fenge and Wrede (2004) pointed out that redistribution within the EU generates externalities. However, they do not refer to the impact of more sophisticated three-tiered federal systems on the implemented level of regional investment and optimal matching grants by both national and EU bodies. Martinez-Lopez (2005) argues that fiscal externalities may results in either under- or over-investment in a setting with two tiers of government by considering additional tax externalities. Since the empirical impact of this finding needs still to be explored, we abstract from his analysis and concentrate on the disincentive effects generated by fiscal externalities.

Although three-tiered federal structures are rather common, only few papers are concerned with this issue. E.g. see Cremer and Pestieau (1996) for a literature review on the distributive implications of European integration. However, in most cases this literature cuts the perspective of regional behavior and thereby falls back on an analysis with two tiers of government, only. One exception is Cremer and Pestieau (1997) considering income redistribution in a setting with three tiers of government. They identify a trade off between inter- and intra-national redistribution under incomplete information. Differently from their approach, we concentrate on fiscal externalities of redistribution and corrective policies in a setting with three tiers of government and complete information. This allows identifying the structural disincentive effects arising in more complex federal systems.

In a broader sense this paper is also related to the bailout problem prominently examined by Wildasin (1997). He also highlights strategic behavior of regions as means to acquire additional federal aid. However, compared to our analysis, Wildasin investigates a rather extreme case concerning strategic jurisdictional bankruptcy. In the present setting, conditional grant payments may be interpreted as instruments to prevent future bailout.

2.3 Benchmark Case: Two Tiers of Government

As a benchmark, we investigate the disincentives for regional investment generated within a redistribution system with two tiers of government. For this purpose consider a federation consisting of one central government and a large number (N) of regions of type 1 and of type 2, respectively. Production in region i is logarithmic and depends on the type specific productivity parameter ρ_i as well as public investment I_i:

$$Y_i = \rho_i \cdot lnI_i \tag{2.1}$$

The analysis is undertaken from the perspective of a particular region of type 1, but results directly apply to any other region. You may interpret I_1 as a public input such as infrastructure or schooling outlays.[2] The representative individual in region 1 exclusively enjoys utility from private consumption C_1. In order to isolate the pure strategic argument in this framework, local public investment is assumed to generate no direct utility or spillover effects. Individuals only benefit from regional public investment through increases in per capita income. The private budget constraint reads

$$C_1 = Y_1 + b \cdot \left(\frac{\sum_k^2 Y_k}{2} - Y_1 \right) - I_1.$$

The redistribution parameter $b \epsilon [0, 1]$ may be referred to as the rate of income equalization among regions. For $b = 0$ no federal redistribution occurs, for $b = 1$ regional income gaps are completely offset.

Regional governments maximize the utility of the representative consumer. Together with the private budget constraint, the regional objective function writes

$$U(C_1) = U\left(Y_1 + b \cdot \left(\frac{\sum_k^2 Y_k}{2} - Y_1 \right) - I_1 \right)$$

The central government maximizes utilitarian welfare over both types of regions.[3]

$$W = \sum_i^2 U\left(Y_i + b \cdot \left(\frac{\sum_k^2 Y_k}{2} - Y_i \right) - I_i \right) \tag{2.2}$$

[2]Note that usually transfers are determined on the basis of GDP in precedent years and investment generates benefits only in the future. However, introducing dynamics into the model complicates the analysis without providing further insights.

[3]Note that in this specification the central government wants to choose b such that marginal utilities are equalized over regions. Since we are only interested in how different tiers of government react to a redistribution system, we henceforth assume parameter b to be exogenously fixed. Indeed, in most countries the degree of federal redistribution seems to be rather inflexible at least in the mid-term, as federal structures are mostly established by complex political processes.

Maximizing the objective functions of the central and regional government wrt. I_1 shows that income equalization at rate b leads to under-investment of both rich and poor regions. Their investment target $\left(I_i = \rho_i \cdot (1 - \frac{b}{2})\right)$ is below the target of the central planer $(I_i = \rho_i)$. In line with Dahlby (1996), fiscal externalities of investment arise due to federal redistribution. Taking the level of redistribution, b, as granted, each region is aware of the positive income effect of its investment as well as its negative impact on redistribution transfers received from other regions: For a rich region, additional investment leads to higher transfers payable to poor regions. For a poor region, higher investment results in fewer transfers received from rich regions. Both types of regions do not account for the positive effects of their own investment on transfer commitments of other regions. The central planer, however, accounts for all fiscal externalities. Thus, its investment target exceeds the actual investment of both rich and poor regions. Clearly, the regional incentives to under-invest can not be resolved without additional intervention by the center.

Since redistribution generates incentives for regions to under-invest, the center has to achieve two objectives at the same time. First, it has to assure an exogenously given degree of redistribution among regions. Second, it wants to implement first best investment by introducing corrective policies. In line with the standard literature in public finance, corrective matching grants are an efficient instrument to provide incentives for regional expenditure (e.g. see Oates (1972)). This reasoning imposes the following sequence on the model:

1. The redistribution parameter, b, is exogenously determined.
2. The central government determines the matching rate γ_1.
3. Regional governments invest $I_1(\gamma_1, b)$.

If regional government 1 receives a conditional matching transfer from the central government, its budget-constraint is given by

$$C_1 = Y_1(I_1) + b \cdot \left(\frac{\sum_k^2 Y_k(\cdot)}{2} - Y_1(\cdot) \right) - (1 - \gamma_1) \cdot I_1 - T_1.$$

γ_i is the matching rate of the center towards region i. Matching transfers are financed by overall lump sum tax T_i, defined as

$$T_i = \frac{\sum_k^2 \gamma_k \cdot I_k}{2}.$$

This leads to

Proposition 2.1: *Assume regional income equalization at rate b. Then,*

i) matching rate $\gamma_1 = 1 - \frac{1-\frac{b}{2}}{(1-\frac{b}{2}+\frac{U_2'}{U_1'}\cdot\frac{b}{2})}$ implements first best investment by region 1.

ii) matching rates for rich regions are higher than for poor regions.

Proof see Appendix 2.6. ■.

We know that without further intervention by the central planer, regional governments under-invest for a given level of redistribution, b. In order to correct for strategic behavior, the central government provides additional matching grants for regional investment. If the center finances a share γ_1 of investment, regions effectively face a lower cost of investment and are therefore willing to invest more. This mechanism assures overall efficiency: The center can meet the exogenously determined redistribution target and at the same time assure first best investment by regional governments.

Note that the matching rate depends on relative marginal utilities. Regions of type 1 are poor relative to regions of type 2 for $U_1' > U_2'$. If the difference in income rises, the center is willing to increase its investment target for the rich regions in order to partly close this gap: More production in the rich regions leads to higher transfers to the poor regions and thereby to a reduction in their marginal productivity. Thus, the center increases its matching rate for the rich type in order to boost overall production in the economy and redistribution towards the poor type. Note that for identical marginal utilities, the result simplifies to $\gamma_1 = \frac{b}{2}$, which corresponds to the externality generated by federal income equalization at share b with two types of regions involved.

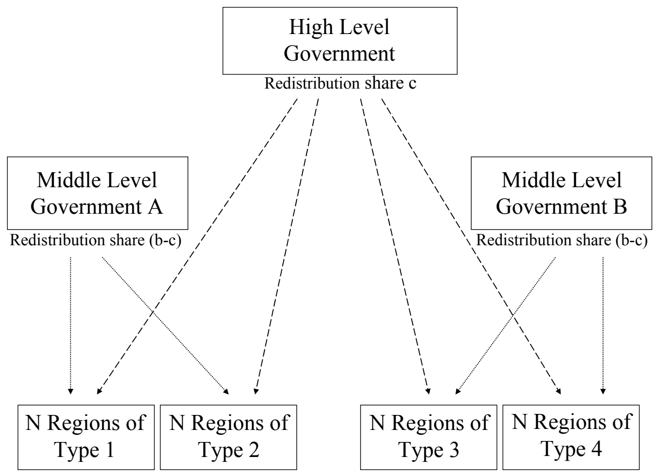
2.4 Analysis with Three Tiers of Government

Disincentive structures and optimal corrective policies are much more complex in a federal system with three tiers of government. E.g. consider the US or the EU: Two tiers of government (federal and state vs. supranational and national governments) with distinct objectives mutually redistribute and engage in corrective policies towards their regions. However, there are crucial differences between the US- and EU-system. In the US, federal and state governments dispose over tax autonomy to finance matching transfers. In the EU, only national governments can levy taxes to finance conditional grants. As we will see this may have far-reaching implications for the implemented level of regional investment.

For the moment, the central government may either represent a federal or a supranational government. We label this the high-level or H-government. The state or national governments in-between are called middle-level or M-governments. In particular, assume two middle-level governments, A and B, both consisting of N regions of type 1 and 2 or of type 3 and 4, respectively, where N is assumed to be large. The high-level maximizes over four representative regions, while each middle level government maximizes over two types of regions. This structure is shown in Figure (2.2).

From the perspective of a regional government, redistribution transfers are determined by two institutions at different hierarchical levels. The region is only concerned with the utility of its representative voter. Parameter c represents the share of redistribution exogenously assigned to the high-level government. Redistribution transfers for each region are now provided by one middle-level as well as high-level government: A share $(b - c)$ of redistribution is accomplished by the middle-level government, while a share c of redistribution is transferred from the middle-level government to the high-level government: For example, if 10 percent of the regional income gap is to be covered by

Figure 2.2: Redistribution with Three Tiers of Government



high-level redistribution, the middle-level government reduces its share of redistribution by the same percentage. This assures that parameter c captures a qualitative shift in redistribution power while leaving its absolute level unchanged. Note that for $c = 0$, we fall back to the benchmark case discussed in Section 2.3.

In the following, preferences are supposed to be linear in consumption. This allows disregarding discrepancies between marginal utilities.[4] Adopting again the perspective of a particular region of type 1, the regional objective function writes

$$U(C_1) = Y_1 + (b-c) \cdot \left(\frac{\sum_{k=1}^{2} Y_k}{2} - Y_1 \right) + c \cdot \left(\frac{\sum_{k=1}^{4} Y_k}{4} - Y_1 \right) - I_1 \qquad (2.3)$$

with $b, c \,\epsilon\, [0,1]$ assumed to be exogenously given and $b \geq c$. We define $Y_i(\cdot) = Y_i(I_i) = Y_i$. Transfers from the middle-level are identical to the redistribution grants of the central planer in Section 3, since it also considers two types of regions, only. The high-level government compares regional GDP with average GDP over all four types of regions and equalizes income disparities by a share c.

The middle-level government A considers utilitarian welfare of representative regions

[4]With a nonlinear utility function, results remain qualitatively unchanged. However, differences in marginal utilities among regions are then accounted for in form of weights, complicating calculations notably.

of type 1 and 2:

$$W_A^M = \sum_{i=1}^{2} \left(Y_i + (b-c) \cdot \left(\frac{\sum_{k=1}^{2} Y_k}{2} - Y_i \right) + c \cdot \left(\frac{\sum_{k=1}^{4} Y_k}{4} - Y_i \right) - I_i \right). \quad (2.4)$$

Finally, the high-level government maximizes utility over all 4 types of regions:

$$W^H = \sum_{i=1}^{4} \left(Y_i + (b-c) \cdot \left(\frac{\sum_{k=1}^{2} Y_k}{2} - Y_i \right) + c \cdot \left(\frac{\sum_{k=1}^{4} Y_k}{4} - Y_1 \right) - I_i \right). \quad (2.5)$$

Before going into the analysis of corrective policies by the two upper tiers of government, let us identify the effect of a shift in redistribution power towards the highest level (as measured by parameter c) on investment incentives of regional, middle-level, and high-level governments. Note that regions can realize their own preferred level of investment, as long as M- and H-governments do not dispose over matching transfers as additional policy instrument. The investment target of the middle-level government for region i is labeled I_i^M, the target for the high-level is labeled I_i^H. These targets are determined by maximizing Equation (2.4) and Equation (2.5) with respect to I_i, respectively. This leads to

Proposition 2.2: *Assume that redistribution is implemented jointly by a M- and a H-government. Then,*

i) the investment incentive of a regional government of type 1 decreases in b.

ii) the regional investment target of the M-government decreases in c.

iii) the regional investment target of the H-government is independent of b and c.

iv) the regional investment target of the H-government exceeds the target of the M-government. Thus, $I_1^H > I_1^M > I_1^*$.

Proof see Appendix 2.6. ■.

Quantitative disincentive effects from redistribution are captured by b. Thus, along the argument in Section 2.3, fiscal externalities at the regional level increase in the redistribution parameter b. For a higher value of b, regions can gain more by exploiting the federal redistribution system. On the other hand, the regional desire to invest is not affected by a shift in redistribution power among high level and middle level government as measured by parameter c. This result holds, since the number of regions of each type is already large: A transfer of more redistribution autonomy to a higher level - considering more regions - does not change the strategic considerations of a regional government competing already with a large number of regions.[5]

A middle-level government only considers regions within its own borders. Due to constant marginal utilities and the symmetry in our model, there is no quantitative effect of redistribution (measured by b) at the middle-level. Redistribution among its regions per se, does not generate disincentives, since the M-government does take into account the fiscal externalities arising among its own regions. On the other hand, it knows well that for any $c > 0$, a lower output in region 1 leads to more redistribution at the central level and thereby potential resource inflows from outside regions. Thus, the middle-level government accounts for the qualitative change in redistribution power by behaving more strategically if parameter c increases. However, its investment target will always exceed the regional target, since it already accounts for strategic behavior among its own regions.

The high-level government maximizes utility over all regions in the federation. It properly accounts for all existing fiscal externalities within the system. Therefore, its investment objective is independent of b. For the same reason a qualitative change of redistribution as measured by a change in parameter c, does not occur at the high level. Its investment target is above the target of both middle level and regional governments and identical to the result for the central planer in Section 2.3.

Without corrective policies, regional under-investment occurs, since H- and M governments do not dispose over any means to affect regional behavior. Therefore, we introduce matching grants from the high and the middle-level government towards their regions. Three settings are of particular interest: Section 2.4.1 and 2.4.2 assume

[5] Note that for small values of N this result does not hold. High level redistribution then implies redistribution over a larger number of (countable) regions resulting in an increase of strategic behavior and thereby additional investment disincentives for each region.

that conditional transfers are financed by region type specific or lump sum taxes, respectively. The latter resembles the federal structure in the US. Section 2.4.3 refers to a structure similar to the EU, where the highest level of government can not impose taxes, but provides redistribution funds conditional on investment.

2.4.1 Non-Redistributive Funding of Matching Grants

In the following, we introduce conditional transfers, which are financed through region-type specific taxes by both the high level and middle level. The high-level government may here be interpreted as a federal government, whereas intermediate governments correspond to state authorities. Consider b and c again to be exogenously determined and a federal structure as described in Figure (2.2). Middle- as well as high-level governments dispose over independent tax autonomy. The structure of the model evolves as follows:

1. Redistribution parameters b and c are exogenously determined.
2. Simultaneous Move Game between M- and H-government in γ_i^M and γ_i^H.
3. Regional governments invest $I_i(\gamma_i^M, \gamma_i^H, b, c)$.

γ_i^M and γ_i^H are region specific matching rates provided by the middle-level and high-level government towards region i, respectively. Intuitively, we impose non-negativity constraints $\gamma_i^H \geq 0$ and $\gamma_i^M \geq 0$. Referring again to a particular region of type 1, Equation (2.3) rewrites

$$U_1 = Y_1 + (b-c)\left(\frac{\sum_{k=1}^{2} Y_k}{2} - Y_1\right) + c\left(\frac{\sum_{k=1}^{4} Y_k}{4} - Y_1\right) - (1-\gamma_1^M - \gamma_1^H)I_1 - T_1$$

with $T_1 = T_1^M + T_1^H$ defined by $N \cdot T_1^M = \sum_k^N \gamma_k^M \cdot I_k$ and $N \cdot T_1^H = \sum_k^N \gamma_k^H \cdot I_k$. In this setting, matching grants are financed by type specific lump sum taxes. This kind of funding does not generate additional investment distortions and isolates the impact of direct redistribution on investment targets and corrective policies.[6] Note also that γ_i^M and γ_i^H are strategic substitutes. The maximization problem of H- and M-governments are set up accordingly by referring to Equation (2.4) and Equation (2.5). Since the number of regions of each type is large, regions do not consider the tax effect in their optimization problem. Solving this game backwards leads to

Proposition 2.3: *Assume that redistribution is implemented jointly by a M- and a H-government and matching transfers are financed by type specific taxation. Then, in the unique Nash Equilibrium,* $\gamma_1^H > 0$ *and* $\gamma_1^M = 0$*. The first best regional investment target of H,* I_1^H*, is implemented.*

Proof see Appendix 2.6. ■.

Conditional grants are provided only by the high-level government, whose regional investment objective exceeds the target of the middle-level. The H-government completely takes into account fiscal externalities and therefore aims at implementing first best investment. On the other hand, the M-government intends to attract additional redistribution funds from outside regions for $c > 0$ (see Proposition 2). Therefore, it wants its regions to invest below first best. It provides a matching rate below the preferred level of the H-government. In response, the high-level increases its matching rate in order to prevent investment below its own target. This leads to over-investment from the perspective of the middle-level government, which in response reduces its matching rate even further. Repeating this line of argument results in a corner solution: The middle-level government does not provide any investment grants, since γ_1^M is bounded from below by $\gamma_1^M \epsilon [0, 1]$. The high-level government can implement its first best target by choosing its matching rate $\gamma_1^H > 0$ high enough.

[6]Section 2.4.2 addresses additional incentives arising from a more plausible funding of matching grants through general lump sum taxes.

2.4.2 Redistributive Funding of Matching Grants

In the following we analyze regional investment targets and corrective policies if the funding of matching grants generates additional incentive effects. Again, assume that c is exogenously determined and preferences are linear in consumption. As before, regions do not consider the tax effect in their optimization problem, since the number of each type of regions is large. Middle as well as high-level governments dispose over tax autonomy to finance conditional investment transfers. However, matching grants are now funded by general lump sum taxes according to $T_i = T^M + T^H$ with $4 \cdot N \cdot T^M = \sum_k^{4N} \gamma_k^M \cdot I_k$ and $2 \cdot N \cdot T^H = \sum_k^{2N} \gamma_k^H \cdot I_k$. In this sense, the general tax system varies over levels of government. Compared to the high-level government, a middle-level government includes fewer regions in the lump sum tax mechanism to finance matching grants. As we will see, funding matching grants thereby generates an additional, indirect redistribution effect. Solving the simultaneous move game backwards leads to

Proposition 2.4: *Assume that federal redistribution is implemented jointly by a M- and a H-government and matching grants are financed by general lump sum taxes. Then, in the unique Nash Equilibrium,* $\gamma_1^H = c$ *and* $\gamma_1^M = b - c$*. Investment targets of H- and M-governments are equal,* $I_1^H = I_1^M$*, and correspond to first best regional investment.*

Proof see Appendix 2.6. ■.

General lump sum taxes generate positive investment incentives at the middle-level. The lump sum tax to finance matching grants varies over levels of government. Compared to the high-level, the tax schedule of the middle-level government includes fewer regions. This generates an additional, indirect redistribution effect: The M-government takes into account that conditional transfers from the high-level towards its regions are partly financed outside its own borders. In consequence, it is interested in attracting additional matching transfers provided by the high-level. Though, the potential of exploiting the redistribution system through under-investment remains unchanged. After all, this leads to an increase in the investment target of the middle-level government compared to the analysis in Section 2.4.1.

In the unique Nash Equilibrium, the H-government responds to the additional investment incentives at the middle-level by reducing its matching transfers. The high-level accounts for the positive impact of its matching rate on the investment target of the middle-level. It sets γ_1^H such that the target of the middle-level corresponds to the first best. This occurs if the tax effect neutralizes the negative effect of federal redistribution on the investment target of the M-government, which is achieved for $\gamma_1^H = c$. A matching grant γ_1^H above this level is not optimal, since it leads to incentives to over-invest for the M-government: Its willingness to exploit the tax system at the high level would be stronger than the disincentives from redistribution. A matching rate below this level is not optimal, since this implies a too low investment target at the middle-level and we would fall back to a situation as described in Section 2.4.1. Lump-sum taxes to fund matching transfers introduce additional, indirect redistribution among regions. In order to minimize this indirect effect, the high-level government wants γ_1^M to be as high as possible. This results in the Nash Equilibrium described above: Matching rates correspond to shares of redistribution c and $(b-c)$, respectively, equalizing the incentives from the tax system and the redistribution system. Interestingly, the willingness of the M-government to attract more conditional transfers from the H-government effectively leads to a reduction of γ_1^H compared to the corner solution in Section 2.4.1 and to an equilibrium in which the M-government itself has to provide conditional transfers.[7]

This result can be related to some interesting patterns in the federal system of the US. There, federal as well as state governments provide redistribution transfers. Further, they all dispose over independent tax autonomy. Our results imply that in this case state governments want their own regions to strategically under-invest to attract additional funds from outside regions. Indeed, to correct for strategic behavior of regional and state governments, the US-federal government runs 600 grant programs, 550 of them being categorical. In addition, the federal government provides notable

[7]Note that this result does not change qualitatively if the assumption of linear utility is relaxed. The tax and redistribution effects remain active also in this case.

conditional transfers also to the states; about 85 % of the transfers towards state governments are earmarked and destined to be distributed among regions. This suggests that the federal government is indeed aware of the strategic behavior of both state and regional governments. Due to its dominant role it can provide sufficient investment incentives to evade strategic behavior of both levels and assure optimal regional investment (see Ford (1999) for further details).

2.4.3 High-Level Government without Tax Autonomy

Let us now turn to a federal system such as the EU, where the highest level of government is restricted in its fiscal autonomy. Consider again a federal structure as in Figure (2.2). However, we now think in terms of two independent nations constituting a supranational organization. Again, a fixed share c of redistribution authority is shifted towards the highest level (e.g. the EU). As before, assume that the number of regions is large and region 1 is poor compared to region 2. Differently from the analysis in Section 2.4.1 and 2.4.2, only middle-level governments can impose taxes. For the regional budget constraint this implies $T_i = T_i^M$. Since the highest level of government does not dispose over tax autonomy, it looses its preferred instrument to finance matching grants.

The only way for the high-level government to influence regional decisions is then to provide its redistribution transfers conditional on regional investment. Technically speaking, the high-level government then faces the additional constraint

$$0 \leq \tau_i + \gamma^H \cdot I_i \leq c \cdot \left(\frac{\sum_{k=1}^{4} Y_k(\cdot)}{4} - Y_i(\cdot) \right), \qquad (2.6)$$

where τ_1 represents a lump sum transfer with $\tau_1 \geq 0$. As before, $\gamma_1^H \; \epsilon \; [0, 1]$. Equation (2.6) can be interpreted as a constraint to finance matching grants through redistribution funds directed towards this particular region. The total amount of matching grants payable to a region can not exceed its eligibility for redistribution funds. If redistribution funds at the high level are available beyond its need to finance matching grants, it can in addition pay a lump sum transfers $\tau_1 > 0$. On the other hand, this implies that the high level government has no means to provide any funds to rich regions (Equation (2.6) is then bounded from below and $\tau_2 = \gamma^H \cdot I_2 = 0$). For that reason, the maximization problem of a rich and a poor region are structurally different. Rich regions face the following maximization objective:

$$C_2 = Y_2 + (b-c) \cdot \left(\frac{\sum_k^2 Y_k}{2} - Y_2 \right) + c \cdot \left(\frac{\sum_k^4 Y_k}{4} - Y_2 \right) - (1 - \gamma_2^M) I_2 - T_2^M.$$

They do not receive matching transfers from the H-government but contribute to finance its redistribution funds towards the poor regions. Using Equation (2.6), the objective function of a poor region writes

$$C_1 = Y_1 + (b-c) \cdot \left(\frac{\sum_k^2 Y_k}{2} - Y_1 \right) - (1 - \gamma_1^M - \gamma_1^H) I_1 - T_1^M + \tau_1.$$

Poor regions receive matching grants from H- and M-governments. The high level finances its matching grants through redistribution funds, while the middle level government can impose type specific taxes to finance its investment grants. As before, the high level government maximizes over four types of regions, while the middle level government considers two types of regions. Solving this game backwards leads to

Proposition 2.5: *Assume that the H-government can finance its matching transfers through its redistribution funds, only. Then,*

i) for a rich region, $\gamma_2^M > 0$ *and* $\gamma_2^H = 0$ *implement* $I_2 = I_2^M$.

ii) for a poor region three cases can be distinguished:

If $c > \overline{c}$, *then* $\gamma_1^H > 0$ *and* $\gamma_1^M = 0$ *implement* $I_1 = I_1^H$.

If $\underline{c} < c < \overline{c}$, *then* $\gamma_1^H > 0$ *and* $\gamma_1^M = 0$ *implement* $I_1^M < I_1 < I_1^H$.

If $c < \underline{c}$, *then* $\gamma_1^H > 0$ *and* $\gamma_1^M > 0$ *implement* $I_1 = I_1^M$.

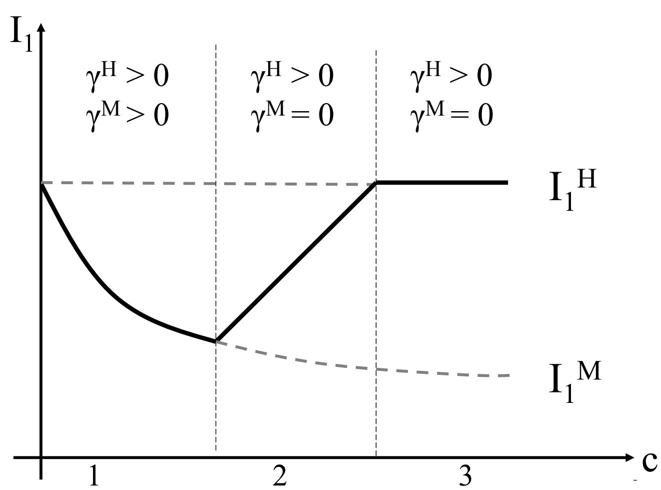
This holds for $\overline{c} = \frac{\frac{b}{2}\rho_1}{\frac{\sum_k^4 Y_k}{4} - Y_1}$ *and* $\underline{c} = \frac{\frac{b}{2} \cdot \rho_1}{\frac{\sum_k^4 Y_k}{4} - Y_1 + \frac{\rho_1}{2}}$.

Proof see Appendix 2.6. ■.

For rich regions, the intuition is straightforward. The high-level government does not dispose over tax autonomy. Since rich regions contribute to the redistribution system, the high level does not have means to provide any funds towards rich regions. On the other hand, the middle-level government finances matching transfers by type specific taxation as before. It is therefore able to finance matching grants also for the rich. Because middle-level governments want all their regions to strategically under-invest (desire to attract redistribution funds from outside regions), they provide too little matching grants. Accordingly investment in rich regions is below the first best.

Figure (2.3) shows that three cases can be distinguished for poor regions.

Figure 2.3: Implemented Level of Investment for a Poor Region Depending on c



In range 3, c is large. The constraint in Equation (2.6) is not binding. The H-government disposes over sufficient redistribution funds paid by rich regions in order to implement first best investment, I_1^H, in poor regions. This is achieved by providing redistribution funds towards the poor conditional on investment (see Equation (2.6)). Redistribution funds which are not needed to provide investment incentives can then be paid in lump sum form, that is $\tau_1 > 0$. This scenario is similar to the corner solution in Section 2.4.1 with $\gamma_1^H > 0$ and $\gamma_1^M = 0$. The high level government can implement its desired level of investment in poor regions by providing a sufficient amount of its redistribution transfers conditional on investment.

In range 2, the value of c is too low in order to assure that the H-government can implement its desired target for regional investment. The constraint in Equation (2.6) is binding. However, c is large enough to allow the H-government to implement a level of regional investment, which is above the target of the middle-level if it provides all its redistribution funds to poor regions conditional on investment. Although first best investment can not be implemented, regions invest above the target of the M-government, that is $I_1^M < I_1 < I_1^H$. Thus, the latter does not provide any matching grants towards the poor.

Finally, in range 1, c is small. Redistribution funds disposable at the high-level are too low to provide sufficient incentives to poor regions to even implement the target of the M-government, I_1^M - even if the H-government provides all its equalization transfers conditional on regional investment. Since the H-government wants to get as close as possible to its own investment target, it provides all its available funds conditional on investment. Therefore, $\gamma_1^H > 0$ and $\tau_1 = 0$. The middle-level then provides additional matching grants until its own target I_1^M is implemented, thus $\gamma_1^M > 0$.

The results in this section can be directly related to the federal system of the EU. We know from Proposition 2.3 that middle level governments also behave strategically in a federation with three tiers of government. In order to implement optimal regional investment, the highest level of government has to provide conditional transfers. However, since the tax autonomy of the EU is restricted, it has no means to influence decisions in rich regions through matching grants (see Figure (2.1)). Since national governments do not provide sufficient matching transfers, rich regions in Europe are likely to under-invest. Also for poor regions, the EU does not seem to dispose over enough redistribution funds to provide sufficient investment incentives: For low values of c, corresponding to a limited redistribution autonomy, the EU provides all its redistribution funds conditional on regional investment. Indeed, this is confirmed by Figure (2.1). Therefore, in terms of our model, the EU-system does most likely correspond to range 1 or 2 in Figure (2.3): Funds from the EU are exclusively conditional on investment suggesting that the EU is bounded in its desire to boost regional investment. This suggests that funds available at the EU level are not high enough (low value of c) and that national governments then restrict their conditional transfers to let their poor regions under-invest. Thus, our analysis suggests that both rich and poor regions in Europe invest below first best.

2.5 Conclusion

Federal systems are often organized beyond more than two tiers of government. This paper has proposed a framework to analyze strategic behavior in a three-tiered federal system. In particular, we investigate federal redistribution accomplished by two different tiers of governments when regional investment generates fiscal externalities. Our model reveals that for a given level of income equalization, a shift in redistribution power towards the highest level of government reduces the investment targets of the middle-level government. This may be interpreted as an additional, qualitative effect of redistribution arising in a federal system with three tiers of government.

Further, we characterize regional investment when the two higher levels of government engage in corrective policies. In this context we find that the design of the tax systems to fund corrective matching grants is one key feature in understanding government behavior, particularly at the intermediate level. Three cases are distinguished. First, we imagine mutual federal redistribution when corrective matching transfers are financed by type specific taxation. This tax schedule does not generate additional incentives and allows concentrating on the pure disincentive effects from redistribution. The middle level government wants its own regions to strategically under-invest in order to attract redistribution funds from outside regions. However, since the highest level government accounts for all existing disincentives in the system, in aims at implementing first best investment. Therefore, in the unique Nash Equilibrium, only the highest level of government provides conditional transfers.

Second, we generalize this setting by allowing for general lump sum taxes to finance corrective matching grants. This tax rule, however, introduces an additional, indirect redistribution effect at the middle level. Since matching grants from the highest level are equally financed by all regions, the middle level government wants its own regions to invest more in order to attract additional conditional transfers from the upper level. Thus, middle level governments now balance a positive indirect income effect of the tax system with the negative effect of redistribution. As a result, both high level and middle level governments provide conditional transfers to implement first best investment in poor regions.

Third, corresponding to the federal structure of the EU, we assume that only middle level governments dispose over tax autonomy to finance matching grants. In this case, the high level government can provide investment incentives towards its poor regions, only if it imposes investment restrictions on its redistribution funds. Therefore, investment of poor regions crucially depends on the redistribution autonomy delegated towards the highest level of government. Only if the upper level disposes over sufficient redistribution funds, it can provide enough transfers conditional on investment to the poor regions to assure first best investment. On the other hand, the high level government has no means to provide any funds to rich regions (they contribute to federal redistribution) resulting in under-investment by the rich.

The implications of our model can be used to explain several features of federalism in Europe and the US. Results from Section 3.2 directly apply to the federal system in the US. They suggest that it is mainly the federal government that should provide investment incentives in order to implement optimal regional investment. This prediction is in line with the increasingly dominant role of the federal government in the US as well as its increased use of categorical grants in recent years. On the other hand, our findings in Section 2.4.3 can be related to the federal system in Europe: The EU does not dispose over tax autonomy. All it can do is to provide its redistribution funds conditional on investment in order to provide investment incentives at least for poor regions. While the desired level of redistribution can still be realized, this allows to implement high regional investment. This holds only if the EU disposes over sufficiently high redistribution funds. The fact that the EU provides all its funds conditional on investment is a strong signal for under-investment in both rich and poor regions in Europe. Thus, our model predicts that national governments are too dominant relative to EU institutions.

The proposed setting is but a first step in the analysis of more complex federal systems. There is plenty of scope for future research in this increasingly important field. In particular, the theoretical foundations for studying complex federal systems remain weak, especially as regards the behavior of the intermediate government in more complex situations. One example is to extend our framework to incorporate debt policy and to study the problem of bailouts, which may help to better understand strategic behavior of regional and state governments. Also it may be interesting to empirically examine the size of the qualitative effect of mutual redistribution as described in our framework. This could be particularly insightful for the EU where basically all member states dispose of at least two tiers of government.

2.6 Appendix

Proof of Proposition 2.1:

i) Maximizing the objective function of region 1 wrt. I_1 yields $I_1^* = \frac{\rho_1(1-\frac{b}{2})}{1-\gamma_1}$.

The maximization problem of the central government wrt. γ_1 leads to its target for the marginal productivity of region 1, $\frac{\partial Y_1(I_1^*)}{\partial I_1^*} = \frac{1}{1-\frac{b}{2}+\frac{U_2'}{U_1'}\cdot\frac{b}{2}}$. These two results determine the optimal matching rate,

$$\gamma_1 = 1 - \frac{1-\frac{b}{2}}{(1-\frac{b}{2}+\frac{U_2'}{U_1'}\cdot\frac{b}{2})}.$$

This matching rate implements first best investment.

ii) If region 1 is poor compared to a region of type 2, then $U_1' > U_2'$. Substituting this in γ_1 yields the result. ■

Proof of Proposition 2.2:

i) Deriving the objective function of the regional government wrt. I_1 yields the FOC of the regional government:

$\frac{U(C_1)}{\partial I_1} = \left(\frac{\partial Y_1(I_1)}{\partial I_1}(1-(b-c)-c)-1\right) = 0.$

Transformation leads to

$$I_1^* = \rho_1 \cdot (1-b)\,.$$

Derivation wrt. b yields the result.

ii) Deriving Equation (2.4) wrt. I_1 yields the FOC of the M-government:

$\frac{\partial W^M}{\partial I_1} = \left(\frac{\partial Y_1(I_1)}{\partial I_1} \cdot (1+(b-c)(\frac{1}{2}-1)+c(\frac{1}{4}-1))-1\right)$
$+\left(\frac{\partial Y_1(I_1)}{\partial I_1} \cdot (b-c)(\frac{1}{2})+c(\frac{1}{4}) \cdot \frac{\partial Y_1(I_1)}{\partial I_1}\right) = 0.$

This simplifies to

$$I^M = \rho_1 \cdot \left(1-\frac{c}{2}\right).$$

Derivation wrt. c yields the result.

iii) Deriving Equation (2.5) wrt. I_1 yields the FOC of the H-government:

$\frac{\partial W^M}{\partial I_1} = \left(\frac{\partial Y_1(I_1)}{\partial I_1} \cdot (1+(b-c)(\frac{1}{2}-1)+c(\frac{1}{4}-1))-1\right)$
$+\left(\frac{\partial Y_1(I_1)}{\partial I_1} \cdot (b-c)(\frac{1}{2})+c(\frac{1}{4}) \cdot \frac{\partial Y_1(I_1)}{\partial I_1}\right)$
$+\left(c(\frac{1}{4}) \cdot \frac{\partial Y_1(I_1)}{\partial I_1}\right)+\left(c(\frac{1}{4}) \cdot \frac{\partial Y_1(I_1)}{\partial I_1}\right) = 0.$

This simplifies to

$$I_1^H = \rho_1.$$

Derivation wrt. b and c yields the result.

iv) Comparing the preferred marginal productivity levels of the M- and the regional government yields

$$\frac{1}{(1-b)} > \frac{1}{(1-\frac{c}{2})}$$

for $b, c \; \epsilon \; (0,1]$ and $b \geq c$. Comparing the preferred marginal productivity level of the H- and the M-government yields

$$1 > \frac{1}{(1-\frac{c}{2})}.$$

for $c \; \epsilon \; (0,1]$. It follows directly that $I_1^* < I_1^M < I_1^H$. ■

Proof of Proposition 2.3:

The proof consists of four steps:

1. The maximization problem of a region of type 1 yields FOC

$\frac{U(C_1)}{\partial I_1} = \left(\frac{\partial Y_1(I_1)}{\partial I_1} (1-b) - (1-\gamma_i^M - \gamma_i^H) \right) = 0.$

This simplifies to

$$I_1^* = \frac{\rho_1(1-b)}{1-\gamma_1^M-\gamma_1^H}.$$

2. The M-government chooses γ_1^M by maximizing its objective function wrt. γ_1^M. Its FOC writes

$$\frac{\partial W^M}{\partial \gamma_1^M} = \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^M} \cdot \left(1 + (b-c)(\tfrac{1}{2}-1) + c(\tfrac{1}{4}-1)\right) - \frac{\partial I_1^*}{\partial \gamma_1^M} \right)$$
$$+ \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^M} \cdot (b-c)(\tfrac{1}{2}) + c \cdot (\tfrac{1}{4}) \cdot \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^M} \right) = 0.$$

This yields the reaction function of the M-government

$$\gamma_i^M = 1 - \gamma_i^H - \frac{1-b}{(1-\frac{c}{2})}.$$

3. The H-government chooses γ_1^H by maximizing its objective function wrt. γ_1^H. Its FOC writes

$$\frac{\partial W^H}{\partial \gamma_1^H} = \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} \cdot \left(1 + (b-c)(\tfrac{1}{2}-1) + c(\tfrac{1}{4}-1)\right) - \frac{\partial I_1^*}{\partial \gamma_1^H} \right)$$
$$+ \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} \cdot (b-c) \cdot (\tfrac{1}{2}) + c(\tfrac{1}{4}) \cdot \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} \right)$$

$$+c \cdot (\frac{1}{4}) \cdot \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} + c \cdot (\frac{1}{4}) \cdot \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} = 0.$$

This yields the reaction function of the H-government,

$$\gamma_1^H = b - \gamma_1^M.$$

4. To determine the Simultaneous Move Nash Equilibrium, substitute γ_1^H in the reaction function of the M-government. This leads to

$$\gamma_1^M = 1 - b + \gamma_1^M - \frac{1-b}{(1-\frac{c}{2})}.$$

There is no interior solution for this problem.

Two potential corner solutions need to be verified given the parameter restrictions $\gamma_1^H, \gamma_1^M \epsilon [0,1]$:

a): $\gamma_1^H = 0$: In this case, $\gamma_1^M = 1 - \frac{1-b}{(1-\frac{c}{2})}$. This in $\gamma_1^H = b - \gamma_1^M$ yields

$$\gamma_1^H = (1-b) \cdot (\frac{\frac{c}{2}}{1-\frac{c}{2}}) > 0.$$

This is a contradiction.

b): $\gamma_1^M = 0$: In this case, the reaction function of the H-government yields $\gamma_1^H = b$. This in the reaction function of the M-government leads to $\gamma_1^M = (1-b)(\frac{-\frac{c}{2}}{1-\frac{c}{2}}) < 0$. The non zero constraint is binding. Therefore,

$$\gamma_1^M = 0.$$

The unique Simultaneous Move Nash Equilibrium of this game is a corner solution.

It remains to be shown that γ_1^H is the first best matching rate of the H-government and therefore implements I_1^H: With γ_1^M and γ_1^H from step 4, the optimality condition of the regional government 1, $I_1^* = \frac{\rho_1(1-b)}{1-\gamma_1^M-\gamma_1^H}$, leads to

$$I_1^* = \frac{\rho_1(1-b)}{1-b} = \rho_1.$$

This is identical to the first best marginal productivity level desired by the high-level government. Thus, γ_1^M and γ_1^H determined in step 4 implement I_1^H. ■

Proof of Proposition 2.4:

The proof consists of four steps:

1. The maximization problem of a region of type 1 yields FOC

$\frac{U(C_1)}{\partial I_1} = \left(\frac{\partial Y_1(I_1)}{\partial I_1} (1-b) - (1-\gamma_i^M - \gamma_i^H) \right) = 0.$

This simplifies to

$$I_1^* = \frac{\rho_1(1-b)}{1-\gamma_i^M - \gamma_i^H}.$$

2. The M-government chooses γ^M by maximizing its objective function wrt. γ^M. Its FOC writes

$\frac{\partial W^M}{\partial \gamma_1^M} = \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^M} \cdot \left(1 + (b-c)(\frac{1}{2N} - 1) + c(\frac{1}{4N} - 1)\right) + (1 - \frac{1}{2N}) \cdot I_1^*$
$- \left((1-\gamma_i^M - \gamma_i^H) + \frac{\gamma_1^M}{2N} + \frac{\gamma_1^H}{4N} \frac{\partial I_1^*}{\partial \gamma_1^M} \right)$
$+ \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^M} \cdot \left((b-c)(\frac{1}{2N}) + c(\frac{1}{4N})\right) - (\frac{\gamma_1^M}{2N} + \frac{\gamma_1^H}{4N}) \frac{\partial I_1^*}{\partial \gamma_1^M} \right) = 0.$

This yields the reaction function of the M-government

$$\gamma_1^M = 1 - \gamma_1^H - \frac{4 - 2 \cdot b - c}{4}.$$

3. The H-government chooses γ_1^H by maximizing its objective function wrt. γ_1^H. Its FOC writes

$\frac{\partial W^H}{\partial \gamma_1^H} = \frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} \cdot \left(1 + (b-c)(\frac{1}{2} - 1) + c(\frac{1}{4} - 1)\right) + (1 - \frac{1}{4}) \cdot I_1^*$
$- \left((1-\gamma_i^M - \gamma_i^H) + \frac{\gamma_1^M}{2} + \frac{\gamma_1^H}{4} \right) \frac{\partial I_1^*}{\partial \gamma_1^H}$
$+ \left(\frac{\partial Y_1(I_1^*)}{\partial I_1^*} \frac{\partial I_1^*}{\partial \gamma_1^H} \cdot \left((b-c)(\frac{1}{2}) + c \cdot (\frac{1}{4})\right) - (\frac{1}{4}) \cdot I_1^* - (\frac{\gamma_1^M}{2N} + \frac{\gamma_1^H}{4}) \frac{\partial I_1^*}{\partial \gamma_1^H} \right)$

$$+\left(c\cdot(\tfrac{1}{4})\cdot\frac{\partial Y_1(I_1^*)}{\partial I_1^*}\frac{\partial I_1^*}{\partial\gamma_1^H}-(\tfrac{1}{4})\cdot I_1^*-(\tfrac{\gamma_1^H}{4})\frac{\partial I_1^*}{\partial\gamma_1^H}\right)$$
$$+\left(c\cdot(\tfrac{1}{4})\cdot\frac{\partial Y_1(I_1^*)}{\partial I_1^*}\frac{\partial I_1^*}{\partial\gamma_1^H}-(\tfrac{1}{4})\cdot I_1^*-(\tfrac{\gamma_1^H}{4})\frac{\partial I_1^*}{\partial\gamma_1^H}\right)=0.$$

This yields the reaction function of the H-government

$$\gamma_1^H = b - \gamma_1^M.$$

4. To determine the Simultaneous Move Nash Equilibrium, we substitute γ_1^H in the reaction function of the M-government. This yields $\gamma_1^M = 1-b+\gamma_1^M-\frac{1-b}{(1-\frac{c}{2})}\cdot\left(1-\frac{b-\gamma_1^M}{2}\right)$, which simplifies to

$$\gamma_1^M = b - c > 0.$$

Substitution into the reaction function of the H-government leads directly to

$$\gamma_1^H = c.$$

This is an interior solution.

We still need to check two potential corner solutions given the parameter restrictions $\gamma_1^H, \gamma_1^M \ \epsilon \ [0,1]$:

a): $\gamma_1^H = 0$: In this case $\gamma_1^M = 1 - \frac{1-b}{(1-\frac{c}{2})}$. This together with $\gamma_1^H = b - \gamma_1^M$ yields

$$\gamma_1^H = (1-b)\cdot(\frac{\frac{c}{2}}{1-\frac{c}{2}}) > 0.$$

This is a contradiction.

b): $\gamma_1^M = 0$: In this case $\gamma_1^H = b$. This together with $\gamma_1^M = 1 - \gamma_1^H - \frac{1-b}{(1-\frac{c}{2})}\cdot\left(1-\frac{\gamma_1^H}{2}\right)$

yields

$$\gamma_1^M = (1-b)(1-\frac{1-\frac{b}{2}}{1-\frac{c}{2}}) > 0$$

for $b > c$. This is again a contradiction. The unique equilibirium of this game is the interior solution characterized above.

It remains to be shown that γ_1^H and γ_1^M together implement first best investment, I_1^H. With γ_1^M and γ_1^H from step 4, the optimality condition of the regional government, $\frac{\partial Y_1(I_1)}{\partial I_1} = \frac{1-\gamma_1^M-\gamma_1^H}{1-b}$, yields

$$\frac{\partial Y_1(I_1)}{\partial I_1} = \frac{1-b+c-c}{1-b} = 1.$$

This is identical to the first best marginal productivity desired by the H-government. Hence, γ_1^M and γ_1^H determined in step 4 yield regional first best investment I_1^H.

In the unique Nash Equilibrium, H- and M-governments are characterized by the same investment target. This can be seen from the optimality condition of the M-government, $\frac{\partial Y_1(I_1^*)}{\partial I_1^M}(1-\frac{c}{2}) = 1-\frac{\gamma_1^H}{2}$. Together with the matching rates from step 4, this simplifies to

$$\frac{\partial Y_1(I_1^*)}{\partial I_1^M} = 1$$

corresponding to the marginal productivity target of the H-government. ■

Proof of Proposition 2.5:

i) Solving the maximization problem of a rich region (type 2) yields

$$I_2^* = \frac{\rho_2(4 - 2 \cdot b - c)}{4 \cdot (1 - \gamma_2^M)}.$$

The maximization problem of the M-government for the rich region yields

$$\gamma_2^M = 1 - \frac{4 - 2 \cdot b - c}{4 - 2c}.$$

This matching rate implements the regional investment target of the M-government,

$$I_2^M = \rho_1 \cdot (1 - \frac{c}{2}) < \rho_1.$$

Investment in rich regions is below first best.

ii) Solving the maximization problem of the poor region yields

$$I_1^* = \frac{\rho_1(1 - \frac{b}{2})}{1 - \gamma_1^H - \gamma_1^M}.$$

Similar to the approach in Proposition 4.2, we derive reaction functions

$$\gamma_1^M = 1 - \gamma_1^H - \frac{1 - \frac{b}{2}}{1 - \frac{c}{2}}$$

for the M-government and

$$\gamma_1^H = 1 - \gamma_1^M - \left(1 - \frac{b}{2}\right)$$

for the H-government. Solving the simultaneous move game by plugging reaction functions into each other reveals again that there is no interior solution for this problem.

Two potential corner solutions remain to be checked given the restriction on parameters, $\gamma_1^H, \gamma_1^M \; \epsilon \; [0,1]$:

a): $\gamma_1^H = 0$: In this case $\gamma_1^M = 1 - \frac{1-\frac{b}{2}}{1-\frac{c}{4}}$. This together with $\gamma_1^H = 1 - \gamma_1^M - \left(1 - \frac{b}{2}\right)$ yields

$$\gamma_1^H = \frac{1-\frac{b}{2}}{1-\frac{c}{4}} - \left(1 - \frac{b}{2}\right) > 0,$$

which is a contradiction.

b): $\gamma_1^M = 0$: In this case $\gamma_1^H = 1 - \left(1 - \frac{b}{2}\right) = \frac{b}{2}$. This in the reaction function of the M-government yields

$$\gamma_1^M = \left(1 - \frac{b}{2}\right) - \frac{1-\frac{b}{2}}{1-\frac{c}{2}} < 0.$$

The non zero constraint is binding. Therefore, $\gamma_1^M = 0$. This is the unique Simultaneous Move Nash Equilibrium with $\gamma_1^H = \frac{b}{2}$ and $\gamma_1^M = 0$, a corner solution. This holds for $\gamma_1^H \cdot I_1 \leq c \cdot \left(\frac{\sum_k^4 Y_k(\cdot)}{4} - Y_1(\cdot)\right)$ or

$$c > \overline{c} = \frac{\frac{b}{2}\rho_1}{\frac{\sum_k^4 Y_k}{4} - Y_1}.$$

In this case $\tau_i > 0$.

Besides this unrestricted solution with large c, we also have to consider the case where c is small. This distinction allows for two additional sub cases:

i): c small: holds for $\gamma_1^H < \gamma_1^{M*}$ and $\gamma_1^H \leq (1 - \frac{1-\frac{b}{2}}{1-\frac{c}{2}})$. In this case we know that $\gamma_1^M + \gamma_1^H = (1 - \frac{1-\frac{b}{2}}{1-\frac{c}{2}})$ and $I_1 = \rho_1 \cdot \left(1 - \frac{c}{2}\right)$.

The M-government implements its suboptimal desired level of investment. This holds if $\gamma^H \cdot I_1 \geq (1 - \frac{1-\frac{b}{2}}{1-\frac{c}{2}}) \cdot \rho_1 \cdot \left(1 - \frac{c}{2}\right)$. Together, this yields $\gamma^H \cdot I_1 \geq (1 - \frac{1-\frac{b}{2}}{1-\frac{c}{2}}) \cdot \rho_1 \cdot \left(1 - \frac{c}{2}\right) >$

$c \cdot \left(\frac{\sum_k^4 Y_k(\cdot)}{4} - Y_1(\cdot) \right)$ which simplifies to

$$c < \underline{c} = \frac{\frac{b}{2} \cdot \rho_1}{\frac{\sum_k^4 Y_k(\cdot)}{4} - Y_1(\cdot) + \frac{\rho_1}{2}}.$$

ii): Finally, $I_1^M \leq I_i \leq I_1^H$ if c lies between the two margins determined above:

$$\frac{\frac{b}{2}\rho_1}{\frac{\sum_k^4 Y_k}{4} - Y_1} = \overline{c} > c > \underline{c} = \frac{\frac{b}{2}\rho_1}{\frac{\sum_k^4 Y_k}{4} - Y_1 + \frac{\rho_1}{2}}.$$

However, note that the left hand side and the right hand side are evaluated at different levels of regional investment ($I_1 = \rho_1$, the first best on the left hand side and $I_1 = \rho_1 \cdot \left(1 - \frac{c}{2}\right)$, the target of the middle-level on the right hand side). To show that this range exists, we need to show that

$$\left[\left(\frac{\sum_k^4 Y_k}{4} - Y_1 \right) | I_1 = \rho_1 \right] < \left[\left(\frac{\sum_k^4 Y_k}{4} - Y_1 \right) | I_1 = \rho_1 \cdot \left(1 - \frac{c}{2} \right) \right],$$

With the production function defined in section 2.3, this can also be written as

$$\frac{\sum_k^4 \rho_k \cdot ln(\rho_k)}{4} - \rho_1 \cdot ln(\rho_1) < \frac{\sum_k^4 \rho_k \cdot ln\left(\rho_k \cdot \left(1 - \frac{c}{2}\right)\right)}{4} - \rho_1 \cdot ln\left(\rho_1 \cdot \left(1 - \frac{c}{2}\right)\right)$$

By transforming left- and right-hand side, one can easily show that this inequality is indeed true. ■

Chapter 3

The Composition of Public Investment and Fiscal Federalism: Panel Data Evidence From Europe[1]

3.1 Introduction

Public investment has received only limited academic attention as an aggregate variable, and its composition has to our knowledge received none at all, at least in the European context. This paper seeks to fill that gap at least in part by presenting an empirical analysis of what drives different types of public investment, with a special focus on the impact of fiscal federalism.

Though public investment is an important variable in economics, its nature, drivers, and impact are still not completely understood. Most notably, there is often confusion about what it is in the first place. Perhaps the most prominent example of this type of confusion is the customary synonymous use of ”public investment” and ”infrastructure investment” in much of economic literature. There is, however, a great deal of infrastructure investment that is not public, and there is a great deal of public investment

[1]This chapter is based on Kappeler and Välilä 2008. The theory part and most of the robustness checks are extensions presented only in this thesis.

that is not infrastructure investment. While it is well-known that many roads, water and sanitation networks, and municipal swimming pools are publicly funded and provided, both economic theory and empirical analyses have hardly distinguished between them when studying what determines "public investment" or how productive "public investment" is.

We are interested in the impact of decentralization on the composition of public investment. In doing so, we refer to the regional competition literature by arguing that regions compete for private capital by increasing the provision of more productive investment relative to less productive investment. However, there are two points worthwhile noting in advance: First, while this strand of literature concentrates on the composition of public expenditure as a whole, we apply this theory to the composition of public investment. This, however, can be done without difficulty. Second, in our empirical analysis we concentrate on regional competition (and therefore regional decentralization) rather than competition among nations to explain the level of different types of public investment. Thereby we account for the fact that public investment is mostly conducted at the regional level - though often influenced by the central government, e.g. by earmarked grants. We also argue that concentrating on regional competition constitutes a lower bound case: Regional and national governments have similar investment targets if externalities arise at both levels. This holds since both tiers of government in this case are biased into the same direction. Thus, national competition renders the effect observable at the regional level weaker. Therefore, significant decentralization parameters in our analysis represent kind of a lower bound case and would support the hypotheses that regional competition in public inputs does exist in Europe.

The theory of fiscal federalism - or any other theory for that matter - does not deal explicitly with the composition of public investment. At best, it distinguishes between consumption-oriented public expenditure and public expenditure to produce "public inputs" for the production processes of private firms. In what is to come we do not consider differences between current public spending and public investment per se; rather, we consider the various types of public investment as enhancements of production potential for different public services. Thus, infrastructure investment is considered to produce more future transportation services, and redistribution investment is considered to produce, e.g., more future recreation services. This perspective allows us to link the theory of fiscal federalism with the kind of data on the composition of public investment that we have.

The traditional theory of fiscal federalism is based on the seminal contributions by Tiebout (1956), Oates (1972), and Musgrave (1959). The underlying assumptions include, most importantly, the benevolence of the policy-maker in the centre (that is, his objective is the maximization of social welfare); the existence of pure local public goods and global public goods (whose benefits accrue locally and nation-wide, respectively); benefit taxation (same incidence for the cost and benefit of public spending); factor mobility; and absence of spill-over effects of fiscal decisions horizontally (between regions) and vertically (between regions and the centre). Considering the responsiveness of public spending to local preferences and the creation of incentives for economic efficiency as policy goals, the theory derives normative conclusions about the optimal task assignment between the central and sub-national levels of government. Responsiveness to local preferences implies that decentralization and fiscal competition are preferable in the provision of local public goods whenever local preferences are heterogeneous. On the other hand, centralization is warranted in the provision of public goods whose optimal supply cannot be achieved by fiscal competition. Such goods include most notably global public goods, and it also includes the macroeconomic stabilization and income redistribution functions of the government (which may be interpreted as providing global public goods as well). Finally, public goods may also have spillover effects, with one region benefiting from a highway built by its neighboring region, for example. Fiscal competition among sub-national levels of government will result in a sub-optimally low level of provision of such goods, as regions do not consider the spillover benefits in their individual decision-making. Oates (1972) suggests that the optimal provision can be achieved by means of matching grants from the centre, which act to internalize the externality.

More recent literature on fiscal federalism has relaxed the assumption of no spillover effects in policy-making. Focusing on horizontal policy spillovers, consider regional tax competition. With capital mobile across regions that seek to attract it, tax competition can lead to sub-optimally low tax rates ("race to the bottom") and, as a consequence, insufficient provision of public services (both public consumption goods and "infrastructure"). In this sense, also Zodrow and Mieszkowski (1986) is a standard reference. Also, Hulten and Schwab (1997) discuss the circumstances where tax competition can lead to a sub-optimally low level of public capital. Competition between regions for an industry with external scale economies is a case in point: in competing for the location of such an industry, regions may reduce their tax rates so low as to unduly suppress public investment.

Several authors have come out against the assumptions in Zodrow and Mieszkowski (1986). E.g. Noiset (1995) argues that regional competition for private capital may reduce marginal costs up to a level where it actually increases the provision of public inputs. Also Keen and Marchand (1997) emphasize that the marginal cost for providing one additional unit of a public input does not necessarily exceed its additional gross return to capital (see also Matsumoto (1998) and Sinn (2003)). This holds if private capital reacts relatively strong to an increase in pubic inputs. Thus, relaxing the assumptions imposed by Zodrow and Mieszkowski (1986) renders over-provision of public inputs more likely. Considering the impact of fiscal competition on the composition of public expenditure, Keen and Marchand (1997) also argue that uncoordinated fiscal competition induces regions to over-invest in "local public inputs" at the cost of (consumption-oriented) local public goods. Investment in public inputs increases the potential of regions to attract mobile private capital, since public inputs reduce production costs for private firms. This generates distortions in the composition of public expenditure. Decentralization leads to an over-supply of public inputs and an under-supply of local public goods.

To sum up, fiscal competition has been argued to reduce public investment across the board (tax competition), but it has also been argued to boost productive public investment, at least relative to local public goods (broader fiscal competition). In terms of the public investment types in Table 1, these results would imply that decentralization increases investment in Infrastructure as well as Hospitals and Schools, while reducing investment in Redistribution, at least in relative terms. This contrasts, notably, with the hypotheses above based on the older fiscal federalism literature, which suggests that regional tax-competition leads to under-provision of any kind of public goods.

As regards empirical literature, different types of public investment are rarely compared. Empirical work on the composition of public spending mostly refers to productive vs. unproductive public expenditure rather than different categories of public investment (Arze del Granado et al. (2005), Gonzalez Alegre (2006a), or Hauptmeier (2007)). There is one empirical paper on Bolivian data by Faguet (2004) investigating different types of public investment. However, he concentrates on the responsiveness of regional governments to local needs by focusing on one particular reform, only. As regards input competition in Europe, Devereux and Griffith (1998) and Devereux and Freeman (1995) argue that competition for private capital indeed does occur among EU countries. They analyze FDI flows from the US to several EU countries and do find competition effects. Further, Benassy-Quere et al. (2005) also show that input competition is an issue among EU-countries.

In the following, we derive hypotheses about the link between fiscal decentralization and the composition of public investment in Section 3.2 We then decompose public investment into different types with distinctly different economic characteristics in Section 3.3. Section 3.4 seeks to articulate empirical tests of the hypotheses, and results are interpreted from an economic perspective, before concluding in Section 3.5.

3.2 Modelling the Composition of Public Spending

This section presents an analytical framework based on Keen and Marchand (1997) to investigate the partly conflicting arguments on the provision of public inputs in more detail.[2] Consider the following utility function of a representative regional voter:

[2]Compared to the more general treatment in Keen and Marchand (1997), we disregard the labor market and only consider capital taxation. Though less general, this framework establishes the same results, which are of interest for the empirical analysis below.

$$V = V(X, G).$$

X is a private good and G is a public consumption good. Regional governments also provide a public input P, which directly enters the production function as specified below. Public goods G and P, can be financed either by a capital tax τ, or by a lump sum tax T. T is imposed independently of where companies locate. This leads to the following budget constraint of the public sector:

$$P + G = \tau \cdot K + T$$

The production function is defined by

$$F = F(P, K(P, \tau)).$$

K depends on the level of public inputs and on tax rate τ. Private capital inflows increase in P, $\frac{\partial K}{\partial P} > 0$, implying that private capital in this region increases in the provision of public inputs. On the other hand, investors try to evade taxes. Therefore, capital inflows decrease in τ, $\frac{\partial K}{\partial \tau} < 0$. The firm's objective is to maximize profits:

$$R = F(P, K) - (r + \tau) \cdot K - T.$$

For perfectly mobile capital, the marginal product of capital equals its gross return ($r + \tau = F_K$), which directly results from the profit-maximization objective of private firms. Thus, the private budget constraint can be written as

$$X = F(P, K) - (r + \tau) \cdot K + \rho \cdot \overline{K} - T.$$

Consumption of good X equals production minus expenses for input K plus net return ρ (with $r = \rho + \tau$) from privately owned capital in this region ($\overline{K}$) minus the lump sum tax. Substituting public and private budget constraints in the utility function yields the objective function of the government:

$$maxV(X, G) = V\left(F(P, K) - (r + \tau) \cdot K + \rho \cdot \overline{K} - T, \tau \cdot K(\tau) + T - P\right) \qquad (3.1)$$

3.2.1 Two Forms of Competition for Private Capital

Maximizing Equation (3.1) with respect to T and τ, respectively, leads to the following quantitative result on the provision of public goods G and P.

Proposition 3.1: *Assume that the stock of private capital invested in the region depends negatively on τ and positively on public input P. Then, compared to first best provision, financing public input P and public consumption good G through a capital tax τ leads to under-provision of G, while P may be either under- or over-provided.*

Proof see Appendix 3.6. ■.

Two externalities distort the provision of P. First, the presence of a distortionary tax instrument negatively affects the level of public inputs: Regions want to attract additional capital at the cost of other regions resulting into a race to the bottom in capital taxes. Second, regions benefit from a higher level of P through its positive effect on private capital inflows. This constitutes an additional externality, which distorts the level of P in the opposite direction: Regions compete in the provision of P in order to attract private capital. The more public inputs are available in a region, the more attractive it is for private firms to invest. Since it is not clear, which effect prevails, public input provision may be either too high or too low.

As regards public services, there is only one of the two effects in place. Distortionary capital taxes generate regional tax competition and thereby an inefficiently low level of G. Since G does not affect the private capital invested in a region, no strategic competition in G arises. There is no additional positive externality that might shift the provision of public consumption goods upwards. After all, marginal utility exceeds marginal costs implying strategic under-provision of local public services.

Concerning our empirical analysis on the composition of public investment, Proposition 1 implies that we expect decentralization to reduce investment in Redistribution. On the other hand, it is not clear whether decentralization increases or decreases the level of public investment in Infrastructure.

3.2.2 Composition of Public Investment

Based on the quantitative effects examined above, Keen and Marchand (1997) argue that uncoordinated fiscal competition induces regions to over-invest in public inputs relative to public services. To see this, consider the differential of the utility function defined above:

$$dV = V_X \cdot dX + V_G \cdot dG. \tag{3.2}$$

From the private budget constraint we know that $dX = F_P \cdot dP$ and from the public budget constraint that $dG = -dP$. Substituting yields

$$dV = \left(F_P - \frac{V_G}{V_X} \right) V_X \cdot dP$$

With this expression, we can test how utility changes, if, everything else constant, expenditure is shifted from G towards P:

Proposition 3.2: *Holding capital tax τ constant, at a symmetric non-cooperative equilibrium, welfare increases through a small shift of expenditure from P towards G.*

Proof see Appendix 3.6. ■.

Regions can attract private capital by increasing the supply of P relative to G. Additional supply of P can attract private capital, while this is not possible with higher levels of G. On the other hand, the financing of additional public inputs through a distortionary capital tax negatively affects the level of private capital invested in this region. Thus, there are two externalities arising in context with the provision of public inputs in a region. This line of argument has direct implications for the relative composition of public investment in terms of P and G: P is overprovided relative to G in order to attract additional private capital. Welfare is thus unambiguously increased by a revenue neutral rebalancing of expenditures from P towards G. Note that Proposition 3.2 does not refer to over- or under-provision of public inputs in absolute terms. What it does say is that we can expect regional competition for private capital to increase productive investment (e.g. in Infrastructure and Hospitals and Schools) relative to public consumption goods (e.g. investment in Redistribution).

It is also worthwhile noting that Proposition 3.2 explicitly deals with welfare. However, it is difficult to empirically verify welfare implications of a certain policy tool. Also, the following empirical analysis will concentrate on levels of different types of public investment rather than shares. We therefore focus mainly on Proposition 3.1 for the economic interpretation of our results.

3.3 Composition of Public Investment in Europe: Stylized Facts

Based on the functional classification of government expenditure in the 1993 UN System of National Accounts and in the 1995 European System of Accounts (ESA 95), Eurostat provides a breakdown of public investment for EU countries starting in the early 1990s. Complete data are available for EU15 countries from 1995 (i.e, the introduction of ESA 95) through 2005.[3] However, many countries have back-dated their time series to 1990.

The "public investment" variable is gross capital formation of the general government. This includes changes in inventories, which may create some undesired noise for our analysis; however, the breakdown between gross fixed capital formation and changes in inventories is not available.

The functional breakdown of public investment is presented in Table 3.1. The right-hand side column shows the functional classification (Classification of Functions of Government, COFOG for short) in ESA 95. The left-hand side shows our aggregation of the 10 available "functions" into four types of public investment with economically distinct roles. This aggregation will be used in the remainder of this paper.

Table 3.1: Functional Breakdown of Public Investment

Types of Investment	*ESA 95 COFOG*
1. Infrastructure (INF)	Economic Affairs;
2. Hospitals and Schools (HS)	Health; Education;
3. Public Goods (PG)	Defence; General Public Services; Environment; Order and Safety;
4. Redistribution (RED)	Housing; Recreation; Social Protection

[3] EU15 comprises Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

The four different types of public investment affect the economy through different channels, with varying degrees of directness, and over different time horizons. Public investment in Infrastructure, consisting of just Economic Affairs in the ESA 95 COFOG,[4] seeks to measure public investment in traditional infrastructure, mainly transport. This type of public investment has the most direct economic impact by reducing firms' production and transaction costs. The economic impact of public investment in Hospitals and Schools is more long-term and less direct in character, as it facilitates the building up and maintenance of the economy's stock of human capital. Investment in Public Goods affects the economy's allocative efficiency indirectly through framework conditions for productive activity. Finally, Redistribution affects the economy's income distribution rather than allocative or productive efficiency per se.

In addition to the composition of Infrastructure investment, some other aggregates shown in Table 1 contain undesirable "noise" as no further breakdowns of the right-hand side "functions" are available. For example, public investment in water supply and wastewater management are not part of Infrastructure as one would wish; instead, they are part of Redistribution (Housing) and Public Goods (Environment), respectively. Similarly, one would wish to include street lightning in Public Goods; now it is in Housing and thereby Redistribution. However, as with Infrastructure, we expect such "noise" to be of sufficiently small magnitude so as not to invalidate the empirical analysis below.

[4]Economic Affairs comprise a number of different sectors, including agriculture; fuel and energy; mining, manufacturing, and construction; transport; communication; R and D; and others. Among these sectors, transport is likely to be by far the dominant recipient of public investment. Note that investment by energy companies owned by the public sector, for example, is classified as private investment in national accounts statistics as long as such companies are commercially run.

3.4 Empirical Analysis

Based on the theoretical findings in Section 3.2, Section 3.4 empirical investigates the impact of decentralization on the level of each type of public investment. Before presenting the methodologies and results of these analyses, we specify the model to be estimated.

3.4.1 Model Specification

The hypotheses formulated in Section 3.2 are based on literature, which considers productive vs. unproductive public spending. We directly apply these findings to analyze the composition of more productive vs. less productive types of public investment, only. For this reason we specify a reduced-form model to be estimated. In so doing we seek to identify exogenous variables measuring the impact of decentralization on public investment, as well as a set of control variables that render the model empirically well-specified.

The reduced-form specification to be used is as follows:

$$I_{c,it} = \alpha + \beta_1 tax_{it-1} + \beta_2 cap_{it} + \beta_3 gdp_{it-1} + \beta_4 debt_{it-1} + \beta_5 lend_{it-1} + \beta_6 pop_{it-1} + \beta_7 year_t + \gamma_i + u_{it}$$

where u_{it} i.i.d $(0,\sigma^2)$, with subscript i referring to observations in the cross-section dimension (individual countries) and t to observations in the time dimension. The dependent variable I_c represents public investment of type c, with $c \epsilon 1, \ldots, 4$ as shown in Table 1. In the analysis I_c is expressed relative to trend GDP,[5] thus in theory assuming values in $\Re_+$.

Our primary interest is in the share of tax revenue attributed to sub-national levels of

[5]Considering ratios to (trend) GDP improves the time series properties of the variables and facilitates the economic interpretation of the estimation results. Note that trend GDP is calculated using the Hodrick-Prescott Filter with a smoothing parameter $\lambda = 100$.

government (regional and local governments), which is denoted *tax*.[6] As regards the control variables, they seek to capture the general economic, fiscal, and demographic developments of significance for the determination of public investment. We control for investment grants from the central government to sub-national levels of government (*cap*); in the empirical analyses it is measured in relation to trend GDP.[7] The tax share is lagged by one period to reflect the fact that investment decisions are most often taken a year before, based on knowledge about the revenue situation at that time. In contrast, capital transfers are contemporaneous with investment, as they finance investment the same year it is undertaken [8] Real GDP, denoted *gdp* in (1), is measured in per capita terms and lagged by one period to remove any simultaneity bias. The short- and longer term fiscal environment is captured by the budget surplus of the general government (*lend*) and public debt (*debt*). Both are measured in relation to trend GDP and lagged by one period, for the reasons mentioned above. We also control for population (*pop*).[9] γ_i denotes unobserved time-invariant country-specific effects that are included in the estimations. Finally, as explained below in greater detail, a linear time trend (*year*) is included, as some of the time series are trend stationary.

3.4.2 Sample Properties

The main sample used in the estimations consists of a panel of EU10 countries (EU15 less the Cohesion countries less Luxembourg) during the period 1990-2005. Data are from Eurostat's New Cronos and OECD statistics. Time series for FDI-stocks, fiscal

[6] See Stegarescu (2005). We also considered other measures of decentralization, including total revenue share of sub-national levels of government; expenditure share of sub-national levels of government; and the ratio of sub-national tax revenue to expenditure. However, none of these alternative measures is conceptually superior to the tax share variable used, and all of them are empirically inferior, as they risk spurious correlation by including capital transfers (total revenue share) or the dependent variable (expenditure share), or by exhibiting non-stationarity (sub-national revenue-to expenditure ratio).

[7] The interaction term of tax and cap turned out to be insignificant in most of the estimations below and is therefore not reported.

[8] See Rodden (2003) for more details.

[9] As a robustness check we also considered unemployment, birth rates, migration rates, and mortality rates as additional control variables. They turned out to be mostly insignificant and did not change the estimation results materially.

variables (budgetary surplus, public debt, and decentralization measures), and population come from the OECD. Not all countries have back-dated all relevant series to 1990, so the panel is unbalanced.

Summary statistics are provided in Table 3.14 (Appendix 3.7). Overall the standard deviation is about 1/2 to 1/3 of the mean. Although this variation in the data is relatively low compared to large sample studies, it is still in line with other studies using national data such as Stegarescu (2005). The summary statistics also reveal that the three decentralization measures (taxsh, tDec1, and tDec3) used in this study have similar statistical properties.

Unit root tests indicate that our variables are either stationary or trend stationary (Appendix 3.7, Table 3.16), thus warranting the inclusion of a time trend as another explanatory variable. We perform Levin, Lin, and Chu test (LLC), [see Levin et al. (2002)] as well as Im, Pesaran and Chin test (IPS); [see Im et al. (1997)] to verify the stationarity properties of our variables.

The dependent variables are highly autocorrelated and persistent (Appendix 3.7, Table 3.17), with first-order autocorrelation coefficients between 0.8 and 0.9 for all types of public investment.

3.4.3 Methodology

The high autocorrelation in our dependent variables suggests a dynamic specification of model (1):

$$I_{c,it} = \alpha + \beta_1 I_{c,it-1} + \beta_2 tax_{it-1} + \beta_3 cap_{it} + \beta_4 gdp_{it-1} + \beta_5 debt_{it-1} + \beta_6 lend_{it-1} + \beta_7 pop_{it-1} + \beta_8 year_t + \gamma_i + u_{it}$$

The estimation of specification (2) will have to account for the correlation between the regressors (lagged dependent) and the composite term ($\gamma_i + u_{it}$), which renders least squares estimators inconsistent even asymptotically. To circumvent this problem we employ General Method of Moments (GMM) estimation, which has become the workhorse in estimating dynamic panel data models.

The intuition underlying GMM estimation is a follows. According to Arellano and Bond (1991) and Bond (2002) the levels equation is first-differenced, which eliminates the fixed effects γ_i, as well as the time trend. A set of (internal) instrumental variables is then specified that are orthogonal to the error term. Assuming that the error term is not serially correlated and that the explanatory variables are weakly exogenous, higher-order lags of the dependent variable ($I_{c,it-2}$,$I_{c,it-3}$,$\cdots$) constitute valid instruments.[10] This results in the following set of instruments

$$Z_i = \begin{pmatrix} I_{c,t-2} & 0 & 0 & \cdots & 0 & \cdots & 0 \\ 0 & I_{c,it-2} & I_{c,it-3} & \cdots & 0 & \cdots & 0 \\ . & . & . & \cdots & . & \cdots & . \\ 0 & . & 0 & \cdots & I_{c,it-2} & \cdots & I_{c,i1} \end{pmatrix}.$$

While identification requires the number of instruments to equal the number of explanatory variables, overidentification is in practice necessary, as it both allows the testing of the moment conditions, as explained below, and improves efficiency.[11] The orthogonality requirement is equivalent to conditions on the first moment of the sample data.

$$E(Z'_{c,i} \triangle u_i) = 0 \text{ for } i = 1, 2, ..., N$$

where $\triangle u_i = (\triangle u_{i3}, \triangle u_{i4}, ..., \triangle u_{iT})'$. The fulfillment of these moment conditions is a sufficient condition for the asymptotic consistency of GMM estimators. The derivation of the GMM estimators can be done in one or two steps (labeled 1-step and 2-step GMM estimation), which are asymptotically equivalent under homoskedasticity of the error term. The two step estimator computes consistent estimate $\widehat{\triangle u_i}'$ in the first step, which are then used in the second step to minimize

[10]Higher-order lags of other explanatory variables can also be used as instruments under the same assumptions.

[11]Note that GMM estimation dominates least squares estimation with instrumental variables, as GMM can be shown to be asymptotically efficient, which is not the case for least squares estimation with instrumental variables.

$$J_N = \left(\frac{1}{N} \sum_{i=1}^{N} \bigtriangleup u_i' Z_{c,i} \right) W_N \left(\frac{1}{N} \sum_{i=1}^{N} Z_{c,i}' \bigtriangleup u_i \right) \tag{3.3}$$

using weighting matrix

$$W_N = \left[\frac{1}{N} \sum_{i=1}^{N} Z_{c,i}' \widehat{\bigtriangleup u_i} \widehat{\bigtriangleup u_i}' Z_{c,i} \right]^{-1}. \tag{3.4}$$

Instead, the one step estimator directly minimizes

$$W_N = \left[\frac{1}{N} \sum_{i=1}^{N} Z_{c,i}' H Z_{c,i} \right]^{-1} \tag{3.5}$$

where H is a (T-2) square matrix with 2's on the main diagonal, -1's on the first off-diagonals and zero elsewhere. The 2-step procedure is more efficient under heteroskedasticity.

To test the validity of the moment conditions, the number of instruments has to exceed the number of explanatory variables. With overidentification, two tests suffice to assess whether the model is well-specified. First, the Sargan test for overidentifying restrictions is conducted to test the joint orthogonality of all instruments. Second, the serial correlation properties of the error term are tested; more specifically, tests developed by Arellano and Bond (1991) allow us to assess whether first order serial correlation is present in the error term (as it should, as our regression equation is estimated in first differences) and whether second order serial correlation is absent (as it should).

3.4.4 Basic Results

Table 2 presents the results of the preferred estimation method, which is one-step difference-GMM. We present results for total expenditure, overall investment, and the four investment types (all relative to trend GDP).

One-step difference-GMM estimation is alone in passing the Sargan test for overidentifying restrictions and residual autocorrelation tests (labeled m1 for first-order and m2 for second-order autocorrelation) for all four estimated models in levels. Two-step difference-GMM estimation is associated with the absence of first-degree residual autocorrelation throughout.

As shown in Appendix 3.7, the residuals from the least squares-based estimations are not always well-behaved. The FE OLS estimation suffers from residual non-normality, as indicated by the p-value of the Jarque-Bera (JB) test statistic.

Table 3.2: Results for One-step GMM by Type of Investment (per Trend GDP)

1-step GMM	*GEXP*	*GINV*	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.36889***	0.46137***	0.425862***	0.51883***	0.61116***	0.49203***
	(4.65)	(4.47)	(4.78)	(3.94)	(4.90)	(4.89)
tax	0.04042	0.03342***	0.01967***	0.00754	0.01193**	0.00077
	(0.33)	(2.08)	(3.36)	(1.04)	(2.38)	(0.16)
cap	3.20978***	0.37123***	0.05091	0.07498***	0.10902*	0.02656
	(4.10)	(2.16)	(1.38)	(3.11)	(1.82)	(0.42)
gdp	-0.35307	1.27741***	0.47619***	0.23047	0.33452***	0.20746**
	(0.17)	(3.16)	(2.46)	(1.41)	(3.55)	(2.39)
lend	0.01427	-0.00424*	-0.00098	-0.00024	-0.00121	-0.00203**
	(0.77)	(1.54)	(0.99)	(0.28)	(0.98)	(2.09)
debt	0.01057	-0.00019	-0.00061	0.00007	0.001839**	0.00067
	(0.40)	(0.07)	(1.06)	(0.08)	(2.36)	(0.90)
pop	15.4208***	0.34454***	- 0.12783	0.22029	-0.03762	0.12006
	(2.44)	(0.03)	(0.43)	(0.98)	(0.08)	(0.45)
Sargan	1.0000	0.6066	1.0000	1.0000	1.0000	1.0000
m1	0.0239	0.0617	0.0465	0.0640	0.0248	0.0349
m2	0.4547	0.3229	0.3212	0.5098	0.1196	0.8624
Obs.	121	104	104	104	102	101

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. We refer to test results from two-step GMM. Results for the constant are omitted. Note that the time trend is dropped for GMM since this procedure is based on first differencing.

Before considering results of types of investment in more detail, let us interpret parameter estimates for overall expenditure and public investment: First, differently from the ”Leviathan hypothesis”, we observe that general expenditure does not depend on decentralization. On the other hand, capital transfers and the lagged dependent variable are highly significant. For our sample, decentralization mainly implies a shift in revenue or spending responsibility rather than a change in overall expenditure per se. Note that GDP does not positively affect the overall level of public expenditure. This is probably due to the inclusion of capital transfers into the equation. However, for consistency reasons, we do not change the model specification across estimations.

As regards estimates for general public investment (per trend GDP), it is roughly the sum of the parameter values for investment types one to four. Parameters for the taxshare, capital transfers, and GDP are significant. However, two exceptions do exist. First, the parameter estimates of the lagged dependent variables do not add up over the four types of investment. This is because the lagged dependent variable is the only variable, which is not identical across estimations (it is the lagged value of each of the four types of public investment per GDP). Thus, parameters are not directly comparable. Second, the four parameter estimates for the debt variable do not add up the debt effect in GINV. This may be due to the low significance of this variable in most regressions.

Considering the results by type of investment in Table 3.2, we conclude that a higher sub-national tax share increases the aggregate level of investment in Infrastructure and Public Goods, but it has no statistically significant impact on the aggregate public investment in Hospitals and Schools as well as Redistribution. The parameter estimates imply that an increase in the sub-national tax share by one percentage point leads to an increase in investment in Infrastructure of about 0.02 percentage points of GDP, or 2 percent, respectively, evaluated at sample mean.

Returning to Table 3.2 and considering the coefficient estimates for capital transfers, we observe a significant positive impact on investment in Hospitals and Schools as well as Public Goods. An increase of capital transfers by 1 percent of GDP boosts these types of investment by 0.07 and 0.11 percentage points of GDP (14 percent and 15 percent, respectively, at sample mean). As regards other control variables, real per capita GDP is positive and significant in all four models, except of hospitals and schools with coefficient estimates of 0.2-0.5. The fiscal variables are mostly insignificant, except that higher budgetary surpluses reduce investment in Redistribution and that higher public debt goes hand in hand with higher investment in Public Goods.

Economic Interpretation

Our results suggest that decentralization increases economically productive public investment, notably investment in public spillover goods (Infrastructure). There is no statistically significant impact of decentralization on public investment in consumption-oriented local public goods (Redistribution). Although one might have expected decentralization to increase Hospitals and Schools - as this could be interpreted as a more indirect kind of public input, this is not confirmed by our results. Thus, public Hospitals and Schools do not function as a public input here.

We saw in Section 2 how the theory of fiscal federalism could be used to derive some hypotheses about the composition of public investment. Most notably, it suggests that decentralized tax autonomy leads to lower provision of public consumption goods, while the level of public inputs may either decrease or increase (see Proposition 3.1). The impact of decentralization on our variable Public Goods was considered ambiguous, depending on whether it is dominated by local or global public goods. In other words, while not readily reconcilable with the traditional theory of fiscal federalism, especially as regards the provision of local public goods, these findings can be interpreted in terms of the literature on fiscal competition, with not only tax rates but also the quality of public expenditure weighing in firms' location decisions. Decentralization increases the level of investment in Infrastructure. This is in line with our theoretical analysis, particularly Proposition 3.1, which claims that public inputs provision may increase with decentralization. This being the case, we do not see any evidence of decentralization being associated with tax competition that would have a detrimental impact on public investment. On the other hand, we expected Redistribution to decrease with decentralization. This parameter, however, is not significant and does therefore not support our theoretical prediction in Proposition 3.1 as regards the provision of public consumption goods. This may be due to the stickiness of public expenditure: Over time public expenditure hardly decreases. But if kept constant (as Redistribution is in our case), inflation and more pronounced expenditure in other sectors, may lead to lower spending for this type of investment.

Note that the estimation results for total expenditure and GINV together suggest that our tax competition argument in terms of public inputs also holds in a more general context: total public expenditure as such is not affected by decentralization, while public investment does increase. This implies that decentralization leads to a shift of public expenditure towards public investment (at the cost of other, more consumption oriented expenditure). This is also in line with other studies such as De Granado (2006) and Arze et al. (2005).

3.4.5 Measuring Decentralization

To measure decentralization, Stegarescu (2005) also accounts for the autonomy of sub-national governments to determine their tax base and/or tax rate. He argues that federal systems are more decentralized if sub-national governments rather than central governments can determine the tax rate or tax base - even if sub-national governments receive the same tax share. According to this argument, the OECD (1999) proposes a classification of taxes by decreasing order of regional control over tax revenues. This is shown in Table 3.3.

Based on this classification of tax autonomy, Stegarescu (2005) proposed three decentralization measures relative to the tax revenue of sub-national governments. We are interested in two of them, TDec1 and TDec3, as defined in Equations 3.6 and 3.7

Table 3.3: Classification of Taxes (in Decreasing Order of Control over Revenue Sources)

(a)	sub-central government (SCG) determines tax rate and tax base
(b)	SCG determines tax rate only
(c)	SCG determines tax base only
(d)	tax sharing:
(d.1)	SCG determines revenue-split
(d.2)	revenue-split only changed with consent of SCG
(d.3)	revenue-split unilaterally changed by centr. gov. (CG) (legislation)
(d.4)	revenue-split unilaterally changed by CG (annual budget)
(e)	CG determines tax rate and tax base

Source: OECD (1999).

$$TDec1 = \frac{SCG\ own\ tax\ rev.\ (a)\ to\ (c)}{GG\ total\ tax\ rev.} \tag{3.6}$$

This index only considers regional tax revenues if the tax base and/or tax rate are independently determined by the regional government. Stegarescu also proposes a more general form of this index to measure decentralization:

$$TDec3 = \frac{SCG\ own\ tax\ rev.\ (a)\ to\ (e)}{GG\ total\ tax\ rev.} \tag{3.7}$$

This measure is closer to the taxshare used so far in this paper, since it relaxes the condition on local tax revenue to be taken into consideration. TDec3 accounts for all seven categories of tax revenue.

The decentralization measure, which we do not consider includes tax revenues of type a to c as well as $d2$ (This is labeled TDec2 in Stegarescu (2005)). Summary statistics in Table A1.1 show that the statistical properties of decentralization measures TDec1 and TDec3 are very similar for our sample. A further distinction among categories as suggested for TDec2 does not lead to further insights in our case.

Re-estimating our model by using TDec1 instead of the taxshare yields the following results:

Table 3.4: Results Using Decentralization Measure tDec1

1-step GMM	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.45033***	0.51164***	0.64227***	0.51713***
	(4.37)	(4.10)	(6.21)	(4.82)
TDec1	0.01944**	0.01093	0.01598***	0.00264
	(2.35)	(1.44)	(2.90)	(0.49)
cap	0.05568*	0.07261***	0.08878*	0.01402
	(1.75)	(2.87)	(1.87)	(0.23)
gdp	0.51547**	0.33063**	0.45739***	0.21523**
	(2.52)	(2.12)	(5.22)	(2.06)
lend	-0.00076	-0.00006	-0.00119	-0.00189**
	(0.77)	(0.07)	(1.01)	(1.99)
debt	-0.00008	0.00047	0.00214**	0.00060
	(0.13)	(0.43)	(2.03)	(0.82)
pop	0.11729	0.31289	0.10848	0.14465
	(0.37)	(1.49)	(0.24)	(0.50)
Sargan	1.0000	1.0000	1.0000	1.0000
m1	0.0511	0.0588	0.0227	0.0287
m2	0.3053	0.7376	0.11074	0.9733
Obs.	105	105	103	102

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. Test results from two-step GMM. Results for constant are omitted.

Substituting TDec1 by TDec3 yields the results in Table 3.5.

It turns out that the significance in general (and for decentralization in particular) follows the same pattern as in Table 3.2, though slightly decreasing for TDec3. TDec1 as well as TDec3 is significant for investment types 1 and 3, whereas parameter estimates for investment types 2 and 4 are not. Thus, the measures of decentralization as proposed by Stegarescu (2005) also confirm that decentralization leads to more investment in public infrastructure, which is the most evident public input among the four categories. This is in line with the theoretical findings in Section 3.2 that decentralization leads to strategic competition for private capital through increased public input provision.

Table 3.5: Results Using Decentralization Measure tDec3

1-step GMM	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.47685***	0.49618***	0.62314***	0.51602***
	(4.85)	(4.10)	(5.56)	(4.83)
TDec3	0.01332*	0.01050	0.01468***	0.00308
	(1.73)	(1.52)	(3.08)	(0.59)
cap	0.06357**	0.07201***	0.09452**	0.01300
	(2.03)	(2.91)	(2.03)	(0.22)
gdp	0.38175**	0.29501**	0.39640***	0.22499***
	(2.05)	(2.40)	(4.97)	(2.62)
lend	-0.00058	-0.00014	-0.00129	-0.00200**
	(0.66)	(0.16)	(1.02)	(2.03)
debt	-0.00043	0.00013	0.00171*	0.00066
	(0.65)	(0.14)	(1.86)	(0.89)
pop	0.00420	0.31694*	0.71817	0.13854
	(0.01)	(1.65)	(0.16)	(0.52)
Sargan	1.0000	1.0000	1.0000	1.0000
m1	0.0538	0.0577	0.0271	0.02715
m2	0.2688	0.6030	0.1073	0.8852
Obs.	105	105	103	102

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. Test results from two-step GMM. Results for constant are omitted.

3.4.6 Identifying Regional Autonomy

There is a further problem with our definition of decentralization. On may argue that decentralization also leads to tax competition among regions. This reasoning implies that tax revenues decline with more decentralization - and as a result also overall public investment (including Infrastructure). Our estimation would still yield a significantly positive decentralization parameter, although the actual effect was reversed.

Indeed, it is local autonomy, in what we are interested. If regions are more autonomous, we argue that they will use this autonomy to compete for private capital by increasing investment in Infrastructure. One way to evade the problem with tax competition is therefore to only concentrate on additional regional funds, which are controlled by the national government. If, e.g. tax revenue is levied by the central government and transferred to regions, they have no means to compete in tax rates. If these centrally levied funds still increase public infrastructure, we confirm that public input competition is the driving force in our setting (as suggested). Therefore, concentrating on spending autonomy allows identifying the competition aspect related to public inputs. Given the definition of decentralization as in Table 3.3, we therefore re-estimate our model by measuring decentralization through centrally controlled taxes, only. This comprises items (d) to (e) in Table 3.3.

Table 3.6: Results for Regional Autonomy (Categories (d) to (e))

1-step GMM	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.59324***	0.56097***	0.69880***	0.52785***
	(4.99)	(5.06)	(7.82)	(5.34)
autonomy	0.03021***	-0.00370	0.00524	-0.00886
	(2.98)	(0.31)	(0.78)	(1.27)
cap	0.08652***	0.08807***	0.09638**	0.02155
	(2.81)	(3.17)	(2.20)	(0.39)
gdp	0.26896*	0.12164	0.17302*	0.17956
	(1.81)	(0.86)	(1.81)	(1.57)
lend	0.00047	-0.00005	-0.00059	-0.00207**
	(0.33)	(0.07)	(0.56)	(2.16)
debt	0.00058	0.00000	0.00132	-0.00055
	(0.61)	(0.01)	(1.55)	(0.67)
pop	-0.23167	0.09492	-0.15547	0.05104
	(1.39)	(0.51)	(0.36)	(0.22)
Sargan	1.0000	1.0000	1.0000	1.0000
m1	0.0418	0.0572	0.0298	0.0212
m2	0.2411	0.3739	0.0868	0.7293
Obs.	105	105	103	102

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. We refer to test results from two-step GMM. Results for constant are omitted.

As before, the decentralization parameter is significant for Infrastructure investment. This suggests that if more funds are transferred from the central government towards its regions (which may be interpreted as higher spending autonomy at the regional level), regions use these additional funds to increase their public infrastructure spending. This finding supports the view of Keen and Marchand (1997): They argue that regional competition (higher autonomy) leads to increased investment into public inputs relative to public consumption. Interestingly, the new decentralization measure has no longer an positive impact on Public Goods. Thus, this additional robustness check is even more in favor of our hypothesis in Proposition 3.1, which concerns Infrastructure and Recreation, only.

3.4.7 Results for Aggregated Types of Investment

In order to directly refer to the theoretical findings in Section 3.2, we re-estimate the model by aggregating types of investment: Investment of type one and two is aggregated and labeled public input. Similarly we label the sum of public investment of type 3 and 4 as public consumption. Estimating the 1-step GMM model for theses two types of investment leads to the following results:

Table 3.7: Results, Public Inputs vs. Public Consumption Goods

1-step GMM	*INPUT*	*CONSUMPTION*
Inv(lag)	0.38411***	0.47162***
	(5.67)	(3.66)
tax	0.03324***	0.0069
	(4.50)	(1.23)
cap	0.12204*	0.19768***
	(1.81)	(2.26)
gdp	0.81818***	0.56898***
	(3.45)	(5.38)
lend	-0.00196	-0.00348*
	(1.15)	(1.71)
debt	-0.00144	0.00068
	(1.18)	(0.67)
pop	0.54318*	0.11267
	(1.74)	(0.17)
Sargan	1.0000	1.0000
m1	0.0462	0.0241
m2	0.3398	0.7701
Obs.	104	104

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. We refer to test results from two-step GMM. Results for the constant are omitted.

Again, the results confirm the theoretical findings in Section 3.2 as regards public input provision. The tax share variable is significant at the 1 percent level only for public inputs, whereas it is insignificant for public consumption goods. This result directly replicates our theoretical finding from Proposition 3.1.[12] Decentralization leads to more competition among regions. In order to attract private capital, they invest more into public inputs. This raises the overall level of Infrastructure Investment in the

[12]The only difference is again that we distinguish among different types of investment, while the standard literature refers to public expenditure.

economy. On the other hand, public investment classified as Public Consumption remains unchanged.

3.4.8 External vs. Internal Competition

So far, we assumed that regional competition for private capital leads to higher overall investment in public inputs. However, given the structure of our data, it is not clear, whether this effect does not also depend on competition at the national level (among EU-countries rather than regions). E.g. Devereux and Griffith (1998) and Devereux and Freeman (1995) argue that competition for private capital indeed does occur among EU countries. Benassy-Quere et all (2005) also show that in this context input competition arises. So far we did not consider this aspect in our analysis. Our results might therefore suffer from an omitted variable bias. In the following we introduce a measure to account for inter-state competition. Thereby we account for the fact that some countries within the EU may be subject to fiercer external competition than others. This, of course, may also have an impact on the composition of public investment. In particular, Foreign Direct Investment is a good measure for the interaction of one economy with other countries. Therefore, we add to our analysis the sum of inward and outward FDI-stocks per GDP as additional explanatory variable. For better comparison, we refer again to the tax share as decentralization measure.

FDI stocks are mainly a measure for the long-term interaction among countries. However, one might argue that short-term variations are more likely to affect the composition of public investment. In order to capture also these short run variations, we also present results for an FDI index including inflows and outflows per GDP in Table 3.9.

Table 3.8: Results Including FDI-Stocks (Stock of Inflows and Outflows, EU15)

1-step GMM	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.48364***	0.57731***	0.52782***	0.42669***
	(5.67)	(4.79)	(4.90)	(3.16)
tax	0.01440***	0.00546	0.00729*	0.00073
	(2.72)	(1.11)	(1.91)	(0.20)
cap	0.08402*	0.07898**	0.12913***	0.04128
	(1.95)	(2.55)	(2.89)	(0.60)
gdp	0.40320*	0.23424*	0.23918**	0.28992
	(1.86)	(1.66)	(2.41)	(1.63)
lend	0.00007	0.00147**	0.00050	-0.00236***
	(0.07)	(1.24)	(0.55)	(3.90)
debt	-0.00033	-0.00000	-0.00074	-0.00051
	(0.29)	(0.00)	(0.71)	(0.32)
pop	-0.06791	0.24900	-0.20590	0.20738
	(0.24)	(1.18)	(0.51)	(0.75)
FDI-stock	-0.04437**	0.0561	0.08142***	0.01085
	(2.22)	(0.72)	(4.07)	(0.25)
Sargan	1.0000	1.0000	1.0000	1.0000
m1	0.0646	0.1055	0.0352	0.0449
m2	0.2901	0.4209	0.2612	0.9588
Obs.	86	86	84	83

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. We refer to test results from two-step GMM. Results for the constant are omitted.

It turns out that the basic findings regarding the impact of decentralization on the composition of public investment do not change by considering the openness of a country (apart from lower significance of Public Goods). Therefore, we conclude that our results are also robust towards external competition effects. However, against our intuition, the FDI-stock has a negative impact on Infrastructure and a positive effect on Public Goods, while FDI-flows are not significant for any type of public investment. These results suggest that competition among nations has no clear-cut effect on the composition of public investment. One possible explanation is that at this level public input competition and tax competition occur at the same time. In this case an unambiguous conclusion about which effect is significant is not possible - at least in our specification. However, this interpretation also confirms our approach to concentrate on regional competition, only, in order to identify public input competition (see also Section 3.4.6)

Table 3.9: Results Including FDI-Index (FDI Flows, In and Out, per GDP, EU15)

1-step GMM	*1.INF*	*2.HS*	*3.PG*	*4.RED*
Inv(lag)	0.43129***	0.65296***	0.54930***	0.40647***
	(7.28)	(4.82)	(5.98)	(2.74)
tax	0.01558***	0.00430	0.00555	0.00448
	(2.72)	(1.05)	(1.28)	(1.50)
cap	0.03187	0.06014*	0.15233**	0.00931
	(0.70)	(1.68)	(2.41)	(0.20)
gdp	0.17770	0.18584	0.10854	0.35270***
	(0.72)	(1.47)	(0.95)	(2.61)
lend	0.00019	-0.00005	-0.00183***	-0.00125**
	(0.13)	(0.06)	(2.61)	(1.99)
debt	0.00037	0.00022	-0.00041	-0.00102
	(0.36)	(0.15)	(0.50)	(0.62)
pop	-0.18475	0.27381	0.13970	0.34492
	(0.47)	(1.56)	(0.65)	(1.13)
FDI-flow	0.00002	0.00000	0.00000	0.00003
	(0.56)	(0.27)	(0.45)	(1.36)
Sargan	1.0000	1.0000	1.0000	1.0000
m1	0.0946	0.0823	0.0672	0.1046
m2	0.1478	0.7339	0.1294	0.3181
Obs.	83	83	81	80

One-step GMM calculated with heteroskedasticity robust standard errors. Sargan test for robust one-step GMM cannot be performed. We refer to test results from two-step GMM. Results for the constant are omitted.

Finally, there is also a theoretical argument why omitting international competition does not weaken our results: Assume that also national governments compete for private capital. In this case also central governments have incentives to increase investment in Infrastructure. In line with Kappeler (2007), the national (or middle level) and regional targets would be subject to a bias in the same direction to exploit the supranational government. Regional decentralization would then exert a limited additional effect on the level of public inputs. Thus, if competition at the national level is an issue, our results would constitute kind of a lower bound case: Though we only account for local competition, our decentralization parameter for infrastructure is significant. We may expect regional competition effect to be even larger if we separately capture an existing competition effect at the national level.

3.4.9 Methodological Robustness-Checks

As Bond et all (2001) suggest, for large T and small N the reliability of standard GMM-methods may be limited due to the large number of instruments generated in this case. To test, whether this problem is of relevance for our sample, we re-estimate our basic model with two alternative approaches: Besides Corrected Least Squares Dummy Variable estimates (LSDVC) as proposed by Bruno (2005), we also refer to 2SLS with only the second lag being used to instrument the lagged dependent variable.

Bond (2002) argues that GMM is generally more suitable for large N and small T. In our case, however, T (16) is large relative to N (10). Similar to OLS, one-step GMM in this case might be biased since the number of instruments becomes relatively large (in our case up to 125). 2SLS allows estimating the model with a smaller number of instruments. Thereby, we can correct for a large part of the bias (though probably not all), while the number of instruments remains low. Therefore, we also estimate the basic model with 2SLS with only the second lag as instrument for the lagged dependent variable allowing for more degrees of freedom.

To properly deal with a small sample bias in dynamic econometric models, a Corrected Least Squares Dummy Variable estimator is recently discussed in the econometric literature. Bruno (2005) proves efficiency of this estimator in case of unbalanced data with large T and small N such as ours. The estimator can be performed in two ways - the Anderson-Hsiao (AH) and Arrelano Bond (AB) based approaches. Judson and Owen (1996) show in a Monte Carlo Study that for $T > N$ and a sample size similar to ours, the Anderson-Hsiao approach is the preferred one. Therefore, we expect the AH-approach to be superior compared to LSDVC AB in our case. For comparison reasons, we report results for both specifications together with 2SLS in Tables 3.10 to 3.13.

Table 3.10: Results in Levels, Investment in Infrastructure per Trend GDP

1.INV (level)	*2SLS FE*	*LSDVC AB*	*LSDVC AH*
Inv1(lag)	-0.787149	0.54962***	0.47006***
	(0.48)	(6.09)	(4.46)
tax	0.023841***	0.01222**	0.01407
	(3.17)	(2.06)	(0.07)
cap	0.08717	0.06166	0.06283
	(1.63)	(1.19)	(0.04)
gdp	0.67749***	0.370**	0.38334
	(2.94)	(1.99)	(0.06)
lend	-0.00470**	0.0003	0.00005
	(2.02)	(0.20)	(0.00)
debt	-0.00323**	0.00019	-0.00027
	(2.03)	(0.16)	(0.01)
pop	0.07607	-0.08348	-0.02325
	(0.21)	(0.25)	(0.00)
R^2-*Adj*	0.3333		
Sargan		0.2861	
m1		0.0389	
m2		0.2021	
Obs.	111	104	104

GLS cross section weights used. Instrument used for 2SLS is the second lag of the dependent variable. For LSDVC, bias correction up to order $O(1/T)$; boostrap variance-covariance matrix with 100 iterations.

Table 3.11: Results in Levels, Investment in Hospitals and Schools per Trend GDP

2.HS (level)	*2SLS FE*	*LSDVC AB*	*LSDVC AH*
Inv2(lag)	0.22737*	0.63470***	0.69218***
	(1.67)	(7.74)	(7.46)
tax	0.00983*	0.00482	0.00352
	(1.89)	(1.03)	(0.52)
cap	0.09906***	0.07822*	0.07039
	(2.74)	(1.93)	(1.38)
gdp	0.27753*	0.23013	0.24561
	(1.84)	(1.58)	(1.27)
lend	0.00004	-0.00055	-0.00072
	(0.03)	(0.53)	(0.54)
debt	0.00021	0.00074	0.00055
	(0.24)	(0.84)	(0.48)
pop	0.62487**	0.20319	0.16069
	(2.25)	(0.71)	(0.44)
R^2-*Adj*	0.4655		
Sargan		0.9542	
m1		0.0052	
m2		0.5355	
Obs.	111	104	104

GLS cross section weights used. Instrument used for 2SLS is the second lag of the dependent variable. For LSDVC, bias correction up to order $O(1/T)$; boostrap variance-covariance matrix with 100 iterations.

Table 3.12: Results in Levels, Investment in Public Goods per Trend GDP

3.PG (level)	*2SLS FE*	*LSDVC AB*	*LSDVC AH*
Inv3(lag)	0.38665***	0.65266***	0.56929***
	(3.07)	(5.58)	(4.94)
tax	0.00817	0.00628	0.0107
	(1.44)	(0.97)	(1.07)
cap	0.15717***	0.10543**	0.09517
	(3.01)	(2.07)	(1.31)
gdp	0.22465	0.21320	0.26253
	(1.34)	(1.28)	(1.05)
lend	0.00022	-0.00045	-0.00021
	(0.14)	(0.29)	(0.09)
debt	0.00122	0.00091	0.00092
	(1.20)	(0.80)	(0.57)
pop	0.17937	0.04649	-0.08657
	(0.64)	(0.13)	(0.17)
R^2-*Adj*	0.5770		
Sargan		0.3576	
m1		0.7438	
m2		0.8014	
Obs.	109	102	102

GLS cross section weights used. Instrument for 2SLS is second lag of the dependent variable. For LSDVC, bias correction up to order $O(1/T)$; boostrap variance-covariance matrix with 100 iterations.

Table 3.13: Results in Levels, Investment in Redistribution per Trend GDP

4.RED (level)	*2SLS FE*	*LSDVC AB*	*LSDVC AH*
Inv4(lag)	0.43572***	.54735***	.46214***
	(3.27)	(5.71)	(4.03)
tax	-0.00013	0.00084	0.00123
	(0.03)	(0.16)	(0.14)
cap	0.05590	0.05183	0.05221
	(1.43)	(1.45)	(0.85)
gdp	0.22701	0.23844*	0.25135
	(1.59)	(1.71)	(1.02)
lend	-0.00168	-0.00157	-0.00179
	(1.32)	(1.39)	(0.91)
debt	-0.00031	-0.00000	-0.00035
	(0.38)	(0.01)	(0.23)
pop	0.10678	0.12188	0.14232
	(0.48)	(0.49)	(0.32)
R^2*-Adj*	0.4943		
Sargan		0.7139	
m1		0.0010	
m2		0.8878	
Obs.	108	101	101

GLS cross section weights used. Instrument for 2SLS is second lag of the dependent variable. For LSDVC, bias correction up to order $O(1/T)$; boostrap variance-covariance matrix with 100 iterations.

It turns out that 2SLS supports our basic estimations in Section 3.4.4: As before, the tax variable is significant for Infrastructure, while Redistribution is unaffected by a change in the tax share. Moreover, Hospitals and Schools are also positively affected by decentralization, while Public Goods are not. Thus, 2SLS speaks even more in favor of our theoretical hypothesis on input competition than 1-step GMM does. The results suggest that the potential bias of 1-step GMM for our sample is likely to be small.

In order to further verify the reliability of 1-step GMM with our data, we also use LSDVC. However, the different specifications of LSDVC do not provide a clear picture: The Sargan test and Arrelano-Bond autocorrelation tests for first-stage regressions do not reject LSDVC AB. Therefore, we conclude that this estimator is consistent. Indeed, the results are in line with our findings in Section 3.4.4 in terms of significance and parameter values - particularly for our decentralization variable. The only difference occurs for investment of type 3: Its decentralization parameter is not significant. This supports our robustness checks in Sections 3.4.5 to 3.4.8. Thus, overall AB LSDVC is in line with our hypothesis that regions compete in public inputs for private capital and suggests that the bias underlying the GMM and FE OLS results does not drive our results.

As mentioned, in theory the LSDVC approach based on Anderson-Hsiao (AH) outperforms the GMM based LSDVC estimator (AB) for N and T as in our sample (again, see Judson and Owen (1996)). Therefore, we also present AH-LSDVC results in Tables 3.10 to 3.13. It becomes evident that all variables apart from the lagged dependent are insignificant. This puts doubts on whether these results should be interpreted in our case. In particular, it seems puzzling that neither GDP nor conditional capital transfers do affect any of the four types of public investment. We would expect at least some of them to be positively correlated with either GDP or conditional transfers. The reason for the weak performance of AH LSDVC is likely to be due to the high level of aggregation of our data and the structural inbalancedness of our sample (there are few years missing for most countries, whereas for other years the sample is complete). Given the discrepancy between the empirical superiority of LSDVC AB (which is accepted by statistical tests) and the theoretical superiority of AH (but its overall insignificance), LSDVC serves as a robustness check rather than our basic regression methodology.

3.5 Conclusion

The analysis of the relationship between fiscal decentralization and the composition of public investment is first-of-a-kind, at least in the European context. It yields some interesting insights, most notably that fiscal decentralization seems to boost economically productive public investment and to curb the relative share of economically less productive public investment.

While not readily reconcilable with the traditional theory of fiscal federalism, especially as regards the provision of local public goods, these findings can be interpreted in terms of the literature on fiscal competition, with not only tax rates but also the quality of public expenditure weighing in firms' location decisions. The finding that decentralization reduces the relative share of Redistribution investment can also signal over-investment in more centralized system with competition for a common pool of resources.

Several robustness checks are conducted to verify model specification and econometric approach: Redefining our measure of decentralization did not affect our result that public inputs increase in decentralization. Also, regrouping types of public investment as well as the inclusion of external competition in the analysis confirm our findings. In terms of methodological robustness checks, Two Stage Least Squares and Corrected Least Squares Dummy Variable estimators suggest that the potential bias of 1-step GMM estimators with macro data is unlikely to drive our results.

Clearly, this is but a first step in the analysis of the composition of public investment. There is plenty of scope for future research to tackle issues that our analysis leaves open. The theoretical foundations for studying the composition of public investment remain thin, especially as regards the articulation of an explicit link between fiscal federalism and different types of investment. Empirical examination of different types of public investment could usefully focus on differences in their productivity, as well as on a more nuanced examination of what drives the different types of investment, including but not limited to fiscal federalism.

3.6 Appendix

Proof of Proposition 3.1:

Proof by comparing first best provision with the non-cooperative equilibrium:

First Best ($T > 0$ and $\tau = 0$):

FOC wrt. T:

$-V_X + V_G = 0.$

Thus, $\frac{V_G}{V_X} = 1$, this implies first best provision of G.

FOC wrt. P:

$V_X \cdot (F_P + F_K \cdot K_P - (r + \tau) \cdot K_P) + V_G \cdot (\tau \cdot K_P - 1) = 0.$

Thus, $F_P = \frac{V_G}{V_X}(1 - \tau \cdot K_P)$.

This implies $F_P = 1$ since $\tau = 0$ and $T > 0$ in the first best and $-V_X + V_G = 0$ by FOC wrt. T.

Non-cooperative equilibrium ($T = 0$ and $\tau > 0$):

FOC wrt. τ:

$V_X \cdot (F_K \cdot K_\tau - K - (r + \tau) \cdot K_\tau) + V_G \cdot (K + \tau \cdot K_\tau) = -V_X \cdot K + V_G \cdot (K + \tau \cdot K_\tau) = -V_X \cdot K + V_G \cdot K(1 + \frac{\tau \cdot K_\tau}{K}) = 0$ (using $r + \tau = F_K$).

Thus, $\frac{V_G}{V_X} = \frac{K}{K\left(1+\frac{\tau \cdot K_\tau}{K}\right)} > 1$. This implies under-provision of G compared to the first best.

FOC wrt. P:

$V_X \cdot (F_P + F_K \cdot K_P - (r+\tau) \cdot K_P) + V_G \cdot (\tau \cdot K_P' - 1) = 0.$

From this,

$F_P = \frac{V_G \cdot (1-\tau \cdot K_P)}{V_X} = \frac{(1-\tau \cdot K_P)}{1+\frac{\tau \cdot K_\tau}{K}}.$

Two effects are responsible for the deviation from first best ($F_P = 1$): $-\tau \cdot K_P$ is the public input effect, which positively affects the provision of P. $\frac{\tau \cdot K_\tau}{K}$ is the tax competition effect, which has a negative impact on the provision of P. It is no longer clear, whether P is over- or under-provided relative to the first best.

■

Proof of Proposition 3.2:

The proof consists of two steps. First determine F_P and $\frac{V_G}{V_X}$ for the non-cooperative equilibrium. Second, substitute these results in Equation (3.2). Thereby, one can show that at the optimum $\frac{dV}{dP} < 0$:

1. Determine F_P and $\frac{V_G}{V_X}$ for the non-cooperative equilibrium:

$$L = V\left(F(P,K) - (r+\tau)\cdot K + r\overline{K} - T, (\tau \cdot K(\tau,P) - P)\right)$$

FOC wrt. P:

$$V_X \cdot (F_P + F_K \cdot K_P - (r+\tau)\cdot K_P) + V_G \cdot (\tau \cdot K_P - 1) = V_X \cdot F_P + V_G \cdot (\tau \cdot K_P - 1) = 0$$
(using $r + \tau = F_K$)

FOC wrt. τ:

$$-V_X \cdot K + V_G \cdot (K + \tau \cdot K_\tau) = 0 \text{ (using } r + \tau = F_K\text{)}$$

From FOC wrt. P:

$F_P = (1 - \tau \cdot K_P) \cdot \frac{V_G}{V_X}$. From FOC wrt. τ: $\frac{V_G}{V_X} = \left(1 + \frac{\tau \cdot K_\tau}{K}\right)^{-1} > 1$

for K_τ smaller zero. The marginal productivity of G is larger than that of the private good. G is underprovided.

2. Plug F_P and $\frac{V_G}{V_X}$ into Equation (3.2):

$$dV = \left(F_P - \frac{V_G}{V_X}\right) V_X \cdot dP = \left((1 - \tau \cdot K_P) \cdot \frac{V_G}{V_X} - \frac{V_G}{V_X}\right) V_X \cdot dP$$

$$dV = \left(\left(\left(1 - \tau \cdot K_P\right) - 1\right)\left(1 + \frac{\tau \cdot K_\tau}{K}\right)^{-1}\right) V_X \cdot dP$$

$$\frac{dV}{dP} = -\left(\frac{\tau \cdot K \cdot K_P}{K + \tau \cdot K_\tau}\right) V_X < 0.$$

Since we know that $\frac{V_G}{V_X} = \frac{K}{K\left(1+\frac{\tau \cdot K_\tau}{K}\right)} > 1$, it directly follows that $K + \tau \cdot K_\tau > 0$.

Thus, $\frac{dV}{dP} < 0$ implies that rebalancing expenditure from P towards G strictly increases utility.

■

3.7 Appendix

Table 3.14: Summary Statistics

Variable	*Obs*	*Mean*	*Std.Dev.*	*Min*	*Max*
inv1	134	0.00766	0.00351	0.00270	0.01849
inv2	134	0.00511	0.00235	0.00127	0.01345
inv3	132	0.00596	0.00196	0.00231	0.00944
inv4	133	0.00456	0.00246	0.00142	0.01215
tax	158	0.18972	0.11003	0.02061	0.35691
tdec1	160	0.12134	0.09319	0.01739	0.30666
tdec3	160	0.16275	0.09616	0.01739	0.31339
captr	151	0.00735	0.00476	0.00130	0.02004
gdp	160	0.02173	0.00403	0.01373	0.03075
lend	157	-0.03798	0.14311	-0.90478	0.45339
debt	159	0.72395	0.28398	0.14797	1.44307
pop	160	30953.0	28077.3	4964.00	82520.0

Table 3.15: Multi-co-linearity

	tax	*cap*	*gdp*	*lend*	*debt*	*pop*
tax	1					
cap	-0.1664	1				
gdp	0.6460	-0.1708	1			
lend	-0.1163	0.0847	0.2037	1		
debt	0.0762	0.0305	-0.2045	-0.1421	1	
pop	-0.4374	0.1374	-0.3317	0.1210	0.1928	1

Table 3.16: Unit Root Tests

	Effect	*Test*	*Statistic*	*P-value*		*Effect*	*Test*	*Statistic*	*P-value*	
1.INF (level)	ft	LLC	-2.8633	0.002	***	f	LLC	-0.6358	0.263	
		IPS	0.0706	0.528			IPS	0.16646	0.566	
2.HS (level)	ft	LLC	-4.472	0.000	***	f	LLC	-4.66191	0	***
		IPS	-0.8755	0.191			IPS	-2.11709	0.017	**
3.PG (level)	ft	LLC	-3.7699	0.000	***	f	LLC	-3.68242	0.000	***
		IPS	0.0221	0.509			IPS	-2.28425	0.011	**
4.RED (level)	ft	LLC	-1.6212	0.053	*	f	LLC	-3.16266	0.001	***
		IPS	-0.5546	0.290			IPS	-1.0984	0.136	
Lend	ft	LLC	-2.0155	0.022	*	f	LLC	-3.98932	0.000	***
		IPS	-1.2798	0.100			IPS	-1.04089	0.149	
Debt	ft	LLC	-10.593	0.000	***	f	LLC	-0.70526	0.240	
		IPS	-2.6409	0.004	***		IPS	0.58686	0.721	
Cap	ft	LLC	-6.4297	0.000	***	f	LLC	-2.80209	0.003	***
		IPS	-2.6135	0.005	***		IPS	-1.94034	0.026	**
Gdp	ft	LLC	-8.8095	0.000	***	f	LLC	2.14455	0.984	
		IPS	-4.586	0.000	***		IPS	5.18343	1	
Otaxshl	ft	LLC	-2.2478	0.012	**	f	LLC	-0.39658	0.346	
		IPS	-1.8406	0.033	**		IPS	-0.03522	0.486	
Pop	ft	LLC	4.96377	0.000	***	f	LLC	0.42430	0.664	
		IPS	3.25404	0.001	***		IPS	4.39171	1.000	

Tests conducted according to the lag length indicated by Akaike (AIC) information criteria. Asterisks ***, **, and * denote significance at 1 percent, 5 percent and 10 percent level, respectively. f denotes fixed effects and individual effects, denotes time trends.

Table 3.17: Q-test of Autocorrelation for Dependent Variable

	AC	*Q-Stat*	*Prob*
1.INF	0.886	107.56	0.000
2.HS	0.844	97.511	0.000
3.PG	0.810	88.663	0.000
4.RED	0.854	99.156	0.000

Chapter 4

Privatization and Public Social Spending

4.1 Introduction

Privatization is often assumed to affect public revenue. However, there is only little literature analyzing the link between privatization and the expenditure of the government. Nevertheless, Sheshinski et all (2003) argue that one objective of privatization programs is to free resources for allocation in other government activities - e.g. related to social policy. It is the objective of this paper to better understand this link between privatization and the composition of public expenditure.

In particular, we are interested in the link between privatization and the level of public social spending. By privatization we mean a reallocation of control rights over firms from a public towards a private decision maker. Thereby, it may also be interpreted as transfer of risk from the public sector towards individuals being exposed to a higher probability of becoming unemployed. Moreover, private firms may provide less social security services than public firms do. In order to outbalance these additional risks, individuals will adjust their demand for social protection by the government. The suggestion that voters require the government to provide insurance is intuitive, given that it is the government's privatization policy that causes the higher risk. Thus, there are good arguments why privatization should generate higher public social spending.

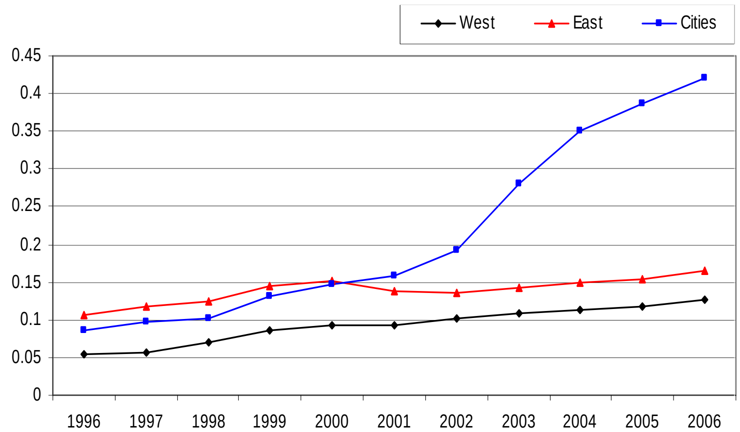
Our theoretical model explains how privatization affects social public spending. Based on Kanbur (1981) and Haskel and Szymanski (1993) we assume two sectors, a private and a public with the risk of becoming unemployed being higher in the private sector. An exogenously given increase of privatization then leads to a higher expected rate of unemployment, and at the same time higher productivity. We investigate how privatization affects the per capita transfer as well as overall redistribution if transfers are financed only through the profits of the public firms or through public profits and a lump-sum tax. Our results suggest that overall redistribution is likely to increase with privatization while per capita transfers decrease if redistribution is financed only through profits of public firms. On the other hand, if lump-sum taxes are available to finance redistribution, overall as well as per capita redistribution increase with privatization. Finally, if it is costly to raise public funds - a commonly accepted characteristic in the literature on public finance - additional distortions arise: The higher need for redistribution (and thereby higher excess burden) leads to additional inefficiencies, which partly offset the productivity gains from privatization.

Although, an empirical analysis of the positive link between privatization and social public expenditure goes beyond the scope of this paper, we provide some data to emphasize our reasoning. We present data on the 31 provinces of China - one of the most dynamic countries in terms of privatization in recent years. Figure 4.1 shows the development of privatization, measured as the share of self- and privately employed individuals over the total number of employees for large cities[1], for the rather developed Eastern Provinces, and for the mostly rural Western Provinces:

The share of employees in the private sector steadily increased from 1996 to 2006. This tendency is most pronounced in urban areas, where privatization increased from 9% to 42%. Although, the development is less pronounced in Eastern (10% to 17%) and Western provinces (5% to 12%) they still follow a clear upward trend. As expected, the level of privatization in the more developed Eastern Provinces is constantly above the level of the more rural Western Provinces. Although huge variation exists among

[1]Cities with provincial status in China include Beijing, Shanghai, and Tianjin

Figure 4.1: Private Sector Employees and Self-Employed as Share of Total, by Type of Province, 1996-2006

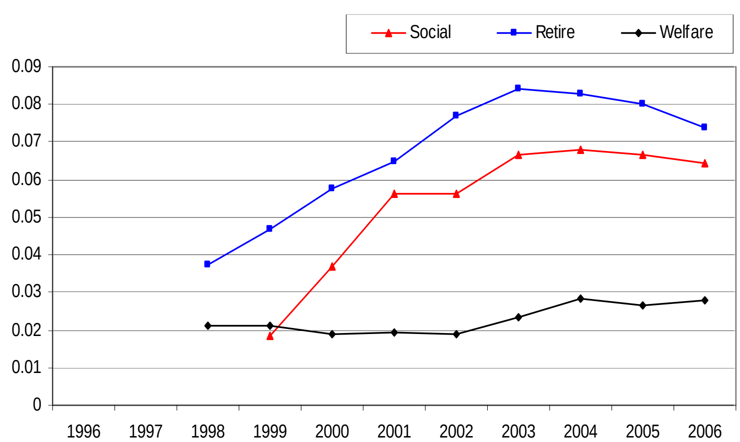


Source: Statistical Office of China, own calculations.

provinces in China, the data suggests that the privatization process is rather dynamic throughout the country.

In contrast, Figure 4.2 shows the development of public social expenditure by category as share of overall public expenditure. Figure 4.2 presents social public expenditure by category as defined by the OECD (2007) upon availability of data.[2]

Figure 4.2: Social Public Expenditure by Category as Share of Total, Province Average, 1996-2006



Source: Statistical Office of China, OECD(2007), own calculations.

It becomes evident that also the composition of public expenditure throughout this

[2]The OECD categorizes social spending into 9 fields. Date on some of them, such as "family" or "other social policy areas", are not available for China

period is characterized by notable changes: There is a clear upwards trend in the development of the three social categories of public expenditure in Figure 4.2. The share of Social Expenditure and Retirement rose from 2% to 6% and from 4% to 7.5%, respectively. Although, the development of Welfare Expenditure (including pensions for disabled and civil affairs) is less pronounced, it still increased by about 50% from 2 percentage points to 3 percentage points. After all, the data suggests that China was characterized by a very dynamic development of privatization as well as an over-proportional increase of social expenditure in the last decade.

The evidence from China is also backed by data from other countries: E.g. Erdmann (1998) investigates the development of social spending relative to GDP in Poland, Hungary and the Slovak Republic throughout the transformation period in the 1990s. Indeed she finds that although GDP decreased in the years after the system transformation, social spending as share of GDP increased for all three countries. Note as that in the case of China, these findings are unable to prove a direct link between privatization and social public spending. Though, the data does provide evidence to motivate the theoretical arguments that we develop below.

The paper is organized as follows. After a short literature review in Section 4.2, Section 4.3 presents a theoretical model to identify the positive link between privatization and social expenditure by the government. In Section 4.4 we analyze the link between privatization and redistribution if transfers are only financed through profits of public firms. In Section 4.5 we extend this setting by introducing lump-sum taxes on workers to finance redistribution. Section 4.6 also accounts for the potential costs of taxation in order to finance redistribution. Finally, Section 4.7 concludes.

4.2 Literature Review

While some macro-implications of privatization are still obscure as outlined by Sheshinski et al. (2003), other aspects have already been discussed in more detail: E.g. several authors looked at the link between privatization and overall economic growth: Barnett (2000) finds a significantly positive link, in particular for non-transition countries. He also shows that privatization goes hand in hand with fiscal consolidation. This is also confirmed by Jeronimo et al. (2000) testing this relationship with data on four southern states in the US from 1990 to 1997.

However, there is hardly any literature on the link of privatization and the composition of public expenditure. The starting point for our theoretical model is an hypothesis developed by Grossman and Hart (1983) and Laffont and Tirole (1993). They show how the relationship between principals and agents changes with privatization due to a risk transfer from the public towards the private sector. In this context, Kanbur (1981) proposes a model with two sectors, employees and entrepreneurs, where the latter face the risk of failing with their business. This allows him to determine the optimal share of workers in each sector. In a broader sense this setting could be interpreted in terms of privatization, with a higher risk of becoming unemployed in the private sector. However, with this interpretation, the basic idea of Kanbur (1981) that individuals in one sector (entrepreneurs) employ workers from the other sector (employees) is problematic. This brings us closer to Haskel and Szymanski (1993). They assume a private and a public production sector, with privatization changing the objective of a firm away from social aspects towards more profit orientation. This implies that employment declines with privatization. They also analyze the implications of privatization for wages; and identify a negative link. Their theoretical findings are also supported by the empirical evidence they provide for a sample of 14 firms in the UK.

The negative effect between privatization and employment is not without controversy. E.g. Brown et al. (2005) find that there is a positive - though small- employment effect of privatization due to its potential positive effect on efficiency. Aghion and Blanchard (1993) show that depending on the level of unemployment privatization may lead to more or less jobs. Balla et al. (2004) extend this setting by distinguishing between skilled and unskilled labor. For our approach, this latter finding implies that a higher need for redistribution can be motivated by arguments going beyond the overall unemployment rate. Indeed, unemployment among unskilled workers is likely to increase, even if privatization leads to notable efficiency gains. Balla et al. (2004)

propose a subsidy towards unskilled workers to smooth this effect. However, their inter-temporal setting does not concentrate on public expenditure in the first place - as we do - but mainly focus on the labor market implications of privatization.

The idea that a certain policy measure implies additional risks for individuals and hence should be accompanied by social measures has already been discussed in other contexts: E.g. Rodrik (1998) claims that the size of government is larger in open economies, because the associated risk for individuals becomes larger through more interactions with other economies. Kreider (2003) shows how income uncertainty - which may be related to the risk of becoming unemployed - affects redistribution. He shows that the degree of risk aversion is an important variable to explain the relationship between uncertainty and redistribution.

4.3 Model

Based on Haskel and Szymanski (1993) and Kanbur (1981) we set up a two sector model - with a private and a public sector. While we assume full employment in the public sector, the deterministic probability of becoming unemployed in the private sector is strictly larger zero. This is a simplified representation of the higher propensity of the state for full employment.[3] Assuming a deterministic rate of unemployment in order to simplify the labor market and thereby receive explicit solutions for other variables of interest (in our case redistribution) is a common feature in public economic theory. Good examples are Kreider (2003) or Boycko et al. (1996).

We assume a productivity parameter of labor being larger in the private than in the public sector, $\gamma_{priv} > \gamma_{pub}$. This assumption is in line with the common belief that profit oriented, private firms are generally more efficient and productive. Higher productivity in the private sector is the justification, why the state should be interested in

[3]For instance, Haskel and Szymanski (1993) introduce a deterministic propensity of the public sector for high employment by introducing a variable A, which is strictly larger in the public sector. Our approach is similar in the sense that we assume a higher preference for employment in the public sector. However, for simplicity we don't introduce a complete labor market, but instead assume the unemployment rate in the private sector to be deterministic.

privatization in our model. The overall labor force in the economy is normalized to 1 with ρ being the share of labor employed by private firms. The government maximizes utilitarian welfare and engages in redistribution from workers towards unemployed individuals.

4.3.1 Firms

Firms only use labor as input in the production process. For simplicity we assume a linear production technology. With prices normalized to one, the profit of a private sector firm writes

$$\pi_{priv} = \rho \cdot (\gamma_{priv} - w) = 0 \tag{4.1}$$

w is the wage rate in the private sector. Given the linear production function, profits in the private sector are defined as the difference between marginal productivity and wage rate times the number of employees. However, in line with the assumptions for perfect competition (large number of firms) in the product market, $w = \gamma_{priv}$ throughout the paper. Wages in the private sector correspond to the marginal productivity of this sector; private profits are consequently equal to zero. In order to simplify our calculations, the labor market in our model is incomplete. We assume a deterministic unemployment rate in the private sector as explained above. This is also the reason, why wages can not adjust to eliminate unemployment. The idea is to capture in a simple manner the assumption that privatization leads to higher unemployment.[4] Similarly, profits in the public sector are defined as

$$\pi_{pub} = (1 - \rho) \cdot (\gamma_{pub} - v) \tag{4.2}$$

with v as the wage rate in the public sector. The profit function of the public sector resembles that of the private sector. There is, however, one important difference: For

[4].e.g. see Haskel and Szymanski (1993) for a theoretical analysis as well as an empirical verification of this hypothesis.

the public sector, we do not impose any restrictions on the value of v a priori: The public sector can, but must not pay wages equal to the marginal productivity of labor - even under perfect competition. This holds since the government can outbalance positive or negative profits of public firms through its budget as it is also proposed in Shleifer and Vishny (1994). Indeed, it is often argued that public firms make losses due to excess employment or higher public wages, which then enter the budget constraint of the government. This is also the case in our setting, as we will see below.

4.3.2 Households

We distinguish among households assigned to the public and private sector, respectively. Public employees do not face any risk of becoming unemployed. On the contrary, households in the private sector are exposed to unemployment with probability $(1-p)$. Correspondingly, p is the probability of being employed once an individual is assigned to the private sector. Together with our assumptions from above, our model implies a deterministic unemployment rate of $\rho \cdot (1-p)$.

We define preferences for each individual as a function V, with $V' > 0$ and $V'' < 0$, depending on net-income, only. The concavity of the utility function introduces a preference of the government for equity.[5] Preferences in the public sector write

$$V(C_{pub}) = V\left(v\right)$$

Correspondingly, the expected utility in the private sector is

$$V(C_{priv}) = p \cdot V\left(w\right) + (1-p) \cdot V\left(b\right)$$

b is the per capita unemployment benefit provided by the government towards unemployed individuals. We assume that $p \cdot w = p \cdot \gamma_{priv} > \gamma_{pub}$. Thus, the expected wage of an individual in the private sector is larger than its deterministic efficiency in the

[5]For the moment no income tax does exist. This assumption will be relaxed later on.

public sector. Or, to put it differently, privatization leads to an overall increase in expected income since the expected productivity of an employee in the private sector exceeds the productivity in the public sector.[6]

4.3.3 State Sector

The state maximizes utilitarian welfare with respect to the individual unemployment benefit, b, subject to its budget constraint. In the following we assume a logarithmic utility function for all individuals - a functional form satisfying the concavity conditions from above. The utilitarian welfare function reads

$$W = (1-\rho) \cdot ln\,(v) + \rho \cdot (p \cdot ln\,(w) + (1-p) \cdot ln\,(b)) \tag{4.3}$$

ρ may be interpreted as a measure for privatization. For the moment, the state does not levy a lump-sum tax to finance individual unemployment benefits, b. Instead, profits of public firms are the only source of income to finance redistribution. Consequently, the government has no tax income to finance redistribution. This assumption is critical for two reasons: First in most countries, redistribution is at least partly financed by taxes on wages. Second, while the number of unemployed individuals steadily increases with ρ, the public sector and thereby the number of contributors to the redistribution systems shrinks. In a completely privatized economy the number of persons financing redistribution converges to zero requiring other means to finance redistribution. Usually, unemployment benefits are at least partly financed through income taxes. For the moment, we concentrate on public profits in order to isolate the link between the public budget and privatization and how it affects the utility of individuals in the public and private sector. Section 4.5 will relax this assumption and introduce taxes to co-finance unemployment benefits. In the present setting, the

[6] This assumption is a lower bound for $\gamma_{priv} > \gamma_{pub}$.

budget constraint of the state writes:

$$(1-\rho)\cdot(\gamma_{pub}-v)=\rho\cdot(1-p)\cdot b \tag{4.4}$$

Thus, the profits in the public sector equal its social expenditure for redistribution. This implies that in the case of positive redistribution transfers b, $\gamma_{pub} > v$ must hold. Since $w = \gamma_{priv} > \gamma_{pub}$, the wage paid in the public sector must therefore be well below the wage in the private sector.[7]

The public budget constraint unambiguously determines the wage rate in the public sector:

$$v=\gamma_{pub}-\frac{\rho}{1-\rho}\cdot(1-p)\cdot b. \tag{4.5}$$

It increases in γ_{pub} and p, and decreases in b and ρ: If the marginal productivity in the public sector γ_{pub} increases, we can see from Equation (4.2) that the public firm's balance increases and therefore the public sector has more funds available. This allows for higher public wages. On the other hand, a higher level of per capita redistribution b requires more public spending. The only way to finance b is to reduce wages in the public sector. Moreover, v decreases in ρ: More privatization yields higher expected unemployment and therefore a higher need of public funds, which can only be generated through a reduction in v. Note also that a higher probability of employment p in the private sector reduces the need for redistribution. The production of public firms can then be used to a larger extent for compensating its employees; v increases.

[7]This result contrasts the findings in Haskel and Szymanski (1993). They determine a wage rate being higher in the public than in the private sector. However, their finding does not account for higher efficiency in the private sector or the financing of redistribution through public profits as we do. Instead, what drives their results is the distinction between different welfare weights for unions and consumer surplus, respectively.

4.4 Result without Lump-Sum Tax

The government redistributes from workers towards unemployed individuals, which is welfare improving due to its utilitarian welfare objective and the concavity of consumers' preferences. To asses the optimal per capita unemployment transfer, the government maximizes Equation (4.3) wrt. b subject to its budget constraint in Equation (4.4). This yields the following first order condition:

$$\frac{\partial W}{\partial b} = (1-\rho) \cdot \frac{1}{v} \cdot \frac{\partial v}{\partial b} + \rho \cdot (1-p) \cdot \frac{1}{b} = 0$$

It states that the negative impact of a higher b on public wages (first term) needs to be exactly outbalanced by the benefits of a larger b for the unemployed (second term). Since we deal with utilitarian welfare, the two opposing effects are weighted by the marginal utility times the number of persons concerned. Solving for b yields Proposition 4.1.

Proposition 4.1:

i) The optimal redistribution rate is characterized by $b = \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p}$.

ii) Higher privatization implies a decrease in the optimal redistribution rate b *and an increase in overall redistribution* $(b \cdot \rho \cdot (1-p))$ *if and only if* $p > \frac{2 \cdot \rho - 1}{\rho^2}$.

iii) Redistribution from public workers to unemployed individuals is perfect, in particular $w > v = b$.

Proof see Appendix 4.8. ■.

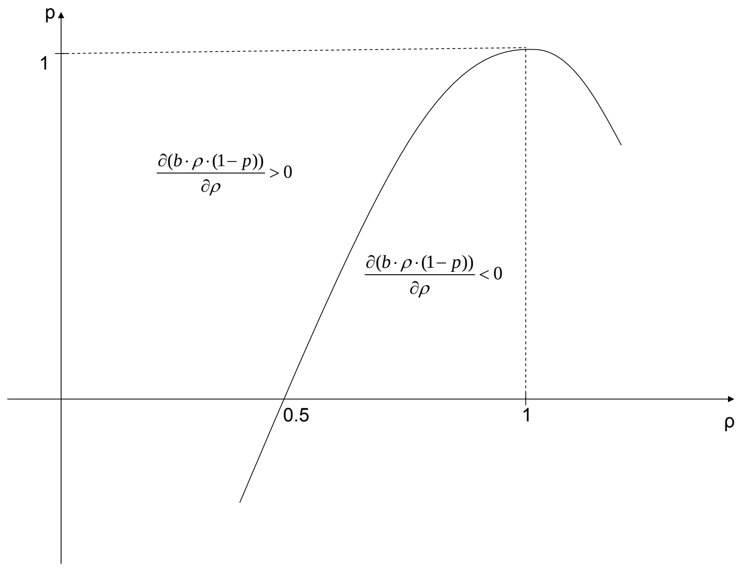
The optimal redistribution rate depends on ρ, γ_{pub}, and p: As expected, b increases in γ_{pub}. Higher productivity in the public sector makes more public funds available, which can be distributed among public workers and unemployed. Intuitively, b also increases in p: A higher probability of being employed in the private sector requires less overall redistribution. The reduced overall requirement for public spending is then transferred partly to workers in the public sector through higher wages and partly to unemployed through higher per-capita transfers in order to equalize marginal utilities.

The second part of Proposition 4.1 claims that privatization leads to lower per-capita redistribution b. If public firms are privatized, more people face the exogenously given risk of becoming unemployed, $(1-p)$. Further, privatization leads - by definition - to a decrease in the number of public workers (and in our case the number of contributors to the redistribution system). If the number of expected transfer receivers increases at the cost of the number of contributors, individual unemployment benefits need to decrease. Otherwise, the tax burden for contributors would be too high to restore the optimality condition for redistribution of equal marginal utilities.

Furthermore, overall redistribution, defined as per capita redistribution times the expected number of unemployed, increases with privatization if $p > \frac{2 \cdot \rho - 1}{\rho^2}$. Privatization increases the expected number of unemployed persons, implying a higher need for redistribution (direct effect). On the other hand, we have seen that per capita redistribution transfers decrease in ρ (indirect effect): Due to the assumed utilitarian welfare objective and the functional form of individual preferences, the government wants to distribute the cost of additional unemployment evenly throughout the society. This has a negative, indirect impact on overall redistribution. Which of these two effects prevails depends on the parameter values of p and ρ determining the share of unemployed individuals in the economy. To see this, Figure 4.3 displays the graph of $p = \frac{2 \cdot \rho - 1}{\rho^2}$, that is the condition determining the sign of the derivative of overall redistribution with respect to privatization.

In an economy with high expected unemployment (ρ high and p low) overall redistribution decreases in privatization, meaning that the indirect effect prevails: With a large number of unemployed, the reduction in b for each transfer receiver has a larger aggregate effect on redistribution than the marginal increase in transfer receivers caused by privatization. On the other hand, if the expected unemployment rate is low (ρ low and p high), the direct effect prevails and overall redistribution increases in privatization: The number of public workers is large relative to the number of unemployed. Therefore, most of the cost of additional unemployment will be financed through lower public wages rather than the reduction in b. Privatization leads then to an increase in

Figure 4.3: Sign of Derivative of Overall Redistribution wrt. ρ



Source: own calculations.

overall redistribution. Loosely speaking, if unemployment is low, the government can generously increase overall redistribution, since this cost is born by a relatively large number of public workers. This is not possible if unemployment is high.

Part three of Proposition 4.1 says that while the income of private employees exceed the income of public workers and unemployed, redistribution between public workers and unemployed is perfect: Since the financing of redistribution through public profits does not imply any loss whatsoever, the government can perfectly redistribute among public workers and unemployed individuals. Thereby, it achieves its first best objective of identical marginal utilities for these two groups. On the other hand, absent taxes, there are no feedback effects of redistribution on private workers - they are simply not involved in redistribution. Since private wages correspond to the higher productivity in this sector, the utility of private workers exceeds the utility of both public workers and unemployed individuals. Thus, the instrument to finance redistribution is incomplete because it does not involve private workers. The government can therefore achieve its objective to equalize marginal utilities only for two out of three consumer groups.

4.5 Result with Lump-Sum Tax

In Section 4.4 public profits have been the only means to finance redistribution. As we have seen this assumption is critical. In this section we therefore introduce an additional tool to raise public funds: lump-sum taxes on public and private workers. This enables the government to also involve private workers in financing unemployment benefits.

With lump sum taxes on workers, the objective function of the government writes.

$$max_{\tau,b}W = (1-\rho)\cdot ln\,(v-\tau) + \rho\cdot(p\cdot ln\,(w-\tau) + (1-p)\cdot ln\,(b)) \tag{4.6}$$

Correspondingly, its budget constraint reads

$$(1-\rho)\cdot(\gamma_{pub}-v) + (1-\rho+\rho\cdot p)\cdot\tau = \rho\cdot(1-p)\cdot b$$

Besides public profits, the lump sum tax on both public workers $(1-\rho)$ and private workers $(\rho\cdot p)$ is available to cover social expenditure. The budget constraint unambiguously determines the wage rate in the public sector:

$$v = \gamma - \frac{1}{1-\rho}\cdot((1-p)\cdot\rho\cdot b - (1-\rho+\rho\cdot p)\cdot\tau)$$

As before, the public wage rate decreases in b and ρ, and increases in p and in the productivity of the public sector. New is the positive impact of τ on v: τ is an additional instrument to finance redistribution, which (differently from public profits) also includes private workers. Thus, while τ does put a burden on workers in the public sector, it also implies a reduced need to generate public profits in order to cover unemployment benefits. This latter effect has a positive impact on v, since τ assures that the cost of redistribution is no longer covered by public workers, only. The linear budget constraint assures that public wages increase faster than the tax rate does, implying an overall increase in the net income of public workers. Using the budget constraint and deriving Equation (4.6) with respect to τ and b yields the following first order conditions:

$$\frac{\partial W}{\partial \tau} = (1-\rho) \cdot \frac{1}{v-\tau} \cdot \left(\frac{\partial v}{\partial \tau} - 1 \right) + \rho \cdot p \cdot \frac{1}{w-\tau} \cdot (-1) = 0$$

and

$$\frac{\partial W}{\partial b} = (1-\rho) \cdot \frac{1}{v-\tau} \cdot \frac{\partial v}{\partial b} + \rho \cdot (1-p) \cdot \frac{1}{b} = 0$$

The first order condition wrt. b is similar to the one in Section 4.4 with the only difference that now incomes net of lump-sum taxes matter. The optimality condition for τ requires that at the margin the positive net effect of higher lump-sum taxes for public workers equals the negative income effect for private employees. This is again weighted by the size and marginal utilities of the two groups. Solving for τ and b results in

Proposition 4.2:

i) The optimal redistribution rate is characterized by $b = \rho \cdot p \cdot w + (1-\rho) \cdot \gamma_{pub}$, the optimal lump-sum tax by $\tau = w - \rho \cdot p \cdot w - (1-\rho) \cdot \gamma_{pub}$.

ii) Privatization implies an increase in b and in overall redistribution $(b \cdot \rho \cdot (1-p))$.

iii) Redistribution is perfect, in particular: $w - \tau = v - \tau = b$.

Proof see Appendix 4.8. ■.

The optimal redistribution transfer corresponds to the weighted sum of the productivity levels in the two sectors, with the weights corresponding to the share of workers in each sector. Since the number of individuals is normalized to one, this is equivalent to the per-capita productivity in the economy. γ_{pub} and now also $\gamma_{priv} = w$ have a positive impact on the optimal choice of b.

The characteristics of the optimal τ yield some interesting insights in the functioning of the model. First, there is a positive relation between τ and w: With a higher productivity in the private sector, it is welfare improving to shift some cost of redistribution towards this sector: The only way to reach this goal is to increase τ. Second, higher productivity in the public sector has a negative impact on τ. The intuition behind this somewhat surprising result is that higher productivity ceteris paribus increases public profits. Thus, less funds need to be acquired through taxation to finance a given level of redistribution. Moreover, the derivative of the optimal tax rate with respect to privatization, $\frac{\partial \tau}{\partial \rho} = -p \cdot w + \gamma_{pub}$, is negative: Since (differently from Section 4.4) public profits are negative, redistribution occurs also from private workers towards public workers. In a highly privatized economy, the most productive group in the economy is relatively large. Thus, the per capita burden of redistribution for this group can be relaxed corresponding to a reduction in τ.

The impact of privatization on per capita redistribution is now positive contrasting the result from Section 4.4. The interpretation is as follows: By assumption, the expected productivity in the private sector exceeds the productivity in the public sector. This implies that an increase in ρ leads to a higher average productivity in the economy allowing for higher per capita transfers towards the unemployed. In Section 4.4 this mechanism did not work. There was no means to tax workers in the more productive sector. The number of contributors decreased one to one with privatization. This also explains why our result from above that overall redistribution increases with privatization is more clear-cut in this section: Privatization leads to a higher expected productivity in the economy and at the same time higher unemployment - both speaking in favor of higher overall redistribution.

The government perfectly insures individuals against the risk of becoming unemployed in the private sector by equalizing marginal utilities beyond all three states (public and private employment as well as unemployment). Indeed, given the risk aversion and identical utility functions of individuals in each state, the best a government can do is to equalize the income of individuals beyond states. The government disposes over two instruments to reach this goal (public profits and lump sum taxes). None of them entails any additional cost. Thus the government can equalize marginal utilities without introducing additional distortions. This is realized in two steps: First, it sets the redistribution transfer b such that it equals net income in the private sector.

Second, with public profits the government has a second tool to assure that the net income in the private and public sector are equal. Since $v < w$ and taxes are imposed in lump-sum form on all workers, public profits must be negative. Thus, the public wage exceeds the productivity of workers in this sector. This result contrasts the result from Section 4.4 where public profits have been positive in order to finance redistribution.

The results in Sections 4.4 and 4.5 can be interpreted in a more policy relevant context. First of all, privatization appears to be an important factor to understand what determines the composition of public spending. Our model suggests that privatization leads to additional risks and thereby a higher demand for social spending of the government. It is therefore not enough to evaluate the efficiency gains of a privatization reform in order to assess its overall performance. Rather, it is necessary to also account for potential shifts in the demand for public goods. While privatization implies less state control in one respect, it leads to higher state intervention in other fields undermining one of the most important aspects of privatization efforts. Thus, in order to properly understand the consequences of a privatization reform, it is imperative to also understand its implications for the level and composition of public spending. This finding is particularly important for transition economies characterized by huge privatization efforts.

4.6 Excess Burden of Taxation

As we have seen, privatization is likely to require higher social public spending and therefore public funds. If these funds are financed through taxation, another undesired effect may arise: Excess burden of taxation. Indeed, it is often argued that raising one unit of public funds generates a tax burden larger than one (Laffont and Tirole (1993)). The most immediate interpretation of this finding is a distortion through taxation. With lump-sum taxes - as assumed throughout this chapter - such distortions do not arise. However, with the approach by Laffont and Tirole (1993) they can be easily implemented without loosing the mathematical simplicity that lump-sum taxes offer. Thus, our discussion from above is incomplete because we disregard the fact that privatization generates an additional negative effect through its higher need for social spending. For this purpose, we extend the model from Section 4.5 by introducing an excess burden of taxation.

Compared to Section 4.5 the welfare function of the government remains unchanged (see Equation (4.6)). On the other hand, the budget constraint of the government rewrites

$$(1-\rho)\cdot(\gamma-v)+(1-\rho+\rho\cdot p)\cdot\tau\cdot(1-\lambda)=\rho\cdot(1-p)\cdot b$$

with λ representing the excess burden. A share λ of each unit of tax-funds raised is omitted from the equation due to the excess burden of taxation.

Maximizing the welfare function of the government wrt. b and τ and considering its new budget constraint yields

$$b=\frac{\gamma\cdot(1-\rho)+(\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda)\cdot\tau}{1-\rho\cdot p}$$

and

$$\tau=\frac{w\cdot\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}-\gamma+\frac{1}{1-\rho}\cdot(1-p)\cdot\rho\cdot b}{\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}+\frac{1-\lambda}{1-\rho}\cdot(1-\rho+\rho\cdot p)-1}.$$

Merging these two expressions leads to the explicit solution of the model and Proposition 4.3:

Proposition 4.3:

i) Excess burden λ leads to a decrease in b and an increase in τ.

ii) Redistribution is no longer perfect, in particular: $w-\tau>v-\tau=b$, if $\gamma\cdot(1-\rho)+w\cdot\rho\cdot p>(1-\rho+\rho\cdot p)\cdot\lambda$.

Proof see Appendix 4.8. ■.

Introducing λ notably complicates the explicit solution for b and τ. However, we do fall back to results in Section 4.5 for $\lambda = 0$. As comparative statics show, λ implies a decrease in b and an increase in τ: If the cost of raising one unit of additional tax income increases, it is no longer optimal to maintain the unemployment benefits from Section 4.5: Exploiting the advantage of lump-sum taxes (redistributing among three instead of two consumer groups) now entails an excess burden. The government wants to evenly distribute this cost among all three groups of consumers. The only way to reach this goal is to increase the tax rate for tax payers (that is the workers in the private and the public sector) and at the same time reduce the redistribution rate b. The reduction in b assures that also unemployed individuals participate in financing the additional cost of taxation.

This has considerable consequences for the overall level of utility of each of the three groups of consumers. Evidently, the utility must decreases for all three groups if τ increases and b decreases as described above. However, a-priori it is not clear, whether utility levels are still equal as in Section 4.5 or not. To address this issue, note that the marginal cost of raising one unit of redistributions funds is larger than one due to λ. Therefore, the government will no longer redistribute until complete equity is restored. At one point the difference in marginal utilities will be lower than the cost of redistribution, λ. The government will choose redistribution below first best implying a net income for private workers above the transfer towards unemployed: $w - \tau > b$. Moreover, financing redistribution through public profits allows evading the additional cost of taxation. At the margin it is profitable to reduce public wages slightly in order to forgo λ. This implies that differently from Section 4.5, $v < w$.[8] Note that public profits introduce another form of inequality since it excludes private workers from financing unemployment benefits. Therefore, a τ strictly larger zero is still desirable. Since this does not affect the optimal redistribution between unemployed individuals and public

[8]Note that $v < w$ holds for $\gamma \cdot (1-\rho) + w \cdot \rho \cdot p > (1 - \rho + \rho \cdot p) \cdot w \cdot \lambda$. This implies that the excess burden must be small enough. In particular this condition says that the actual production needs to exceed the maximal possible excess burden in the economy. Indeed, we have seen in Section 4.5 that v increases in τ and we know that a large λ requires high taxes.

workers, the government implements identical utility levels for both unemployed and public workers similar to Section 4.4. In consequence, net wages in the public sector equal redistribution transfers. Thus, overall, $w - \tau > v - \tau = b$. This result is due to the fact that more general instrument to finance redistribution (τ) implies additional costs, whereas the instrument to redistribute between public workers and unemployed (public profits) does not.

The findings in this section allow for interesting policy insights. Privatization may lead to further, indirect distortions: If privatizations increases the need for public social funds, the well known excess burden of taxation may increase and at least partly offset the efficiency gains generated by privatization: Although privatization may lead to higher overall productivity in the economy, it also requires additional redistribution as this paper shows. Additional redistribution, however, may be costly and offset some of the gains from privatization. Thus, in order to correctly evaluate a privatization policy, potential indirect (and undesired) effects need to be taken into account. Thinking further, one could also imagine that the higher need for social spending we found in this paper could imply lower public spending in other sectors (e.g. public investment) rather than higher taxes. If, for instance, the government reduces public investment to finance social spending, the productivity of the private sector may go down.[9] This may outbalance most of the efficiency gains from privatization. After all, this section suggests that for a thorough understanding of privatization, its potential indirect distortions matter.

4.7 Conclusion

Most of the literature on privatization focuses on its micro-economic implications. On the other hand, only few studies exist, which examine its link to macro-variables. In particular it is still unclear, how privatization affects the composition of public

[9] There is a huge literature on the functioning of public investment as a public input. See e.g. Keen and Marchand (1997) for more details.

spending. It is the aim of this paper to contribute to a better understanding of this link.

This paper investigates the impact of privatization on the composition of public expenditure. If the likelihood of becoming unemployed is higher in the private sector, privatization can be interpreted as transfer of risk from the public sector towards individuals. Consequently, individuals demand additional social protection (redistribution) by the government to insure against this risk. Our model shows that this holds under rather mild restrictions, namely that the number of workers in the economy is large enough relative to the unemployed. Further, per capita unemployment benefits do decrease if redistribution is financed by public profits, only: With privatization the number of contributors (public workers) steadily decreases and at the same time the number of transfer receivers (unemployed) increases. This conflict can only be resolved through a reduction in per capita unemployment benefits. On the other hand, results change if the government disposes over lump sum taxes for private and public workers as additional tool to finance redistribution: Per capita transfers then increase with privatization since the higher productivity of an increasing number of private workers is taken into account to determine the optimal redistribution rate. Finally, we also consider excess burden of taxation: If it is costly to raise money for public funds, privatization entails undesired distortions through a higher need of public social spending. In this case, the government is no longer willing to implement optimal redistribution.

The results in this paper allow for several policy insights: Privatization may lead to additional risks, in particular a higher probability of becoming unemployed. This in turn is likely to affect the demand and therefore also level and composition of public expenditure. E.g. while privatization implies less state control in one respect it leads to higher state intervention in other fields undermining one of the most important aspects of privatization efforts. Moreover, we have seen that privatization may lead to additional inefficiencies in the economy: E.g. if more public funds are required to finance the additional social expenditure, the commonly known excess burden of taxation - e.g. administrative costs - may arise and at least partly offset the productivity gains generated by privatization. Thus, in order to properly evaluate a specific privatization reform, one needs to account for its potential indirect distortions in other respects.

Our analysis shows that future research in this direction is highly valuable, in particular, as regards the empirically verification of the link between privatization and redistribution. Further, it might also be interesting to endogenize privatization in order to better understand the tradeoff between the potential efficiency gains through privatization and the potential distortions in other sectors. Finally, a thorough analysis of the link between privatization and different types of public spending could be highly valuable: For instance, higher public social spending may lead to a reduction in other types of public expenditures such as public investment. If public investment serves as public input factor for private firms, this adjustment in the composition of public spending would partly offset the potential productivity gains from privatization.

4.8 Appendix

Proof of Proposition 4.1:

Proof of i):

With the logarithmic utility function, the first order condition wrt. b writes

$\frac{\partial W}{\partial b} = (1-\rho) \cdot \frac{1}{v} \cdot \frac{\partial v}{\partial b} + \rho \cdot (1-p) \cdot \frac{1}{b} = 0.$

Using the budget constraint, this simplifies to

$b = \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p}$

■

Proof of ii):

In order to determine the effect of privatization on redistribution transfers, derive b wrt. ρ:

$\frac{\partial b}{\partial \rho} = \gamma_{pub} \cdot \frac{-(1-\rho \cdot p)-(1-\rho)\cdot(-p)}{(1-\rho \cdot p)^2} = \gamma_{pub} \cdot \frac{-1+\rho \cdot p+p+\rho \cdot (-p)}{(1-\rho \cdot p)^2} = \gamma_{pub} \cdot \frac{-(1-p)}{(1-\rho \cdot p)^2} < 0$

Overall redistribution is defined by $b \cdot \rho \cdot (1-p)$ (per capita transfer times number of unemployed). Using the explicit solution of b and deriving wrt. ρ yields

$\frac{\partial(b \cdot \rho \cdot (1-p))}{\partial \rho} = b \cdot (1-p) + \frac{\partial b}{\partial \rho} \cdot \rho \cdot (1-p) = \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p} \cdot (1-p) + \gamma_{pub} \cdot \frac{-(1-p)}{(1-\rho \cdot p)^2} \cdot \rho \cdot (1-p) =$
$\gamma_{pub} \cdot \frac{1}{1-\rho \cdot p} \cdot (1-p) \cdot \left((1-\rho) + \frac{-(1-p)}{(1-\rho \cdot p)} \cdot \rho\right)$

In order to prove that overall redistribution unambiguously increases with privatization, this expression needs to be larger than 0:

$\gamma_{pub} \cdot \frac{1}{1-\rho \cdot p} \cdot (1-p) \cdot \left((1-\rho) + \frac{-(1-p)}{(1-\rho \cdot p)} \cdot \rho\right) > 0$

or

$1 - 2 \cdot \rho + \rho^2 \cdot p > 0.$

This yields

$p > \frac{2 \cdot \rho - 1}{\rho^2}$.

The graph of this function is displayed in Figure (4.3).

■

Proof of iii):

Show that $v = b$:

$v = \gamma_{pub} - \frac{\rho}{1-\rho} \cdot (1-p) \cdot b = b$

or

$\gamma_{pub} - \frac{\rho}{1-\rho} \cdot (1-p) \cdot \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p} = \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p}$.

This simplifies to

$1 - \rho = 1 - \rho$

qed.

Show that $w > v$:

$w > v = \gamma_{pub} - \frac{\rho}{1-\rho} \cdot (1-p) \cdot b$

or

$w > \gamma_{pub} - \frac{\rho}{1-\rho} \cdot (1-p) \cdot \gamma_{pub} \cdot \frac{1-\rho}{1-\rho \cdot p}$

This simplifies to

$w > \gamma_{pub} \cdot \left(1 - \frac{\rho \cdot (1-p)}{1-\rho \cdot p}\right)$.

Since by definition $w > \gamma_{pub}$ and $1 > \frac{\rho \cdot (1-p)}{1-\rho \cdot p} > 0$ this is always true.

■

Proof of Proposition 4.2:

Proof of i):

With the logarithmic utility function, the first order condition wrt. τ reads

$$(1-\rho)\cdot\frac{1}{\gamma_{pub}-\frac{1}{1-\rho}\cdot((1-p)\cdot\rho\cdot b-(1-\rho+\rho\cdot p)\cdot\tau)-\tau}\cdot\left(\frac{1}{1-\rho}\cdot(1-\rho+\rho\cdot p)-1\right)-\rho\cdot p\cdot\frac{1}{w-\tau}=0.$$

This can be transformed into

$$\tau=\frac{(1-\rho)\cdot(w-\gamma_{pub})+\rho\cdot(1-p)\cdot b}{1-\rho+\rho\cdot p}.$$

The first order condition wrt. b reads

$$(1-\rho)\cdot\frac{1}{\gamma_{pub}-\frac{1}{1-\rho}\cdot((1-p)\cdot\rho\cdot b-(1-\rho+\rho\cdot p)\cdot\tau)-\tau}\cdot\frac{\rho}{1-\rho}\cdot(1-p)-\rho\cdot(1-p)\cdot\frac{1}{b}=0,$$

which yields

$$b=\frac{\gamma_{pub}\cdot(1-\rho)+\rho\cdot p\cdot\tau}{1-\rho\cdot p}.$$

Substituting b and τ respectively yields the result:

$$\tau=w-\rho\cdot p\cdot w-(1-\rho)\cdot\gamma_{pub}$$

and

$$b=\rho\cdot p\cdot w+(1-\rho)\cdot\gamma_{pub}.$$

■

Proof of ii):

Deriving the per capita redistribution transfer b wrt. ρ yields

$\frac{\partial b}{\partial \rho} = (p-1) \cdot \gamma_{pub} + p \cdot (w - \gamma_{pub}) = p \cdot w - \gamma_{pub} > 0$ (by definition).

Deriving overall redistribution $b \cdot \rho \cdot (1-p)$ wrt. ρ yields

$\frac{\partial (b \cdot \rho \cdot (1-p))}{\partial \rho} = b \cdot (1-p) + \frac{\partial b}{\partial \rho} \cdot \rho \cdot (1-p) =$

$= (1-p) \cdot ((1-\rho+\rho \cdot p) \cdot \gamma_{pub} + \rho \cdot p \cdot (w - \gamma_{pub}) + (p \cdot w - \gamma_{pub}) \cdot \rho) > 0.$

■

Proof of iii):

Rewriting τ yields:

$\tau = w - \rho \cdot p \cdot w - (1-\rho) \cdot \gamma_{pub} = w - b$. Thus, $w - \tau = b$.

Since the lump sum tax is equal for workers in the public and private sector, it still needs to be shown that $v = w$: Plugging b and τ into the budget constraint of the government yields

$v = \gamma_{pub} - \frac{1}{1-\rho} \cdot ((1-p) \cdot \rho \cdot b - (1-\rho+\rho \cdot p) \cdot \tau)$

With the explicit solutions for b and τ, this yields

$v = \gamma_{pub} - \frac{\rho \cdot p \cdot w + (1-\rho) \cdot \gamma_{pub} - (1-\rho+\rho \cdot p) \cdot w}{1-\rho}$

or

$v = w$

■

Proof of Proposition 4.3:

Proof of i):

With the logarithmic utility function, the first order condition wrt. τ reads

$$\frac{\partial W}{\partial \tau} = (1-\rho) \cdot \frac{1}{v-\tau} \cdot \left(\frac{\partial v}{\partial \tau} - 1\right) + \rho \cdot p \cdot \frac{1}{w-\tau} \cdot (-1) = 0$$

or

$$\frac{1}{\gamma_{pub} - \frac{1}{1-\rho} \cdot ((1-p) \cdot \rho \cdot b - (1-\rho+\rho \cdot p) \cdot \tau \cdot (1-\lambda)) - \tau} \cdot ((1-\rho+\rho \cdot p) \cdot (1-\lambda) - (1-\rho)) = p \cdot \rho \cdot \frac{1}{w-\tau}.$$

Solving for τ yields

$$\tau = \frac{w \cdot \frac{\rho \cdot p - (1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho} - \gamma_{pub} + \frac{1}{1-\rho} \cdot (1-p) \cdot \rho \cdot b}{(1-\rho+\rho \cdot p) \cdot \left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p \cdot \rho}\right)}.$$

The first order condition wrt. b reads

$$F = \frac{\partial W}{\partial b} = (1-\rho) \cdot \frac{1}{v-\tau} \cdot \frac{\partial v}{\partial b} + \rho \cdot (1-p) \cdot \frac{1}{b} = 0$$

or

$$(1-\rho) \cdot \frac{1}{\gamma_{pub} - \frac{1}{1-\rho} \cdot ((1-p) \cdot \rho \cdot b - (1-\rho+\rho \cdot p) \cdot \tau \cdot (1-\lambda)) - \tau} \cdot \frac{\rho}{1-\rho} \cdot (1-p) = \rho \cdot (1-p) \cdot \frac{1}{b}.$$

Solving for b yields

$$b = \frac{\gamma_{pub} \cdot (1-\rho) + (\rho \cdot p - (1-\rho+\rho \cdot p) \cdot \lambda) \cdot \tau}{1-\rho \cdot p}.$$

Substituting b and τ respectively yields the result:

$$\tau = \frac{w \cdot \frac{\rho \cdot p - (1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho} - \gamma_{pub} + (1-p) \cdot \rho \cdot \frac{\gamma_{pub}}{1-\rho \cdot p}}{(1-\rho+\rho \cdot p) \cdot \left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p \cdot \rho}\right) - \left(\frac{1}{1-\rho} \cdot (1-p) \cdot \rho \cdot \frac{(\rho \cdot p - (1-\rho+\rho \cdot p) \cdot \lambda)}{1-\rho \cdot p}\right)}$$

and

$$b = \frac{\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right)\cdot\gamma_{pub}\cdot(1-\rho) + \left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\cdot\left(w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right) - \gamma_{pub}\right)}{(1-\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right) - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\right)}$$

It still needs to be shown that the derivative of the per capita transfer b wrt. λ is smaller than zero, thus:

$$\frac{\partial b}{\partial\lambda} = \frac{\left((1-\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right) - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\right)\right)\cdot\left(-\gamma_{pub} - \frac{(1-\rho)\cdot\gamma_{pub}}{\rho\cdot p} - w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right) + \gamma_{pub} - \left(w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right)\right)\right)}{\left((1-\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right) - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\right)\right)^2} -$$
$$\frac{\left((1-\rho\cdot p)\left(-\frac{1}{1-\rho} - \frac{1}{\rho\cdot p}\right) + \frac{(1-p)\cdot\rho}{1-\rho}\right)\cdot\left(\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right)\cdot\gamma_{pub}\cdot(1-\rho) + \left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\cdot\left(w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right) - \gamma_{pub}\right)\right)}{\left((1-\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right) - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\left(\frac{\rho\cdot p}{1-\rho+\rho\cdot p} - \lambda\right)\right)\right)^2} < 0.$$

This can be transformed into

$$\left((1-\rho\cdot p)\left(-\frac{1}{1-\rho} - \frac{1}{\rho\cdot p}\right) + \frac{(1-p)\cdot\rho}{1-\rho}\right)\cdot$$
$$\cdot\left(\frac{\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda}{(1-\rho)\cdot\rho\cdot p}\cdot\gamma_{pub}\cdot(1-\rho) + \left(\frac{\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda}{1-\rho+\rho\cdot p}\right)\cdot\left(w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right) - \gamma_{pub}\right)\right) -$$
$$-\left((1-\rho\cdot p)\cdot\frac{\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda}{(1-\rho)\cdot\rho\cdot p} - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\left(\frac{\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda}{1-\rho+\rho\cdot p}\right)\right)\right)\cdot$$
$$\cdot\left(-\frac{(1-\rho)\cdot\gamma_{pub}}{\rho\cdot p} - 2\cdot w\cdot\left(1 - \frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right)\right) > 0,$$

which finally yields

$0 < w\cdot(p\cdot\rho - (1-\rho+\rho\cdot p)\cdot\lambda)$ for $p\cdot\rho - (1-\rho+\rho\cdot p)\cdot\lambda > 0$ and

$0 > w\cdot(p\cdot\rho - (1-\rho+\rho\cdot p)\cdot\lambda)$ for $p\cdot\rho - (1-\rho+\rho\cdot p)\cdot\lambda < 0$.

This is always true.

Further, it needs to be shown that the derivative of the lump-sum tax τ wrt. λ is larger than zero:

$$\frac{\partial\tau}{\partial\lambda} = \frac{\left(-(1-\rho+\rho\cdot p)\cdot\left(\frac{1}{1-\rho} + \frac{1}{\rho\cdot p}\right) + \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\frac{(1-\rho+\rho\cdot p)}{1-\rho\cdot p}\right)\right)\cdot\left(w\cdot\frac{\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho} - \gamma_{pub} + \frac{(1-p)\cdot\rho\cdot\gamma_{pub}}{1-\rho\cdot p}\right)}{\left((1-\rho+\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p\cdot\rho}\right) - \left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\frac{(\rho\cdot p - (1-\rho+\rho\cdot p)\cdot\lambda)}{1-\rho\cdot p}\right)\right)^2} -$$

$$-\frac{\left((1-\rho+\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho}-\frac{\lambda}{p\cdot\rho}\right)-\left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\frac{(\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda)}{1-\rho\cdot p}\right)\right)\cdot\left(-w\cdot\frac{(1-\rho+\rho\cdot p)}{\rho\cdot p}\right)}{\left((1-\rho+\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho}-\frac{\lambda}{p\cdot\rho}\right)-\left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot\frac{(\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda)}{1-\rho\cdot p}\right)\right)^2} > 0.$$

This can be simplified to

$$((1-\rho+\rho\cdot p)\cdot(1-\rho\cdot p)-((1-p)\cdot\rho)\cdot\rho\cdot p)\cdot\frac{p\cdot\rho-(1-\rho+\rho\cdot p)\lambda}{\rho\cdot p\cdot(1-\rho\cdot p)}\cdot w >$$
$$> \frac{1-\rho}{(1-\rho\cdot p)}\cdot\left(w\cdot\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}-\frac{1-\rho}{1-\rho\cdot p}\cdot\gamma_{pub}\right)$$

or

$$0 > -\frac{1-\rho}{1-\rho\cdot p}\cdot\gamma_{pub},$$

which yields the desired result.

■

Proof of ii):

To show that redistribution is no longer complete, we need to prove that $w-\tau > v-\tau$ and $v < w$:

1. $w-\tau > v-\tau$.

This rewrites

$$w > v = \gamma_{pub} - \frac{1}{1-\rho}\cdot((1-p)\cdot\rho\cdot b-(1-\rho+\rho\cdot p)\cdot\tau\cdot(1-\lambda))$$

or

$$w > \gamma_{pub} - \frac{1}{1-\rho}\cdot(1-p)\cdot\rho\cdot\frac{\left(\frac{1-\lambda}{1-\rho}-\frac{\lambda}{p\cdot\rho}\right)\cdot\gamma_{pub}\cdot(1-\rho)+(\frac{\rho\cdot p}{1-\rho+\rho\cdot p}-\lambda)\cdot\left(w\cdot\left(1-\frac{(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right)-\gamma_{pub}\right)}{(1-\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho}-\frac{\lambda}{p\cdot\rho}\right)-\left(\frac{(1-p)\cdot\rho}{1-\rho}\cdot(\frac{\rho\cdot p}{1-\rho+\rho\cdot p}-\lambda)\right)} + (1-\rho+$$
$$\rho\cdot p)\cdot\frac{w\cdot\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}-\gamma_{pub}+(1-p)\cdot\rho\cdot\frac{\gamma_{pub}}{1-\rho\cdot p}}{(1-\rho+\rho\cdot p)\cdot\left(\frac{1-\lambda}{1-\rho}-\frac{\lambda}{p\cdot\rho}\right)-\left(\frac{1}{1-\rho}\cdot(1-p)\cdot\rho\cdot\frac{(\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda)}{1-\rho\cdot p}\right)}\cdot\frac{1-\lambda}{1-\rho}).$$

After some transformations this yields

$$(\gamma_{pub}-w)\cdot\left((1-\rho\cdot p)\cdot\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}-\left((1-p)\cdot\rho\cdot\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{1-\rho+\rho\cdot p}\right)\right) < (1-p)\cdot\rho\cdot$$
$$\left(\frac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\cdot\gamma_{pub}+\frac{p\cdot\rho-(1-\rho+\rho\cdot p)\cdot\lambda}{1-\rho+\rho\cdot p}\cdot\left(w\cdot\left(\frac{p\cdot\rho-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\right)-\gamma_{pub}\right)\right)-(1-\lambda)\cdot(1-\rho\cdot$$

$p) \cdot \left(w \cdot \frac{\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho} - \frac{1-\rho}{1-\rho \cdot p}\gamma_{pub}\right)$

or

$$\gamma_{pub} \cdot (1-\rho) + w \cdot \rho \cdot p > w \cdot (1-\rho+\rho \cdot p) \cdot \lambda,$$

which yields the desired result.

2. $v - \tau = b$:

$\gamma_{pub} - \frac{1}{1-\rho} \cdot ((1-p) \cdot \rho \cdot b - (1-\rho+\rho \cdot p) \cdot \tau \cdot (1-\lambda)) - \tau = b.$

This rewrites

$(1-\rho) \cdot \gamma_{pub} - ((1-\rho+\rho \cdot p) \cdot \lambda - \rho \cdot p) \cdot \tau = (1-p \cdot \rho) \cdot b$

or

$$(1-\rho) \cdot \gamma_{pub} - ((1-\rho+\rho \cdot p) \cdot \lambda - \rho \cdot p) \cdot \frac{w \cdot \frac{\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho} - \gamma_{pub} + (1-p) \cdot \rho \cdot \frac{\gamma_{pub}}{1-\rho \cdot p}}{(1-\rho+\rho \cdot p) \cdot \left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p \cdot \rho}\right) - \left(\frac{1}{1-\rho} \cdot (1-p) \cdot \rho \cdot \frac{(\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda)}{1-\rho \cdot p}\right)} = (1-p \cdot \rho) \cdot \frac{\left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p \cdot \rho}\right) \cdot \gamma_{pub} \cdot (1-\rho) + \left(\frac{\rho \cdot p}{1-\rho+\rho \cdot p} - \lambda\right) \cdot \left(w \cdot \left(1 - \frac{(1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho}\right) - \gamma_{pub}\right)}{(1-\rho \cdot p) \cdot \left(\frac{1-\lambda}{1-\rho} - \frac{\lambda}{p \cdot \rho}\right) - \left(\frac{(1-p) \cdot \rho}{1-\rho} \cdot \left(\frac{\rho \cdot p}{1-\rho+\rho \cdot p} - \lambda\right)\right)}.$$

After some transformations this yields

$$(1-\rho) \cdot \gamma_{pub} \cdot \left((1-\rho+\rho \cdot p) \cdot \frac{\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda}{(1-\rho) \cdot p \cdot \rho} - \left(\frac{(1-p) \cdot \rho}{1-\rho} \cdot \frac{\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda}{1-\rho \cdot p}\right)\right) - ((1-\rho+\rho \cdot p) \cdot \lambda - \rho \cdot p) \cdot \left(w \cdot \frac{\rho \cdot p-(1-\rho+\rho \cdot p) \cdot \lambda}{p \cdot \rho} - \frac{(1-\rho) \cdot \gamma_{pub}}{1-\rho \cdot p}\right) =$$

$$= (1-\rho+\rho\cdot p)\cdot\left(\tfrac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}\cdot\gamma_{pub}+\tfrac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{1-\rho+\rho\cdot p}\cdot\left(w\cdot\tfrac{\rho\cdot p-(1-\rho+\rho\cdot p)\cdot\lambda}{p\cdot\rho}-\gamma_{pub}\right)\right)$$

or

$$\gamma_{pub}\cdot(1-\rho)\cdot\left(\tfrac{1-\rho\cdot p-1+\rho\cdot p}{(1-\rho\cdot p)\cdot p\cdot\rho}\right)=0.$$

This is identical to

$$0=0,$$

which is always true.

■

Chapter 5

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