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# Sharing the financing of common public goods and macroeconomic risks

Guillaume Claveres

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## **THÈSE**

Pour l'obtention du titre de Docteur en sciences économiques

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**Guillaume Claveres**

### **Sharing the financing of common public goods and macroeconomic risks**

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# Contents

<b>Remerciements</b>	<b>i</b>
<b>Contents</b>	<b>iii</b>
<b>Introduction</b>	<b>1</b>
<b>I Optimal centralization and tax base mobility</b>	<b>12</b>
1 Introduction . . . . .	12
2 Related literature . . . . .	17
3 Local and central policies . . . . .	19
3.1 Model set-up . . . . .	20
3.2 Equilibrium levels of public goods . . . . .	24
3.3 Capital allocation . . . . .	26
4 Optimal centralization . . . . .	27
4.1 Impact of centralization on public good provision . . . . .	27
4.2 Evaluation of centralization efficiency . . . . .	29
4.3 Does base erosion favor centralization? Does heterogeneity? . . . . .	32
4.4 The optimal degree of centralization . . . . .	35
5 Conclusion . . . . .	39
6 Appendix . . . . .	42
<b>II Tax competition and club formation</b>	<b>45</b>
1 Introduction . . . . .	45

2	Model set-up . . . . .	49
3	Tax equilibrium . . . . .	54
	3.1 No cooperation . . . . .	55
	3.2 Partial cooperation . . . . .	56
	3.3 Full cooperation . . . . .	58
4	Club formation . . . . .	59
	4.1 How does the tax equilibrium evolve with $m$ ? . . . . .	59
	4.2 When does a club emerge? Can full cooperation be reached? . . . . .	63
	4.3 Illustration and robustness checks . . . . .	67
5	Conclusion . . . . .	71
6	Appendix . . . . .	73

**III Unemployment insurance union 82**

1	Introduction . . . . .	82
2	Literature review . . . . .	85
3	Model . . . . .	88
	3.1 Labor markets . . . . .	89
	3.2 Households . . . . .	93
	3.3 Firms . . . . .	96
	3.4 Nash bargaining . . . . .	98
	3.5 Monetary policy . . . . .	101
	3.6 National governments . . . . .	101
	3.7 Goods and financial trade . . . . .	102
4	Design of the European unemployment insurance . . . . .	102
	4.1 European benefits and taxes . . . . .	102
	4.2 EUI scenarios . . . . .	105
5	Calibration . . . . .	108
	5.1 Euro area calibration . . . . .	108
	5.2 Model steady-state and second moments . . . . .	110
6	Results . . . . .	112

6.1	Impulse response functions : baseline . . . . .	112
6.2	Impulse response functions : EUI . . . . .	113
7	Conclusion . . . . .	117
8	Appendix . . . . .	119
<b>IV Euro area unemployment insurance and the ZLB</b>		<b>124</b>
1	Introduction . . . . .	124
2	Related literature . . . . .	128
3	Model . . . . .	130
3.1	Labor markets . . . . .	131
3.2	Households . . . . .	132
3.3	Firms . . . . .	135
3.4	Wage . . . . .	137
3.5	Governments . . . . .	137
3.6	Market clearing . . . . .	139
4	Calibration . . . . .	140
4.1	Euro area calibration . . . . .	140
4.2	Second moments of the model . . . . .	142
5	Simulations . . . . .	143
5.1	Assessing the benefits of the EUBS at the zero lower bound . . . . .	143
5.2	Extension: periphery government cut from financial markets . . . . .	146
6	Conclusion . . . . .	147
7	Appendix . . . . .	149
<b>Résumé</b>		<b>155</b>
<b>Bibliography</b>		<b>168</b>



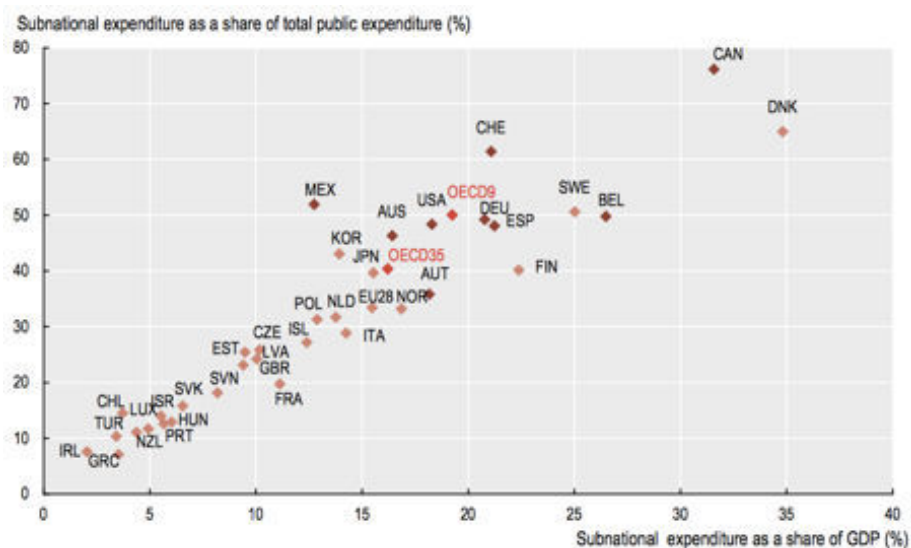
# Introduction

In a world where 40% of total population lives in federations or confederations, fiscal resources are collected and spent simultaneously by different tiers of government. The allocation of policy tasks between sub-central governments, which in 2014 accounted on average for 33% of consolidated government expenditure in OECD countries, and central governments depends on complex institutional arrangements and raises the issue of how to distribute policy areas between localities, regions and states, and sometimes federal entities.

The degree of decentralization, understood as the devolution of responsibilities to sub-central governments, varies greatly across countries: local spending accounts for 7% of total consolidated public expenditure in Greece, while it is 75% in Canada (Figure 5). There is a high heterogeneity in the distribution of competencies among regional and local authorities, and in some cases sub-central governments enjoy high policy and taxing autonomy, like the Swiss cantons.

The degree of centralization/decentralization also varies across policy areas: in terms of shares in total expenditure, while housing and community services appear as local services, public order and social security are provided at the center (Figure 6). Some areas are shared across multiple layers of government. For example, regarding education, local governments can be tasked with pre-elementary and primary education, regional governments with secondary education while central governments provide legislation. However, it should be noted that simple decentralization ratios can be misleading, as the true power of local governments depends on how much tax and regulatory autonomy they retain, as determined by institutional factors such as fiscal constitutions. It can be that financial in-

**Figure 1:** Subnational government expenditure as a percentage of GDP and total public expenditure (2016)

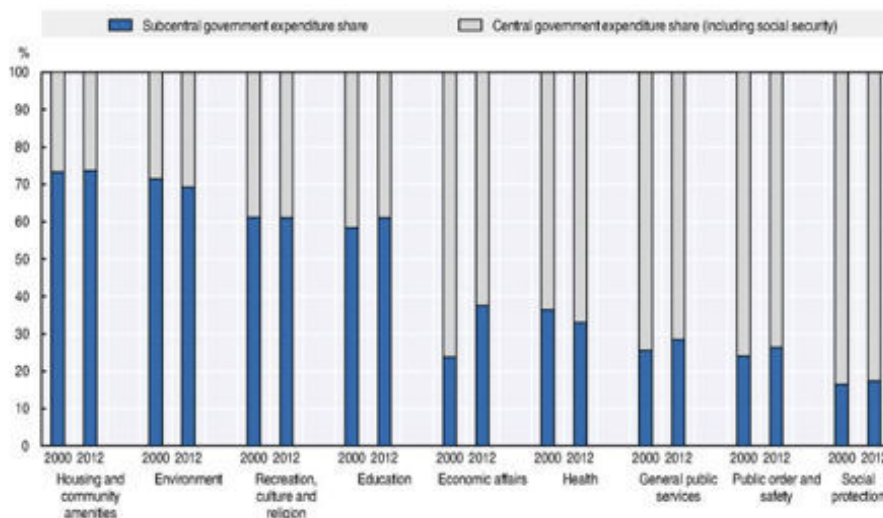


Source: OECD fiscal decentralization database, Allain-Dupré (2018)

dicators such as spending and revenue ratios have increased for localities, without a genuine transfer of power due to tighter regulation and supervision from the center.

Keeping this issue in mind, and looking at revenue and spending as well as competencies over the last two decades at least, decentralization seems to have progressed with more policy tasks shifted to local levels, notably in Italy and Spain, but also in France (Blöchliger et al., 2016). Some countries have also re-centralized such as Norway. But in general, the fact that government functions are distributed over several levels of decision can create spirited debates or even conflicts over the right level of competencies. Frequent quarrels between Catalonia and Madrid provide a good example. In Europe, members of the European Union compose an unprecedented case of an economic union where the common budget accounts for no more than 2% of total public spending, with member states keeping a high degree of autonomy. At the same time, entire policy areas are the competence of the Union and other national policies are constrained by a common set of rules. Size and scope of supranational institutions have led to numerous and significant

**Figure 2:** Sub-central and central government expenditure by policy area



*Source: OECD National accounts, Blöchliger et al. (2016)*

disagreements from the start of integration between EU countries, let alone between citizens of the same countries. Such diverging views over the right perimeter for the EU can be seen, among others, as causes to explain the outcome of the 2016 referendum in the UK.

Hence, multi-layered government intervention involves complex joint decision-making and shared fiscal resources to finance common budgets with various public services. This observation raises the crucial question of how to distribute policy tasks between tiers of government. One may wonder what motivates countries to centralize or decentralize some policies, what drives them to cooperate by sharing fiscal resources, and how can economic theory guide choices on the allocation of competencies.

The four research articles composing this PhD dissertation are designed independently, however they all study the sharing of fiscal resources used to provide common public goods or transfers to contribute to macroeconomic stabilization. The first two chapters are devoted to the provision of common public goods, while the other two chapters focus on a central stabilization capacity.

### **First theme: providing common public goods in the presence of tax base mobility**

The theoretical literature on fiscal federalism identifies various principles regarding the assignment of responsibilities between different government layers. Notably, in the presence of economies of scale, there is an advantage in sharing fiscal revenue at the center to provide public goods. Indeed, for the same amount of resources, more provision is delivered than at the local level where such economies cannot be exploited, or equivalently fewer resources are needed to be raised by the center to provide the same amount of public services. A typical example is the provision of infrastructure and networks, whose cost diminishes with size. A central provision is also more likely to internalize spillovers: decentralized policy-making can fail to recognize the effects of local provision on other localities, resulting in under-investment in infrastructure projects. Externalities and economies of scale can help explain the centralization of some allocation policies in Europe. For example, the mobility of goods between EU countries justifies to centralize regulation of the single market at the supranational level. Then, the single market for goods yields an economic case for a single currency and centralized monetary policy, since benefits of the free movement of goods and capital flows can be better reaped in the absence of exchange rate risks (Bénassy-Quéré et al., 2010).

Still, although defense can be thought as a public good with strong externalities, European countries have so far failed to assign responsibility over this domain or that of foreign relations to the center. There could be two avenues to explain this: a co-ordination failure, where each country would rather free ride on others spending. Alternatively, preference heterogeneity might provide an explanation for why there is no European defense, because the amount to be spent or the common objectives could potentially clash with national interests.

Divergence in preferences is a core element of the fiscal federalism literature: decentralized provision of public goods is supposed to match preferences better than central provision. Either because of a lack of information at the central level, or because the

central government provides uniform levels of taxes and public goods, local governments are believed to operate closer to preferences. Alesina et al. (2005a) model of international unions illustrates well this balance between preference heterogeneity and economies of scale for defense.

The trade-off between economies of scale (or spillovers) and the heterogeneity of preferences relates to Oates (1972) famous decentralization theorem. In the absence of economies of scale or externalities, decentralization is preferable or at least equivalent to centralization. According to this idea, the burden of justifying the level of intervention falls on the central level. In a European context, the subsidiarity concept obeys to that rationale, and might also be related to political economy concerns explaining further the desire for decentralization. Indeed, a greater role for sub-central entities can tame the tendencies of governments to over-spend or over-tax i.e. to behave like Leviathans (Weingast, 1995). Competition among local governments compels them to respect their citizens preferences since those can vote with their feet, quoting Tiebout (1956), which rules out excesses.

The discipline effect of decentralization is also argued by the advocates of tax competition: the fact that tax bases are mobile incentivizes governments to reduce spending and provide public goods efficiently, otherwise production factors relocate to other regions offering more competitive tax/spending bundles. There is some empirical evidence on the positive effects of base mobility on the efficiency of the public sector (Blöchliger and Campos, 2011).

However, tax base mobility can lead to distortions and externalities which provide a rationale for a centralization. First, theoretically, base erosion can increase the cost of the public sector, leading to a race to the bottom in taxes associated with an under-provision of public goods (Zodrow and Mieszkowski, 1986; Wilson, 1986). Without coordination or intergovernmental grants, competing governments cannot achieve an efficient level of public spending. The inefficiency linked to base erosion is magnified if different government tiers share the same base, leading to vertical externalities (Keen, 1998). The other consequence of base mobility is the shift of the tax burden to less mobile tax bases such as

unskilled labor (Bucovetsky and Wilson, 1991). Then, centralization may be a remedy: a central layer can internalize tax spillovers and resolve coordination failure among local governments. Indeed, a central government can levy uniform taxation, has by definition a bigger size than local ones (hence it suffers less from base erosion) and can organize fiscal compensation schemes. As such, deciding on the degree of centralization consists in balancing tax inefficiencies such as base erosion and respecting preferences: such trade-off is at the core of the first chapter of this dissertation.

The joint study of base erosion at the local level and the heterogeneity of preferences presented in the first chapter, Optimal centralization and tax base mobility, is novel to the literature. If one considers that the tax base is sensitive to local tax policy<sup>1</sup>, then base erosion increases the cost of the local public sector. This form of inefficiency has to be balanced out with the benefits of local provision in terms of adaptability to preferences.

In this first chapter, we consider an optimal centralization problem with jurisdictions that have heterogeneous preferences for public goods and tax a mobile base to finance them. We adopt a theoretical model with a federal structure and a continuum of public goods. As a first step, we lay out local and central policies. Due to base erosion, local governments underprovide public goods while the central government provides a uniform level immune to base erosion but with a cost in terms of adaptability to preferences. Once local and central policies have been described, we define an optimality criterion, which isolates the two inefficiencies under analysis: base erosion at the local level and lack of adaptability to preferences at the central level. We draw several normative conclusions from the study of the optimal degree of centralization. We demonstrate first that centralizing the provision of some public goods increases the level of the goods staying at the local level. Second, we highlight that when local governments face base erosion when setting their taxes, it might be that a high level of heterogeneity is consistent with a high level of centralization, which

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<sup>1</sup>Empirical evidence of base mobility to taxes set by sub-national governments is documented in Blöchliger and Campos (2011). Local is understood generally here in opposition to uniform central taxation, hence local taxation can refer to policies decided by municipalities, regions, states or even countries which are part of an economic union.

goes against the standard thinking from the literature. Third, we characterize the optimal degree of centralization and show that while a fully centralized system cannot be optimal, full decentralization might be.

While the first chapter investigates the degree of centralization between countries that are all part of a federal structure, the second chapter analyses the number of countries participating in a union. The contribution of this second chapter, Tax competition and club formation, is to consider a tax competition model where public goods potentially exhibit cross-border spillovers. Even if there are spillovers or economies of scale, cooperation for the shared provision of public goods may not happen if governments compete in taxes. It might be that exploiting spillovers is not enough for common public good provision to emerge: spillovers must be important enough to outweigh the benefits of remaining outside of the cooperation and free-ride tax harmonization in other regions. In this chapter, we augment the tradition model of tax competition with spillovers in public good provision. Identical countries compete for mobile capital. Among them, a subset of countries can coordinate in taxes and in return share public good spillovers. Then, they form a club of high taxes. Closed-form solutions for taxes and capital allocation are obtained through specific forms for the utility and production functions (linear in public good and quadratic in the capital/labor ratio, respectively), however robustness checks complement the theoretical analysis to show that the mechanisms at play are not restricted to these assumptions. Once we calculate the equilibrium tax rates and capital allocation, we show that the utility of both club and non-club countries is increasing in the number of participating members. In our model, the stable union size, the one where no country would rather enter or leave, depends on the strength of spillovers and there can be full or partial cooperation, or none at all. We show that full cooperation can be attained if spillovers in public good provision are high enough to remove the incentives to remain a low-tax non-cooperative player. An implication for policy is that to induce cooperation, countries should complement tax coordination projects with the financing of public goods whose provision yields a high degree of spillovers, especially if tax competition is strong.

## **Second theme: sharing macroeconomic risks in a monetary union with a fiscal capacity**

Pooling fiscal resources in a common budget, to reinforce the ability of decentralized governments to stabilize their economies, has been the center of much discussion in the euro area, where no such central capacity exists. Federal states are typically endowed with substantial centralized budget often dedicated, among other functions, to stabilization purposes. For example, following the financial crisis, an Emergency Unemployment Compensation scheme was launched in 2008 in the US, as a fully federal program to extend benefit duration past the regular 26 weeks, up to 99 in some states. Empirically, studies show that fiscal transfers provide a non-negligible share of cross-border risk-sharing in the US (Asdrubali et al., 1996). More generally, federal countries often assign fiscal stabilization to the central level, while local and regional governments are constrained by tight fiscal rules. In the euro area, the Stability and Growth Pact allows for some macroeconomic stabilization. However, this flexibility has proved insufficient during the 2012-13 crisis where the member states reacted with pro-cyclical policies.

The idea of a community budget dates back to way before the creation of the monetary union, with the MacDougall report (1977). The fact that the euro area lacks significant stabilization instruments relates to the issue of how much fiscal policy coordination is needed between countries that have already fully centralized their monetary policy.

One could argue that private channels are likely to provide the bulk of risk-sharing. Functional financial markets should deliver enough possibilities for agents to smooth out asymmetric shocks by accessing credit in other countries and diversified portfolios independent of national income. But sticking with the European example, private risk-sharing channels broke down during the crisis, exactly when needed the most, and financial markets remain fragmented (Furceri and Zdzienicka, 2015). Moreover, Farhi and Werning (2017) argue theoretically that private and public risk-sharing are complements. Indeed,



even with complete financial markets, purely private risk-sharing is inefficiently low as private agents do not internalize the macroeconomic demand externalities of their insurance choices. Hence, there is a rationale for public intervention to correct this market failure.

In the end, compared to the United States, the euro area lacks both public and private risk-sharing mechanisms (Nikolov et al., 2016). In the debate on euro area reforms, supporters of a fiscal stabilization capacity argue that such a common scheme could complement national fiscal policies to deal with asymmetric shocks and increase risk-sharing. A capacity could also address coordination failures between national governments and allow for a more appropriate fiscal stance, depending on the position in the cycle. The monetary-fiscal mix would also improve in case the monetary policy cannot face large symmetric shocks, even more so considering that fiscal multipliers may be higher in recessions and at the ZLB (Auerbach and Gorodnichenko, 2012; Eggertsson, 2011). Several proposals have been put out, with different opinions over which form should the common capacity adopt. However, the reluctance from member states to set-up a shared stabilization instrument reflects deep concerns and red lines regarding how the scheme would actually operate, both in the short and the long run.

First, political feasibility depends on the scheme ruling out permanent transfers. Generally, risk-sharing and redistribution arrangements are difficult to disentangle, because pooling resources to face macroeconomic shocks might translate into long-run shifts of income. However, the issue of permanent transfers is not clear in the current debate. Is it that transfers should be delivered only temporarily around the cycle? Or is it that countries should repay the totality of the support they received from the capacity? This ambiguity should be addressed by careful design choices.

Another area of disagreement is whether or not a fiscal capacity should be able to borrow in financial markets. Such a borrowing capacity could lead to centralized debt issuance and to implicit transfers between countries. Moreover, as with any risk-sharing arrangements, moral hazard concerns arise, potentially on two fronts. The first is between

governments: if expected in times of crisis, support could reduce incentives to carry-out structural reforms that decrease the risks of income loss or improve the ability of the domestic economy to withstand shocks. Another potential source of moral hazard is present if the capacity provides interpersonal support, for example in the form of unemployment benefits. Such policy could distort job search incentives, and also conflict with national preferences if the overall amount of insurance is altered by the centralized intervention. The heterogeneity in preferences then represents an issue to design the appropriate common level of support.

The issues of permanent transfers and heterogeneity in national social policies are at the center of the debate on euro area fiscal capacity. We tackle them in the third chapter, Unemployment insurance union, co-authored with Marius Clemens<sup>2</sup>. The fiscal capacity discussed here consists in a common unemployment insurance scheme. We build a DSGE model of the euro area (with a core and a periphery) with nominal, labor and financial rigidities. A baseline model where policies are only national, as it is the case now, is set as the reference for calibration which reproduces key empirical observations for the euro area. Then, we implement a common unemployment insurance and transfer part of the national stabilizers to the central level. Unemployed workers are insured by both layers and when a negative shock hits they receive positive net transfers from the central fund. It is often argued that due to the heterogeneity in national benefits and entitlement durations, a common scheme would require harmonization in insurance systems. Harmonization could prove difficult, since social policy remains a national prerogative deeply linked to preferences, and governments retain most of the autonomy when deciding how much to insure unemployed workers and for how long. The novelty of our paper is to present a design which plugs into national policies, to show that it is possible to build a common unemployment insurance without requiring convergence or even changes in the overall amount of insurance. We also show that debt issuance is important if the capacity has to face asymmetric

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shocks. Moreover, permanent transfers are discussed. Studying whether or not transfers should operate even at the steady-state is left out of the analysis. It would be a scheme of redistribution, where countries with more efficient labour markets finance those with less efficient ones, which is politically unfeasible. As such, all our scenarios include rules so that transfers only happen around the cycle. Then, we provide a scenario where permanent transfers are completely avoided, in the sense that countries reimburse the fund of the same amount they drew on it. In this sense, there is no risk-sharing, but stabilization is provided by a European fiscal rule which is looser than the national one, so that fiscal stabilization is delivered from the common layer.

Finally, the fourth chapter, Euro area unemployment insurance and the ZLB co-authored with Jan Stráský<sup>3</sup>, focuses on how a fiscal capacity targeting directly households can improve stabilization at the zero lower bound (ZLB). We build on the DSGE model of Chapter 3 to which we add a ZLB constraint on monetary policy. To our knowledge, the benefits of a fiscal capacity in the presence of a ZLB has never been studied. In this chapter, we start-off with a demand shock originating in the periphery. The common monetary is by construction unable to deal with this asymmetric shock. However, the ZLB further reduces its stabilization power. Once we introduce an area-wide unemployment insurance scheme that is entitled to borrow in financial markets, counter-cyclical fiscal transfers mitigate the demand shock, as they supports demand in the periphery and, through trade linkages, the core economy as well. Financial imperfections play a key role here: it is because some households cannot smooth consumption that fiscal transfers are effective at stabilizing the economy. In an extension, we also show that the fiscal capacity delivers additional benefits if the periphery government is cut from financial markets. Indeed, fiscal support from the center tames the pro-cyclical tax increase needed to balance the budget, which improves further stabilization compared to a scenario without transfers.

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<sup>3</sup>Jan Stráský, Economist, Economics Department, OECD.

# Chapter I

## Optimal centralization and tax base mobility

### 1 Introduction

The extent to which countries should centralize the provision of public goods depends on a well-known trade-off : the positive spillovers and returns to scale allowed by a central provision must balance the lack of adaptability to local preferences, better met by a decentralized system. The issue of how should taxation and spending in multi-layered government structures be assigned dates back to Oates et al. (1972). A central government can exploit spillovers but provides a 'one size fits all' level of public goods that might leave some jurisdictions worse-off as not all households desire the same amount of public spending.

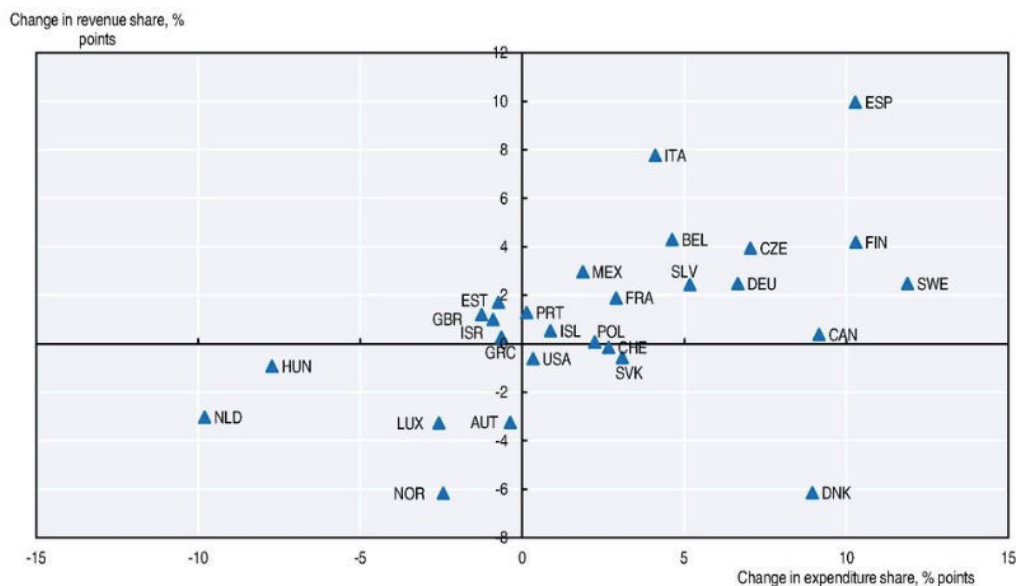
We take a fresh look at the issue of centralization through the lens of tax base mobility and erosion. In the existing literature on optimal fiscal federalism, spillovers and returns to scale in public good provision usually favor the central level (as in Lorz and Willmann (2005) or Besley and Coate (2003) for example). The novelty of our paper is to consider an optimal centralization problem balancing heterogeneous preferences and local tax distortions caused by base erosion. In particular, we see the central government as

an entity providing public goods without suffering from base erosion, instead of exploiting spillovers. In a federal structure where regional governments finance public goods while capital is freely mobile between them, local public goods are underprovided (Zodrow and Mieszkowski, 1986; Wildasin, 1988). Local governments set their tax rates to maximize their respective household's utility. Due to capital mobility, the cost of public spending is distorted and leads to a suboptimally low equilibrium level of public good provision. In our setting, a central government levies uniform taxation without triggering any capital flow, hence without any tax distortion. The drawback being, as mentioned, that a uniform level of spending may conflict with local preferences.

The study of the optimal allocation of public good provision between the central and local levels compares many aspects studied in the literature on fiscal federalism, such as vertical tax competition or strategic delegation. We mainly retain two features which, to our knowledge, have not been combined in the existing literature. In this paper, we focus on preference heterogeneity and tax distortions due to tax base mobility.

Empirically, a trend towards decentralization can be observed among OECD countries (Blöchliger et al., 2016). Looking at how much the sub-central public sector accounts in terms of total government revenue and expenditure, many countries have increased the portion of taxes and spending at the local or regional levels (Figure 1), most notably in Spain and Italy for example. As local governments retain more fiscal power and responsibilities, local taxes become important instruments shaping incentives and allocation of factors: numerous studies highlight the sensitivity of tax bases to local taxation (Blöchliger and Campos, 2011). For instance, Swiss cantons are among the strongest regional governments in terms of tax autonomy and competencies, and at the same time evidence of tax competition among them is strong (Feld and Kirchgässner, 2001). At the other side of the spectrum, Norway embarked in a re-centralization process, while in a context of fiscal competition regarding local welfare systems (Fiva and Rattsø, 2006). Notably, with the 2002 health care reform, the central government took over ownership and management of public hospitals. Before the reform, the decentralized health care system at the county

**Figure 1:** Change in share of sub-central revenue and expenditure as % of total government, change 1995-2014



Source: OECD Fiscal decentralization database, Blöchliger et al. (2016).

level was blamed for inefficiencies in public good provision, with long waiting lists or low financial responsibility (Hagen and Kaarbøe, 2006). The centralization reform took place although disparities in terms of desire for hospital services, such as specialized medicine for example, between rural areas and cities were strong. One may wonder what drives these choices regarding the allocation of public goods.

At the European level, the extent of centralization in public good provision is of prime importance, in connection with the issue of subsidiarity. So far, few areas of economic policy are centralized such as competition and trade policies, common agricultural policy and monetary policy for members of the Eurozone. The existing EU budget remains at a very low level,<sup>1</sup> and it relies on national contributions that are sometimes negotiated downwards by the Member states, in relation with the controversial issue of the "juste

<sup>1</sup>Total revenue for the EU budget amounted to 145 billions euros in 2015, representing 1% of Member states' GNI.

*retour*” (fair return).<sup>2</sup> Projects to provide the EU budget with own resources, such as a European corporate income tax, are still in the infancy. Hence, despite the fact that some policies exhibit significant externalities and returns to scale that would justify their provision at the Union level, such as defense or security, the central budget remains small. As for the EMU, there is no Eurozone budget although fiscal capacity is identified by both theory and policy circles as an important alternative stabilization instrument to compensate for the loss of monetary policy. Yet, the existing EU budget finances policies that do not necessarily respect the subsidiarity principle (CAP, structural funds). Hence, over the past few decades, EU involvement has extended to policy domains with low economies of scale while remaining absent on areas where its action appears justified (Alesina et al., 2005b).

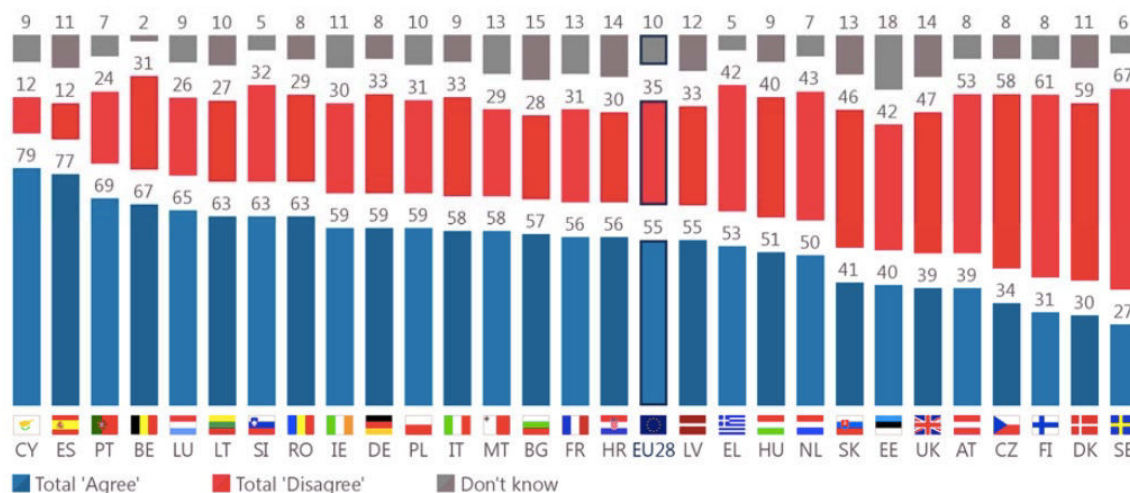
Tax externalities and preference heterogeneity may explain why European countries have proved unwilling to set up a significant central budget. Looking at preferences, European citizens diverge on whether more decision should be taken at the EU level or not. Figure 2 reveals heterogeneous taste of citizens for centralization at the EU level.

Against this background, our contribution is to analyze optimal centralization among jurisdictions which not only exhibit heterogeneity in their tastes for public goods, but also set their taxes on a mobile tax base to provide those public goods. We build a one-period theoretical model with a federal structure made of one central authority and  $n$  small local jurisdictions. In our model, central and local governments levy source taxes on mobile capital to finance their respective allocation from a continuum of public goods. The contribution of this paper is to analyze the design of fiscal federalism, where the optimal degree of centralization makes the balance between the strength of base erosion and the heterogeneity in preferences. On the one hand, local governments provide public goods that only their respective households enjoy. But due to base erosion, those are underprovided. On the other hand, the central government provides public goods that all households enjoy, and since it levies a uniform federal tax those goods are protected against base erosion.

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<sup>2</sup>see *European Budget: the poisonous budget rebate debate*, Le Cacheux J., Notre Europe, 2005. The current system also includes correction mechanisms such as rebates that add to its complexity and opacity. See *How the EU budget is financed the own resource system and the debate on its reform*, EPRS, 2014.

**Figure 2:** Eurobarometer survey : More decisions should be taken at the EU level



Source: European Commission, Standard Eurobarometer 89, Public opinion in the European Union, 2018.

However, the level of good being uniform, it incurs a cost in terms of adaptability to preferences. Hence, the optimal centralization makes the balance between eliminating base erosion and respecting local tastes for public goods.

Our model comprises two stages. First, the degree of centralization, i.e. the allocation of each public good policy between the local and central levels is established. Second, governments (central and local) set taxes and expenditures for each good. Solving backwards, we start by presenting how public goods are provided, then we study the optimal degree of centralization. We adopt a measure to assess the efficiency of centralization close to Janeba and Wilson (2011), although their paper does not study preference heterogeneity. We evaluate the optimality of the federal structure by isolating two types of inefficiencies: local tax distortions and lack of adaptability to preferences at the center. We characterize optimal centralization as the system minimizing the total deadweight loss of public good provision associated with these two aspects.



The first result of the paper is that centralizing the provision of some public goods increases the level of the goods that stay at the local level. Second, we explain that while centralization is desirable when base erosion is high, it can also be the case with high heterogeneity of preferences. Third, we show that full centralization cannot be an optimal system, while full decentralization might be depending on base erosion and preference heterogeneity.

The paper is organized as follows. Section 2 briefly reviews the existing literature. Section 3 displays local and central policies. Section 4 examines optimal centralization. Section 5 concludes.

## 2 Related literature

The distribution of public goods between the local and the central level is key to the fiscal federalism literature.<sup>3</sup> Recent contributions have shed new light on Oates' seminal decentralization theorem (1972), which stipulates that strong spillovers in public good provision favor the central level while high heterogeneity in preferences makes the case for a decentralized system. The trade-off between adaptability to local tastes and economies of scale is at the core of the international unions model in Alesina et al. (2005a). They study the conditions under which the members of a union, where some public goods are centralized to exploit spillovers but provided according to the mean preference, will accept a new member. They find that for the new member to be included, the greater positive externality that comes from the inclusion of another country must make up for the change in the political equilibrium that may move to a point that conflicts with preferences. The amount of public good and size of the union are then endogenously determined by the number of members, the strength of spillovers and the preferences of the median country. Adopting a political economy approach, Besley and Coate (2003) depart from the assumption that the central government provides a uniform level of public good to identify other costs of centralization. Namely, they show that strategic delegation (voters electing a local representative to set policy at the central level) induces constituents to delegate policy-making to a represen-

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<sup>3</sup>See Oates (1999) and Wilson (2006) for literature reviews.

tative that has a different taste than their own, leading to sub-optimal outcomes. Janeba and Wilson (2011) also stress the importance of the political process and focus on the optimal level of decentralization. They define it as the one yielding the best trade-off between inefficiencies at the regional (underprovision due to tax competition) and at the central level (provision being decided by a minimum winning coalition that does not represent the interests of all citizens). Finally, Lorz and Willmann (2005) establish that under strategic delegation, the level of centralization will be too low compared to social optimum as voters have an incentive to elect representatives with a lower taste for public good than their own.

An important branch of empirical studies attempt at measuring the sensitivity of tax bases to changes in taxation. For example, there is evidence of some international tax competition when it comes to the corporate income tax.<sup>4</sup> In theoretical models including capital mobility, the size of base erosion depends on the number of competing regions and on the concavity of the production function. Early studies by Zodrow and Mieszkowski (1986), and Wildasin (1988) assume a large number of regions, each of them having an insignificant impact on the global after-tax return of capital. In turn, Bucovetsky (1991) predicts that larger regions will set higher tax rates than smaller ones. The Zodrow-Mieszkowski model and its extensions have been widely used in the literature because of their tractability (see Wilson (1999) for an overview). The setting can easily be augmented with less restrictive assumptions while preserving the traditional key features. Krogstrup (2004) proposes a synthesized version of the standard models. However, those assume benevolent governments that only seek utility maximization. This vision is challenged by Leviathan models (Brennan and Buchanan, 1980), in which governments inflate the size of the public sector in the absence of tax base mobility. The fact that factors can reallocate in reaction of tax changes then be conducive of public sector efficiency. A summary of the different viewpoints on the positive and negative impacts of tax base mobility and tax competition is presented by Wilson and Wildasin (2004).

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<sup>4</sup>The tax sensitivity of foreign direct investment, supposed to capture the extent of base erosion, is measured by De Mooij and Ederveen (2003). Devereux et al. (2008) study corporate tax competition among OECD countries. See Zodrow (2010) for an overview of the empirical literature.

In federal structures, different layers of government share the same tax base. This can create vertical externalities, often considered as negative since tax policy set at one level affects the tax levying capacities at the other level, with suboptimal outcomes. Theoretical studies are presented by Flowers (1988), Boadway et al. (1998) and Dahlby and Wilson (2003). The interaction between horizontal externalities (base mobility between same-level governments) and vertical competition (tax base being shared by different layers of government) is studied by Keen and Kotsogiannis (2002). While horizontal externalities put a downward pressure on tax rates, vertical ones tend to lead to excessively high taxes. Both effects pulling tax rates in opposite directions, it is unclear which of the two externalities dominates. They show that the horizontal effect dominates if capital mobility between regions is large enough while the vertical one dominates if the responsiveness of the tax base to the state tax instrument is large enough.

Our paper draws features from these strands of literature, with two notable elements that have been not combined. In our optimal centralization problem, jurisdictions have heterogeneous tastes for public goods and tax a mobile base to finance them, which creates tax distortions. The trade-off presented here balances base erosion with preference heterogeneity which is novel to the literature.

### 3 Local and central policies

We adopt a one-period model in which  $n$  jurisdictions with  $n > 1$  tax capital that moves costlessly wherever the after-tax return is highest (Wildasin, 1988; Zodrow and Mieszkowski, 1986). On top of the jurisdictions, a central layer acts independently. Our model rests on several assumptions. First, we regard  $n$  as finite but large enough so that jurisdictions treat the after-tax return as fixed.<sup>5</sup> This feature removes strategic incentives for local governments to manipulate the after-tax return, so we depart from traditional models of tax competition (DePeter and Myers, 1994). Hence, we shut off the strategic interaction

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<sup>5</sup>The after-tax return is an endogenous variable determined by the capital market equilibrium, but we assume that local governments treat it as fixed.

also know as "horizontal tax competition" and only include in the model the distortion associated to base erosion (the capital flight caused by a tax increase). According to this assumption, in the model we study small jurisdictions equal in size which set their policies without internalizing their impact on the after-tax return. Such representation is consistent with reality if one consider that governments, even those of large countries, do not factor in the influence of their own policy on international variables. For example, this is the case in a monetary union where national governments do not internalize the impact of their budgetary policy on the common interest rate: a country can implement a stimulus regardless of the fact that such policy can trigger a hike in the interest rate for all union members.

Our second assumption is that the central layer levies its uniform tax rate across all capital in the economy. As such, we exclude "vertical tax competition": policy set at each level of government bears no impact on the tax base of the other, although both central and local governments tax the same mobile base (capital).

Third, we study benevolent governments implementing policies following preferences, both at the local and central levels.

### 3.1 Model set-up

In each jurisdiction there is a local policy-maker, assumed benevolent, that implements a tax and expenditure policy following local preferences.<sup>6</sup> The central policy described further on is decided by a central government which acts independently of the local governments.

Jurisdictions are equal in size and composed of three sectors: the firms, a local government and the households. Population is immobile and normalized to one i.e. all variables are measured in per capita terms. The representative household of jurisdiction  $i$ ,  $i \in [1, n]$ , is endowed with one unit of untaxed, immobile factor which we call labor, and  $\bar{k}$  unit of

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<sup>6</sup>We abstract from strategic delegation issues regarding local level elections, differing from Lorz and Willmann (2005).

capital. Both these factors are supplied for production:

$$y_i = f(k_i, 1) = f(k_i) \quad (1)$$

where  $k_i$  is the per-capita capital amount located in the countries, and  $f$  is characterized by decreasing marginal productivity: we have  $f'(k_i) > 0$  and  $f''(k_i) < 0$ . It is the same for all jurisdictions as technologies are the same.<sup>7</sup>

The representative household receives residual wage  $w_i = f(k_i) - f'(k_i)k_i$  from the supply of labor, plus a return on capital endowment  $\rho\bar{k}$  where  $\rho$  is the international after-tax return. There is no saving in this static model: all the disposable income is spent in consumption of the private good. Consumption in jurisdiction  $i$  is:

$$x_i = f(k_i) - f'(k_i)k_i + \rho\bar{k} \quad \forall i \in [1, n] \quad (2)$$

While labor is immobile, households can move capital freely wherever the after-tax return is the highest ex ante. After-tax returns on capital are equalized ex post through arbitrage condition:

$$\rho(t_1, \dots, t_n, T) = f'(k_i) - t_i - T \quad \forall i \in [1, n] \quad (3)$$

where  $t_i$  denotes the local tax rate of jurisdiction  $i$  and  $T$  the tax rate of the central government. Taxes are levied on capital by the local and the central governments according to the source principle to finance public goods. For  $\rho$  not to be negative (otherwise we would be in an excess supply regime)<sup>8</sup> the consolidated tax rate has to be lower than the marginal product of capital: we need  $t_i + T < f'(k_i)$ . (3) defines the demand for capital for each jurisdiction  $k_i$ .

Total supply of capital equals total demand, according to the following market clearing condition:

$$\sum_{i=1}^n k_i = n\bar{k} \quad (4)$$

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<sup>7</sup>There is no public input in the production process. Including public goods as a production factor does not change the results qualitatively.

<sup>8</sup>See Bucovetsky (1991).

Each representative household benefits from a continuum of public goods financed through capital taxation.<sup>9</sup> Those public goods are indexed by  $j$ , with  $j \in [0, 1]$ . Each public good  $j$  can either be provided at the local level or at the central level. Households do not distinguish between public goods and have the same preference regardless of  $j$ . They also do not differentiate between local and central levels of provision. The use of the continuum simply allows us to have partial centralization, with a portion of public goods provided at the central level and the rest at the local level.

Accordingly, a range of the continuum, from 0 to  $c$ , is provided by the central layer: the central government levies a uniform tax  $T$  on all capital to finance the interval  $[0, c]$  of public goods. Centrally-provided public good are noted  $g^j$  with  $j \in [0, c]$ , provided to all households in the economy. Note that the central provision of public goods does not exhibit economies of scale or spillovers in this model. The central government therefore faces the following budget constraint:

$$n \int_0^c g^j dj = T \sum_{i=1}^n k_i = Tn\bar{k} \quad (5)$$

Each local government  $i$  taxes capital at rate  $t_i$  that locates within its borders to finance an interval  $[c, 1]$  of public goods. Locally-provided public goods in this interval are denoted by  $g_i^j$  with  $j \in [c, 1]$ , and only enjoyed by households residing the jurisdiction  $i$ .<sup>10</sup> The local budget constraint reads:

$$\int_c^1 g_i^j dj = t_i k_i \quad (6)$$

It follows that  $c$  is the degree of centralization in the economy with  $0 \leq c \leq 1$ .

If the local government of jurisdiction  $i$  with  $i \in [1, n]$  raises its tax rate to increase public revenue, it triggers a capital outflow. How much capital has to flow out to regain equilibrium after a tax hike depends on the elasticity of capital to the tax rate. Differentiating (3) with respect to  $t_i$  and accounting for the fact that the local government treats

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<sup>9</sup>See Janeba and Wilson (2011); Lorz and Willmann (2005) for an analogous use of continua of public goods.

<sup>10</sup>Hence, there are no cross-border spillovers in local public good provision.

$\rho$  as fixed, we have  $\forall i \in [1, n]$ ,  $f''(k_i) \frac{\partial k_i}{\partial t_i} - 1 = 0$ . We obtain the following capital flow:

$$\frac{\partial k_i}{\partial t_i} = \frac{1}{f''(k_i)} < 0 \quad (7)$$

In turn, the central tax rate  $T$  is uniform so that a marginal increase does not translate into any movement of capital across the economy. We have  $\forall i \in [1, n]$ ,  $\frac{\partial k_i}{\partial T} = 0$ . A rise in  $T$  just lowers  $\rho$  by the same amount (which means that there is full capitalization). Differentiating (3) with respect to  $T$ :  $\frac{\partial \rho}{\partial T} = -1$ .

The representative household in jurisdiction  $i$  receives utility from the consumption of the private good  $x_i$ , the set of public goods provided at the central level  $g^j$  with  $j \in [0, c]$  and the set of public goods provided at the local level of its jurisdiction  $g_i^j$ , with  $j \in [c, 1]$ . Preferences are quasi-linear in the private good, utility function writes  $\forall i \in [1, n]$ :

$$U_i = f(k_i) - f'(k_i)k_i + \rho \bar{k} + \gamma_i \left[ \int_0^c u(g^j) dj + \int_c^1 u(g_i^j) dj \right] \quad (8)$$

where  $\gamma_i > 0$  measures the preference for public spending of jurisdiction  $i$ . The preference parameters are ordered as such:  $\gamma_1 \leq \gamma_2 \leq \dots \leq \gamma_n$ . As mentioned above, the preference parameter  $\gamma_i$  of jurisdiction  $i$  is the same for all public goods  $j$ , and for both levels of provision.

For the representative household of jurisdiction  $i$  with preference  $\gamma_i$ , we define the efficient level of public good, noted  $\tilde{g}_i$ , as the one equalizing marginal utility with the marginal rate of transformation:

$$\gamma_i u'(\tilde{g}_i) = 1 \quad (9)$$

The above expression is known as the Samuelson rule for efficient public good provision.

<sup>11</sup> It defines the efficient price of public good provision as unity. To calculate equilibrium public good provision, we define  $u(g) = \ln g$  for tractability, which ensures positive  $u'(g) > 0$  and decreasing  $u''(g) < 0$  marginal utility for public goods.

Hence, the efficient provision level for jurisdiction  $i$  writes:

$$\tilde{g}_i = \gamma_i \quad (10)$$

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<sup>11</sup>Put differently, the efficient level of public good is obtained through utility maximization of the household:  $\frac{dU_i}{dg_i} = 0 \Leftrightarrow u'(\tilde{g}_i) = 1$ .

### 3.2 Equilibrium levels of public goods

The model proceeds in two stages. The level of centralization  $c$  is set in the first stage, which we will describe in the next section. Then, the  $n$  local and the central governments set their policies which is the second stage of the model. The outcome of this second stage characterizes the equilibrium level of taxes and public goods, the capital allocation and the after-tax return, at  $c$  given.

Local government  $i$  sets its tax rate  $t_i$  and the level of local public goods  $g_i^j$  with  $j \in [c, 1]$ , so as to maximize the utility (8) of its representative household, subject to the local budget constraint (6). The following optimality condition defines the equilibrium level of local public good in jurisdiction  $i$ , that we denote by  $g_i^l$ . We have  $\forall j \in [c, 1] g_i^j = g_i^l$ , such that:

$$\gamma_i u'(g_i^l) = \frac{1}{1 - \epsilon_i} = p_i^l \quad (11)$$

where  $\epsilon_i$  is the elasticity of capital to the local tax rate, with  $\epsilon_i \equiv -\frac{t_i}{f''(k_i)k_i} > 0$ , and  $p_i^l$  the price of the local public good. We assume  $\epsilon_i < 1$  so that we are on the upward-sloping side of the Laffer curve: an increase in the tax rate cannot lead to a loss of tax revenue.

Due to base erosion, a marginal increase in the local tax rate triggers capital flight: a one unit decrease in private consumption translates into less than a one unit increase in local public spending. Comparing the first-order condition (11) and the Samuelson rule (9), we see how the cost of the local public sector is distorted above one such that local public goods are provided below the efficient level i.e.  $g_i^l < \tilde{g}_i$ . In other words, while the efficient price for public good provision is one, reflected in the Samuelson rule, households face an inefficiently high price  $p_i^l = \frac{1}{1 - \epsilon_i} > 1$  according to (11).

With  $u(g) = \ln g$ , the equilibrium local public good provision reads:

$$g_i^l = \gamma_i(1 - \epsilon_i) < \tilde{g}_i \quad (12)$$

Note that the local public sector exists only for some positive degree of decentralization i.e.  $c < 1$ . If there is full centralization, when  $c = 1$ , we have  $t_i = \epsilon_i = g_i^l = 0$ .



Next, we turn to the policy of the central government. The central government charges all capital at rate  $T$  to finance its set of public goods. Optimal values for  $T$  and  $g^j$  with  $j \in [0, c]$  are chosen to maximize the total utility of economy, according to the budget constraint (5). Total utility that the central government aims at maximizing, denoted with  $W$ , is simply defined as the aggregation of individual utility functions of each representative household:

$$W = \sum_{i=1}^n U_i \quad (13)$$

The equilibrium level of centrally-provided public goods, denoted by  $g^f$  with  $\forall j \in [0, c]$ ,  $g^j = g^f$ , is determined by the first-order condition:

$$\sum_{i=1}^n \gamma_i u'(g^f) = n \Leftrightarrow \bar{\gamma} u'(g^f) = 1 = p^f \quad (14)$$

where  $\bar{\gamma} = \frac{\sum_{i=1}^n \gamma_i}{n}$  is the mean preference and  $p^f$  the price of centrally-provided public goods. The central government can provide public goods according to the Samuelson rule (the sum of marginal utilities for the  $n$  jurisdictions enjoying the public good equals the rate of transformation,  $n$ ). The resulting price for centrally-provided public goods is one i.e.  $p^f = 1$ , the efficient price for public good provision. Hence, public goods are not underprovided at the central level since the cost of the public sector is not distorted by base erosion.

However, the level of centrally-provided public goods is not efficient from the viewpoint of jurisdictions with a different preference for public good than the mean. Centrally-provided public goods are underprovided for a jurisdiction that has a higher taste for public goods than the mean i.e.  $\gamma_i > \bar{\gamma}$ . Conversely they are over-provided for jurisdictions that have a lower preference than the mean i.e.  $\gamma_i < \bar{\gamma}$ . To see this, we use the Samuelson condition (9) and the first-order condition (14) to show:

$$\gamma_i < \bar{\gamma} \Leftrightarrow \frac{1}{u'(\tilde{g}_i)} < \frac{1}{u'(g^f)} \Leftrightarrow \tilde{g}_i < g^f$$

Equivalently,  $\gamma_i > \bar{\gamma} \Leftrightarrow \tilde{g}_i > g^f$ . Only a jurisdiction with a preference equal to the mean enjoys an efficient provision from the central level, since for this jurisdiction  $\gamma_i = \bar{\gamma}$ . With

$u(g) = \ln g$ , the equilibrium central public good provision reads using (14):

$$g^f = \bar{\gamma} \quad (15)$$

and we immediately see that  $\tilde{g}_i < g^f$  if  $\gamma_i < \bar{\gamma}$  and  $\tilde{g}_i > g^f$  if  $\gamma_i > \bar{\gamma}$ . The only way for a public good not to be over or underprovided by the central layer for all jurisdiction is if preferences are homogenous, if  $\gamma_i = \gamma \forall i \in [1, n]$ . In that case, we have  $g^f = \gamma = \tilde{g}_i \forall i \in [1, n]$ .

Moreover, if there is full decentralization, with  $c = 0$ , we have  $T = g^f = 0$ . As long as some public goods are provided at the central level, when  $c > 1$ , those goods are provided according to the equilibrium described above.

Both layers of government suffer from an inefficiency. They are unable to provide the efficient amount of public good,  $\gamma_i$ , to each jurisdiction. On the one hand, local governments face base erosion when setting their taxes and provide  $g_i^l = \gamma_i(1 - \epsilon_i) < \gamma_i$ . On the other hand, the central government cannot match the preference of each jurisdiction and provides  $\bar{\gamma}$  to all of them. Centrally-provided public goods are over- or underprovided depending on preferences.

### 3.3 Capital allocation

Heterogeneity in preferences means that some jurisdictions levy higher local taxes than others, and therefore attract less capital. To see this, we consider a marginal increase in the preference parameter of jurisdiction  $i$ ,  $\gamma_i$ , leaving all others unchanged. As shown in the Appendix, the elasticity of the local tax rate with respect to the preference parameter writes:

$$\frac{\gamma_i}{t_i} \frac{\partial t_i}{\partial \gamma_i} = \frac{1}{1 - \epsilon_i + \frac{t_i}{1 - \epsilon_i} \frac{\partial \epsilon_i}{\partial t_i}} \quad (16)$$

where  $\frac{\partial \epsilon_i}{\partial t_i} = -\frac{1 + \epsilon_i \left(1 + \frac{f'''(k_i)k_i}{f''(k_i)}\right)}{f''(k_i)k_i}$  is the reaction of the tax elasticity to a change in the tax rate. The sufficient but not necessary condition for this term to be positive is if

$1 + \frac{f'''(k_i)k_i}{f''(k_i)} > 0$ , which is true for usual production functions and assumed in many papers mentioned above. We assume  $1 + \frac{f'''(k_i)k_i}{f''(k_i)} > 0$  for the rest of the paper so that:

$$\frac{\partial \epsilon_i}{\partial t_i} > 0 \quad (17)$$

which means that the higher the local tax rate, the higher the tax elasticity of capital.

From (16), we have  $\frac{\partial t_i}{\partial \gamma_i} > 0$  and  $\frac{\partial \epsilon_i}{\partial \gamma_i} = \frac{\partial \epsilon_i}{\partial t_i} \frac{\partial t_i}{\partial \gamma_i} > 0$ . Hence the higher the taste parameter, the higher the local tax rate and the higher the tax elasticity of capital.

Since jurisdictions are ordered such as  $\gamma_1 \leq \gamma_2 \leq \dots \leq \gamma_n$ , we have  $t_1 \leq t_2 \leq \dots \leq t_n$  and  $g_1 \leq g_2 \leq \dots \leq g_n$ . It follows that, due to capital mobility and through the arbitrage condition (3),  $k_1 \geq k_2 \geq \dots \geq k_n$ . Jurisdictions with lower taste for public goods set lower tax rates and attract more capital.

## 4 Optimal centralization

We move to the first stage of the model in which the optimal degree of centralization  $c$  is studied. The analysis is made knowing the level of taxes and public goods exposed in the previous section.

### 4.1 Impact of centralization on public good provision

We start by examining the impact of a marginal increase in  $c$ , meaning a marginal shift of public good provision from the local to the central level. Using the budget constraint of the central government (5) and the equilibrium level of centrally-provided public goods (15), we can write the tax rate  $T(c) = \frac{c\bar{\gamma}}{k}$ . Deriving with respect to  $c$ , with  $c > 0$ , yields:

$$\frac{\partial T(c)}{\partial c} = \frac{\bar{\gamma}}{k} > 0 \quad (18)$$

The tax rate of the central government  $T(c)$  increases with  $c$  by the amount necessary to finance the newly centralized public good.

Turning to local governments, the level of  $g_i^l(c)$  depends on the tax elasticity of capital, itself a function of the level of centralization  $c$ . To see this, we first derive the equilibrium level of locally-provided public goods (12) with respect to  $c$  with  $c < 1$ :

$$\frac{\partial g_i^l(c)}{\partial c} = -\gamma_i \frac{\partial \epsilon_i(c)}{\partial c} \quad (19)$$

We also derive the local government budget constraint with respect to  $c$  and plug the above equation (19) to obtain:<sup>12</sup>

$$\frac{1-c}{t_i(c)} \frac{\partial t_i(c)}{\partial c} = -\frac{1}{1 - \epsilon_i(c) + \frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}} < 0 \quad (20)$$

With more public good transferred to the central level, the local tax rate decreases since there is less public good to finance at the local level. But a decrease in the local tax rate affects the equilibrium level of local public good through (11): a lower local tax rate reduces the tax elasticity of capital. Indeed we have using (17) and (20):

$$\frac{\partial \epsilon_i(c)}{\partial c} = \frac{\partial \epsilon_i(c)}{\partial t_i} \frac{\partial t_i(c)}{\partial c} < 0 \quad (21)$$

The tax elasticity represents a distortion in public good provision as it raises the price of public goods  $p_i^l(c)$  above one. Since the elasticity decreases with  $c$ , it follows that a marginal increase in  $c$  raises the level of  $g_i^l(c)$  since the distortion is reduced. Centralization softens base erosion for the public goods remaining at the local level. Using (20) and (21), we rearrange (19) into:

$$\frac{1-c}{g_i^l(c)} \frac{\partial g_i^l(c)}{\partial c} = \frac{\frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}}{1 - \epsilon_i(c) + \frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}} > 0 \quad (22)$$

As  $\frac{\partial g_i^l(c)}{\partial c} > 0$ , a marginal increase in centralization increases the provision of each public good that stays at the local level.

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<sup>12</sup>Full calculations are presented in the Appendix.

**Proposition 1** Centralization of public good provision raises the provision of the public goods that stay at the local level.

In the end, as  $c \rightarrow 1$ ,  $\epsilon_i(c) \rightarrow 0$  and  $g_i^l(c) \rightarrow \gamma_i$ . In other words, as centralization increases, local public goods are provided towards their efficient value, however there are less and less of them remaining at the local level.

## 4.2 Evaluation of centralization efficiency

The optimal federal system consists in the most efficient allocation of public goods between local and central levels. As the previous section demonstrates, both these levels provide public goods with inefficiencies. Local governments face base erosion, while the central government has to deal with a "one size fits all" problem, as long as preferences are heterogeneous. It follows that the optimal degree of centralization, noted  $c^*$ , allows for the right blend between the adaptability to preferences of local public good provision and the protection against base erosion of central provision.

Our criterion for assessing optimal centralization is the deadweight loss associated with public good provision, similarly to Janeba and Wilson (2011). The deadweight loss for a particular public good is defined as the decline in utility caused by an inefficient provision, compared to a first-best level characterized by the Samuelson rule. Then,  $c^*$  minimizes the total deadweight losses summed across all goods and all jurisdictions.

It is important to note that this criterion disregards other inefficiencies present in the model that also impact household utility. For example, the tax equilibrium affects the allocation of capital and the consumption of the private good across jurisdictions. Our paper focuses on the two inefficiencies described above, only related to public good provision.

Finally, due to our assumption of quasi-linear utility, there are no income effects in public good demands such that deadweight losses can be approximated by Harberger tri-

angle formulas, as developed below.<sup>13</sup>

We start by calculating the deadweight loss of local provision in jurisdiction  $i$  for  $c < 1$ . While the efficient provision for a local public good would satisfy the Samuelson rule (9),  $\gamma_i u'(\tilde{g}_i) = 1$ ,  $g_i^l(c)$  is provided such that  $\gamma_i u'(g_i^l(c)) = \frac{1}{1 - \epsilon_i(c)}$ . We define the implicit tax, positive or negative,  $\tau_i^l(c)$  as the wedge between equilibrium (11) and efficient (9) local provisions.  $\tau_i^l(c)$  is such that  $\gamma_i u'(g_i^l(c)) = 1 + \tau_i^l(c)$ , or:

$$\tau_i^l(c) = \frac{\epsilon_i(c)}{1 - \epsilon_i(c)} > 0 \quad (23)$$

Base erosion creates a distortion causing a deadweight loss. As explained in the previous section, households face an inefficiently high price for local public goods,  $p_i^l(c) = \frac{1}{1 - \epsilon_i(c)}$ , compared to a first-best price of one. The difference between the two is  $\tau_i^l(c) = p_i^l(c) - 1$ . Next, we write demand for local public good defined by equation (12) as:

$$g_i^l(p_i^l(c)) = \frac{\gamma_i}{p_i^l(c)} \quad (24)$$

Deriving the above expression with respect to  $p_i^l$  yields the demand derivative for local public goods:

$$\frac{\partial g_i^l(p_i^l(c))}{\partial p_i^l} = -\frac{\gamma_i}{(p_i^l(c))^2} = -\gamma_i(1 - \epsilon_i(c))^2 < 0 \quad (25)$$

We multiply this demand derivative (25) by one half and by the square of the implicit tax (23) to obtain the deadweight loss created by the inefficient provision of a local public good in jurisdiction  $i$  for  $c < 1$ :

$$L_i^l(c) = -\frac{1}{2}(\tau_i^l(c))^2 \frac{\partial g_i^l(p_i^l(c))}{\partial p_i^l} = \frac{1}{2}\gamma_i \epsilon_i^2(c) \quad (26)$$

Given that at  $c = 1$ , there is no local public sector, we have  $L_i^l(1) = 0$ . Then, since  $\epsilon_i(c)$  is increasing in the taste for public goods, we notice that the loss caused by local provision  $L_i^l(c)$  is increasing in  $\gamma_i$ :

$$\frac{\gamma_i}{L_i^l(c)} \frac{\partial L_i^l(c)}{\partial \gamma_i} = 1 + 2 \frac{\gamma_i}{\epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial \gamma_i} > 0 \quad (27)$$

<sup>13</sup>A graphical representation is presented in the Appendix.

Hence jurisdictions with a high preference for public goods face a high loss from the inefficient provision of local public goods.

In the end, by summing equation (26) across all jurisdictions, we obtain the deadweight loss from having a public good provided at the local level for the economy for  $c < 1$ :

$$L^l(c) = \sum_{i=1}^n \frac{1}{2} \gamma_i \epsilon_i^2(c) \quad (28)$$

with  $L^l(1) = 0$ .

We turn to centrally-provided public goods, at  $c > 0$ . We know that while the efficient provision is  $\gamma_i u'(\tilde{g}_i) = 1$ ,  $g^f$  is provided such that  $\bar{\gamma} u'(g^f) = 1$ . The corresponding implicit tax for this provision, noted  $\tau_i^f$  and defined for some positive level of centralization  $c > 0$ , is such that  $\gamma_i u'(g^f) = 1 + \tau_i^f$ . Hence we have:

$$\tau_i^f = \frac{\gamma_i}{\bar{\gamma}} - 1 \quad (29)$$

This implicit tax is either negative if  $\gamma_i < \bar{\gamma}$  i.e. centrally-provided goods are over-provided and their price is inefficiently low, or positive if  $\gamma_i > \bar{\gamma}$  i.e. they are under-provided and their price is too high. The jurisdiction enjoys an efficient provision from the central level only if  $\gamma_i = \bar{\gamma}$ . Note that  $\tau_i^f$  is independent of  $c$ : the inefficiency in central provision depends only on preferences. The demand derivative for centrally-provided public goods is obtained by deriving the following demand function:

$$g^f(p^f) = \frac{\bar{\gamma}}{p^f} \quad (30)$$

with respect to  $p^f$ :

$$\frac{\partial g^f(p^f)}{\partial p^f} = -\frac{\bar{\gamma}}{(p^f)^2} = -\bar{\gamma} < 0 \quad (31)$$

We obtain the deadweight loss associated with central provision of a public good for jurisdiction  $i$ , with  $c > 0$ :

$$L_i^c = -\frac{1}{2} (\tau_i^f)^2 \frac{\partial g^f}{\partial p^f} = \frac{1}{2} \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} \quad (32)$$

When decentralization is complete, there is no central provision so that  $L^c = 0$  at  $c = 0$ .

Summing (32) across all jurisdictions yields the deadweight from the central provision of a public good when  $c > 0$ :

$$L^c = \frac{1}{2} \sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} \quad (33)$$

and  $L^c = 0$  for  $c = 0$ . When  $c > 0$ , deadweight loss (33) is increasing in the heterogeneity of preferences measured by the dispersion term  $\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}}$ . A heterogeneity increases the "one size fits all" problem of the central government which penalizes central provision. Note that this loss (33) does not depend on  $c$  when  $c > 0$ .

Finally, summing across all public goods, the total deadweight loss of the system writes for  $c \in [0, 1]$ :

$$L(c) = cL^c + (1 - c)L^l(c) \quad (34)$$

Using (28) and (33) and rearranging, we obtain:

$$L(c) = \frac{1}{2} \left[ c \sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} + (1 - c) \sum_{i=1}^n \gamma_i \epsilon_i^2(c) \right] \quad (35)$$

### 4.3 Does base erosion favor centralization? Does heterogeneity?

The elasticity of the taxable base to the tax rate creates inefficiencies at the local level through capital flight. Intuitively, increased base erosion raises the cost of local provision for all jurisdictions. Hence, the deadweight loss of local provision  $L^l$  increases with base erosion. On the contrary, more base erosion leaves central provision and the associated deadweight loss  $L^c$  unaffected.

We apply this insight to our model by using a quadratic production:<sup>14</sup>

$$f(k_i(c)) = \left( a - \frac{b}{2} k_i(c) \right) k_i(c), \quad a, b > 0 \quad (36)$$

where we assume  $0 < k_i(c) < \frac{a}{b}$ . We have a marginal product of capital of  $f'(k_i(c)) = a - bk_i(c) > 0$ , while  $f''(k_i(c)) = -b < 0$  and  $f'''(k_i(c)) = 0$ .  $b$  determines the strength of

<sup>14</sup>Analogous production functions have been adopted in tax competition papers such as Wilson (1991); Bucovetsky (1991); Peralta and van Ypersele (2005).



base erosion. Indeed, we now write the capital outflow following a local tax hike (7) as:

$$\frac{\partial k_i(c)}{\partial t_i} = -\frac{1}{b} < 0$$

The lower the  $b$ , all else equal, the higher the capital outflow following an increase in  $t_i(c)$  needed to restore the arbitrage condition, so that the elasticity is higher:  $\frac{\partial \epsilon_i(c)}{\partial b} < 0$ . While  $L^c$  is independent of  $b$ :  $\frac{\partial L^c}{\partial b} = 0$ , we have for local provision:

$$\frac{\partial L^l(c)}{\partial b} = \sum_{i=1}^n \gamma_i \frac{\partial \epsilon_i(c)}{\partial b} \epsilon_i(c) < 0 \quad (37)$$

We see that a lower  $b$ , consistent with more base erosion, increases the loss from local provision without affecting that of central provision.

**Proposition 2a** Stronger base erosion favors the central provision of public goods.

According to traditional thinking, strong heterogeneity in preferences builds the case for a decentralized system. On the contrary, in our model higher heterogeneity does not necessarily favors a decentralized provision of public goods.

High heterogeneity penalizes central provision as the "one size fits all" problem is more pronounced. Indeed, a rise in the dispersion term in (33) increases the deadweight loss of central provision  $L^c$ . To illustrate this, suppose that the economy is composed of two types of jurisdictions, equally remote on opposite sides of the mean preference.<sup>15</sup> For a given mean preference  $\bar{\gamma}$ , half of the jurisdictions is type- $l$  with a low preference  $\gamma_l = \bar{\gamma} - \gamma$  while the other half is type- $h$  with a high preference  $\gamma_h = \bar{\gamma} + \gamma$ .  $\gamma > 0$  represents here the preference heterogeneity. The loss caused by central provision writes:

$$L^c = \frac{n\gamma^2}{2\bar{\gamma}} \quad (38)$$

We see that the above loss function (38) is increasing in  $\gamma$ :

$$\frac{\partial L^c}{\partial \gamma} = n \frac{\gamma}{\bar{\gamma}} > 0 \quad (39)$$

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<sup>15</sup>The reasoning exposed here would be valid for more than two types of preferences.

The higher the heterogeneity in preferences  $\gamma$ , the higher the loss from central provision.

However, an increase in preferences heterogeneity also affects the equilibrium at the local level and how local governments provide their public goods, impact the deadweight loss of local provision  $L^l(c)$ . Consider a rise in  $\gamma$  for a given mean preference. Jurisdictions  $l$  have their taste decreasing i.e.  $\frac{\partial \gamma_l}{\partial \gamma} < 0$  and as a result reduce their local tax rate  $t_l(c)$ . This lowers the distortion of local provision, and jurisdictions  $l$  are also less hurt by the local inefficiency since they care less about public goods. Overall, the deadweight loss of local provision decreases for jurisdictions  $l$ :

$$\frac{\partial L_l^l(c)}{\partial \gamma} = -\frac{1}{2}\epsilon_l^2(c) \left[ 1 + 2\frac{\gamma_l}{\epsilon_l(c)} \frac{\partial \epsilon_l(c)}{\partial \gamma_l} \right] < 0 \quad (40)$$

Jurisdiction  $h$  have their taste increasing  $\frac{\partial \gamma_h}{\partial \gamma} > 0$  and thus raise their local tax rate  $t_h(c)$ . The local tax distortion is worsened and jurisdictions  $h$  are also increasingly hurt by this distortion since they care more about public goods. The deadweight loss of local provision increases for jurisdictions  $h$ :

$$\frac{\partial L_h^l(c)}{\partial \gamma} = \frac{1}{2}\epsilon_h^2(c) \left[ 1 + 2\frac{\gamma_h}{\epsilon_h(c)} \frac{\partial \epsilon_h(c)}{\partial \gamma_h} \right] > 0 \quad (41)$$

We know from (27) that the elasticity of the local deadweight loss to the preference parameter is positive. So for a marginal variation in  $\gamma$ , the increased loss for high taste jurisdictions outweighs the decreased loss for low taste ones:

$$\frac{\partial L_h^l(c)}{\partial \gamma} > \left| \frac{\partial L_l^l(c)}{\partial \gamma} \right|$$

On aggregate, the deadweight loss of local provision  $L^l$  increases as a result of this change in heterogeneity:

$$\frac{\partial L^l(c)}{\partial \gamma} = \frac{n}{2} \left( \frac{\partial L_l^l(c)}{\partial \gamma} + \frac{\partial L_h^l(c)}{\partial \gamma} \right) > 0 \quad (42)$$

In the end, looking at (39) and (42), an increased heterogeneity inflates deadweight losses for both local and central provision.

**Proposition 2b** Increased heterogeneity of preferences penalizes both decentralization and centralized provisions of public goods.

In the traditional literature on optimal centralization, the fact that the central government has a 'one size fits all' provision favors a decentralized system. If heterogeneity increases, it is usually considered that more public goods should be provided at the local level. On the contrary, in our model, if low taste jurisdictions start liking public goods less while high taste ones start liking public goods more, it is unclear whether central or decentralization is more desirable. Indeed, high taste jurisdictions might face such inefficiencies at the local level because of capital mobility that it may be optimal to centralize more: although the central government underprovides public goods to them, it still protects them against base erosion.

#### 4.4 The optimal degree of centralization

The optimal degree of centralization  $c^*$  is the one minimizing the total deadweight loss function as defined in (35).

First, we note that absent base erosion, there would be no inefficiency in local provision i.e.  $L^l(c) = 0$ . It follows that the level of  $c$  minimizing the loss function would be  $c^* = 0$ , in other words complete decentralization. Instead, with homogenous preferences, there would be no deadweight loss in central provision since the central government would provide an efficient level of public goods to all jurisdictions. We would have  $L^c = 0 \forall i \in [1, n]$ . Full centralization would then be optimal i.e.  $c^* = 1$ .

In the presence of both heterogeneous tastes for public goods and base mobility at the local level, we need to study the impact of a marginal increase in  $c$  on the loss function (35) to determine the optimal centralization:

$$\frac{\partial L(c)}{\partial c} = L^c - L^l(c) + (1 - c) \frac{\partial L^l(c)}{\partial c} \quad (43)$$

$$= \frac{1}{2} \left[ \sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} - \sum_{i=1}^n \gamma_i \epsilon_i^2(c) \right] + (1 - c) \sum_{i=1}^n \gamma_i \frac{\partial \epsilon_i(c)}{\partial c} \epsilon_i(c) \quad (44)$$

First, an increase in the degree of centralization raises the total deadweight loss proportionally to the dispersion term  $\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}}$  (first bracketed term). This term represents the deadweight loss caused by a central provision of public goods and its "one size fits all" problem.

Second, a rise in  $c$  decreases the total deadweight loss proportionally to the tax elasticities (second bracketed term). Indeed, transferring additional provision at the central level removes the inefficiencies of local provision caused by base erosion.

Third, in our model, a rise in  $c$  yields an additional benefit which reduces the total loss function (35) (third term in (43)). We know from equation (21) that the tax elasticity of capital is decreasing in  $c$ , reducing the inefficiency of local provision (Proposition 1). An increase in centralization reduces the inefficiency of all public goods remaining at the local level. Indeed,  $L^l(c)$  is a decreasing function of  $c$  over  $[0, 1]$ :

$$\frac{\partial L^l(c)}{\partial c} = \sum_{i=1}^n \gamma_i \frac{\partial \epsilon_i(c)}{\partial c} \epsilon_i(c) < 0 \quad (45)$$

with  $L^l(0) = \sum_{i=1}^n \gamma_i \epsilon_i^2(0)$  and  $L^l(1) = 0$ .

The optimal degree of centralization is then determined by equalizing the derivative (43) to zero:

$$\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} = \sum_{i=1}^n \gamma_i \epsilon_i^2(c^*) \left[ 1 - 2 \frac{1 - c^*}{\epsilon_i(c^*)} \frac{\partial \epsilon_i(c^*)}{\partial c} \right] \quad (46)$$

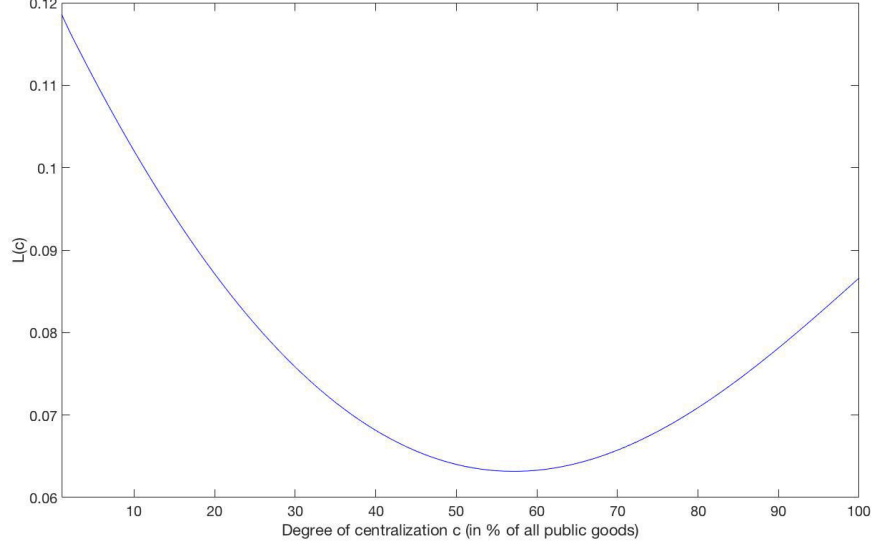
With a quadratic production function as defined by (36), the above first-order condition (46) transforms into:<sup>16</sup>

$$\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} < \sum_{i=1}^n \gamma_i \epsilon_i^2(c^*) \left[ 1 + 2 \frac{1 - \epsilon_i^2(c^*)}{1 - \epsilon_i(c^*) + 2\epsilon_i^2(c^*)} \right] \quad (47)$$

Figure 3 provides a numerical example of the deadweight loss  $L(c)$  as a function of  $c$  with a quadratic production function.<sup>17</sup> In this example, the optimal degree of centralization is about  $c^* = 0.57$ .

<sup>16</sup>Complete calculation is reported in the Appendix.

<sup>17</sup>For this numerical example, we set  $\bar{k} = 1$ ,  $a = 10$ ,  $b = 0.25$ ,  $n = 30$ . Preference parameters are uniformly distributed over the interval  $[0.05, 0.13]$ . These values rule out excess supply regimes.

**Figure 3:** Total deadweight loss as a function of  $c$ 

Next, we study corner solutions of the optimal centralization problem, the full decentralization ( $c = 0$ ) and full centralization ( $c = 1$ ) cases starting with the former.

The loss function  $L(c)$  is also continuous at  $c = 0$ . Indeed, we have  $\lim_{c \rightarrow 0} L(c) = L^l(0) = L(0)$ . Evaluating the derivative (43) at  $c = 0$  gives us:

$$\frac{\partial L(0)}{\partial c} = \frac{1}{2} \left[ \sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} - \sum_{i=1}^n \gamma_i \epsilon_i^2(0) \right] + \sum_{i=1}^n \gamma_i \frac{\partial \epsilon_i(0)}{\partial c} \epsilon_i(0) \quad (48)$$

We know from (21) that  $\epsilon_i(c)$  is a maximum when  $c = 0$  and  $\frac{\partial \epsilon_i(c)}{\partial c} < 0$ . Hence, some centralization is optimal if and only if  $\frac{\partial L(0)}{\partial c} < 0$ , or in other terms if:

$$\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} < \sum_{i=1}^n \gamma_i \epsilon_i^2(0) \left[ 1 - 2 \frac{1-c}{\epsilon_i(0)} \frac{\partial \epsilon_i(0)}{\partial c} \right] \quad (49)$$

The total loss function is decreasing with respect to  $c$  at  $c = 0$  only if the taste heterogeneity is low enough compared to local tax distortions. If the above condition is not satisfied, then  $\frac{\partial L(c)}{\partial c} > 0 \forall c \in [0, 1]$  such that  $c = 0$  is a minimum. In this case,  $c^* = 0$  and full decentralization is optimal, because the heterogeneity in preferences is so high that the "one size fits all" problem of central provision always dominates the reduction in local

provision inefficiencies.

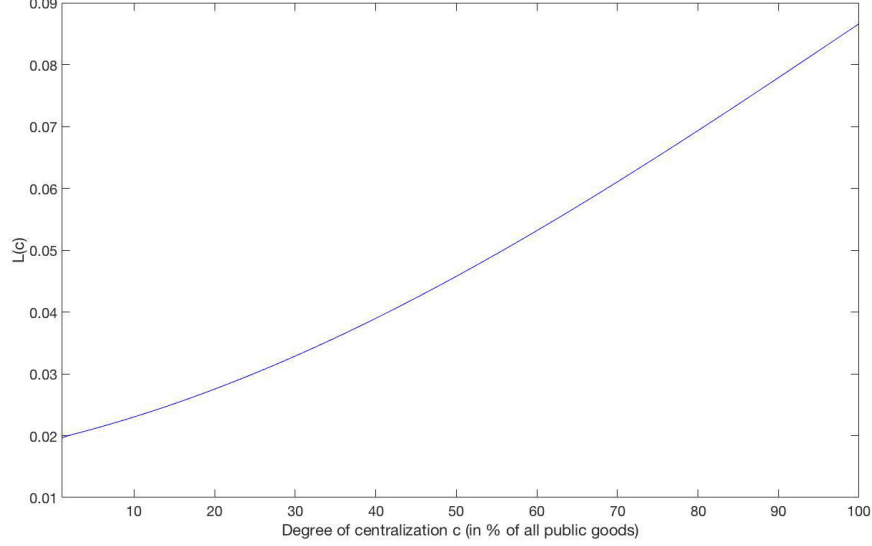
We turn to the second corner solution which is full centralization  $c = 1$ . The total deadweight loss is a continuous function at  $c = 1$ . Indeed, since  $\lim_{c \rightarrow 1} \epsilon_i(c) = 0 = \epsilon_i(1)$ , we have  $\lim_{c \rightarrow 1} L^l(c) = 0 = L^l(1)$ . It follows that we have  $\lim_{c \rightarrow 1} L(c) = L^c = L(1)$ . Formally, we see that the derivative of the loss function (43) evaluated at full centralization  $c = 1$  is positive:

$$\frac{\partial L(1)}{\partial c} = \frac{1}{2} \sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} > 0 \quad (50)$$

Hence the total deadweight loss cannot be minimized at  $c = 1$ . The implication of (50) is that it is never optimal to have full centralization i.e.  $c^* < 1$ . It is optimal to have at least some provision of public goods remaining at the local level.

The deadweight loss caused by central provision  $L^c$  defined by (33) is independent of  $c$ . A rise in  $c$  increases the total loss function  $L(c)$  by the same constant amount  $L^c$  regardless of the level of centralization. On the contrary, the deadweight loss of local provision  $L^l(c)$  decreases with centralization (Proposition 1). As fewer and fewer public goods remain at the local level, the tax elasticity is reduced such that inefficiencies of local provision vanish. As a result, as  $c$  rises to full centralization, the deadweight loss of local provision tends to zero and will necessarily for some  $c < 1$  be outweighed by the flat deadweight loss of central provision. The fact that a rise in  $c$  reduces inefficiencies at the local level builds the case for centralization, but also means that a fully centralized system is not optimal. At one point, the share of public goods allocated at the local level is so low that the local tax distortions become insignificant compared to the lack of adaptability of central provision. It then becomes non optimal to further shift public goods away from the local to the central level.

Hence, while some decentralization of public good provision is always optimal, some centralization is not necessarily preferable. A similar result can be found in Janeba and Wilson (2011), which we confirm in our set-up with heterogeneous preferences.

**Figure 4:** Total deadweight loss as a function of  $c$  with lower base erosion

**Proposition 3** Some decentralization of public good provision is always optimal. Some centralization is optimal if the heterogeneity of preference is low enough compared to local tax distortions under full decentralization.

Using a quadratic production function as defined by (36), the condition for some centralization being optimal (49) becomes:

$$\sum_{i=1}^n \frac{(\gamma_i - \bar{\gamma})^2}{\bar{\gamma}} < \sum_{i=1}^n \gamma_i \epsilon_i^2(0) \left[ 1 + 2 \frac{1 - \epsilon_i^2(0)}{1 - \epsilon_i(0) + 2\epsilon_i^2(0)} \right] \quad (51)$$

Figure 4 depicts a case where condition (51) is not satisfied. The heterogeneity of preferences is too high compared to base erosion such that the loss function strictly increases with  $c$ . Hence, full decentralization is optimal and  $c^* = 0$ .<sup>18</sup>

## 5 Conclusion

Our paper revisits the traditional Oates' theorem. We contribute to the literature on optimal centralization through a novel trade-off between adaptability to preferences and

<sup>18</sup>Compared to the numerical example presented in figure 3, we decreased base erosion by setting  $b = \frac{15}{20}$ .

protection against base erosion. We adopt a federal structure where public goods can be provided by either the local or the central government. If positive spillovers are usually considered as favoring the central provision, here we consider the protection against base erosion as the benefit of centralizing public goods.

We present three main results. First, centralization increases provision of the goods staying at the local level. The literature on fiscal federalism identifies various costs of centralization in terms of local public finances (vertical tax externalities, administrative costs...), however we present an argument that goes against the standard thinking: centralization reduces the price distortion of local provision.

Second, we show that increased base erosion favors a centralized provision of public goods. Indeed higher capital outflows mean increased deadweight loss for the local provision, without affecting central provision. A federal system where some taxable bases react strongly to tax changes, as it seems to be the case for CIT in Europe, benefits from centralization and the optimal allocation of provision is likely to favor the central level. It also means that efforts to reduce base erosion render public good centralization less relevant. In turn, a high heterogeneity of preferences does not necessarily favors decentralized provision, contrary to traditional thinking, because of base erosion. Increased heterogeneity of preferences raises inefficiencies both at the central and local levels. More heterogeneity makes the central government increasingly unable to meet local tastes. However, if base erosion is strong, local inefficiencies for high taste jurisdictions also rise substantially. Central provision, although remote from their preferences, protects them against base erosion. Hence, diverging tastes for public goods in a federal system of heterogeneous jurisdictions should not necessarily translate into a lower degree of centralization, if base erosion is high.

Third, we characterize the optimal degree of centralization as the one that yields the best trade-off between the strength of base erosion and the dispersion of preferences. The fact that centralization mitigates inefficiencies at the local level is also what makes a fully central system non optimal. Indeed, as local distortions vanish, the cost of central provision in terms of unadaptability to preferences will always dominate for some degree of central-



ization, such that at one point shifting more public goods to the central level is undesirable. However, whether some centralization is optimal depends on heterogeneity in preferences being lower than local tax distortions, so that a fully decentralized system might be optimal.

## 6 Appendix

**Calculation of**  $\frac{\gamma_i}{t_i} \frac{\partial t_i}{\partial \gamma_i}$

We know that local provision writes  $g_i^l = \gamma_i(1 - \epsilon_i)$ . Deriving with respect to  $\gamma_i$  yields:

$$\frac{\partial g_i^l}{\partial \gamma_i} = 1 - \epsilon_i - \frac{\partial \epsilon_i}{\partial \gamma_i} \gamma_i \quad (\text{A1})$$

Next, deriving the local government budget constraint (6) with respect to  $\gamma_i$ :

$$(1 - c) \frac{\partial g_i^l}{\partial \gamma_i} = (1 - \epsilon_i) k_i \frac{\partial t_i}{\partial \gamma_i} \quad (\text{A2})$$

Deriving the tax elasticity of capital with respect to  $\gamma_i$ , we have:  $\frac{\partial \epsilon_i}{\partial \gamma_i} = -\frac{1 + \epsilon_i \left(1 + \frac{f'''(k_i)k_i}{f''(k_i)}\right)}{f''(k_i)k_i} \frac{\partial t_i}{\partial \gamma_i} = \frac{\partial \epsilon_i}{\partial t_i} \frac{\partial t_i}{\partial \gamma_i}$ . Using this expression and (A2), we rewrite (A1) as:

$$\frac{1 - \epsilon_i}{1 - c} k_i \frac{\partial t_i}{\partial \gamma_i} = 1 - \epsilon_i - \frac{\partial \epsilon_i}{\partial t_i} \frac{\partial t_i}{\partial \gamma_i} \gamma_i \quad (\text{A3})$$

which we rearrange into:

$$\frac{\partial t_i}{\partial \gamma_i} = \frac{1 - \epsilon_i}{\frac{1 - \epsilon_i}{1 - c} k_i + \frac{\partial \epsilon_i}{\partial t_i} \gamma_i} \quad (\text{A4})$$

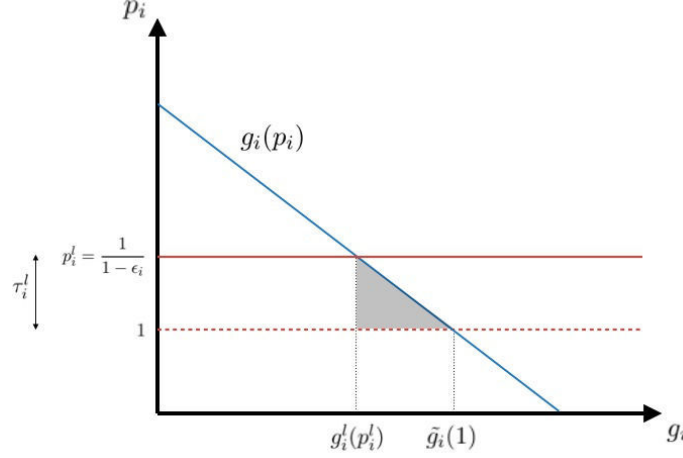
Multiplying both sides by  $\frac{\gamma_i}{t_i}$  and using  $g_i^l = \gamma_i(1 - \epsilon_i)$ , we obtain:

$$\frac{\gamma_i}{t_i} \frac{\partial t_i}{\partial \gamma_i} = \frac{1}{1 - \epsilon_i + \frac{t_i}{1 - \epsilon_i} \frac{\partial \epsilon_i}{\partial t_i}}$$

### Deadweight loss calculation

Figure 5 represents the local deadweight loss caused by inefficient public good pricing. For simplification, a linear demand curve  $g_i^l(p_i^l)$  is represented while in our model, the specification for  $u(g)$  implies a non linear demand curve. Harberger formulas are then approximations of the deadweight losses, which would become exact with linear demand curves.

For a price of 1, demand for public good is  $g_i^l(1) = \gamma_i = \tilde{g}_i$ , the efficient level consistent with the Samuelson rule (9). The equilibrium price for local public goods is  $\frac{1}{1 - \epsilon_i}$ , which

**Figure 5:** Deadweight loss

returns a level of public goods of  $g_i^l\left(\frac{1}{1-\epsilon_i}\right) = \gamma_i(1-\epsilon_i)$ . The deadweight loss associated with this inefficient pricing is represented by the grey triangle. Its surface can be calculated by:

$$\frac{1}{2}\Delta p_i^l \Delta g_i^l \quad (\text{A5})$$

where  $\Delta p_i^l$  is the difference between efficient and inefficient pricing. We have  $\Delta p_i^l = \frac{1}{1-\epsilon_i} - 1 = \tau_i^l$ .  $\Delta g_i^l$  is the change in public good provision resulting from this price difference. We have  $\Delta g_i^l = \frac{\Delta g_i^l}{\Delta p_i^l} \Delta p_i^l = \frac{\Delta g_i^l}{\Delta p_i^l} \tau_i^l$ . Expression for the deadweight loss (A5) rewrites:

$$\frac{1}{2}(\tau_i^l)^2 \frac{\Delta g_i^l}{\Delta p_i^l}$$

### Proof of Proposition 1

Using the fact that  $\frac{\partial \epsilon_i}{\partial c} = \frac{\partial \epsilon_i}{\partial t_i} \frac{\partial t_i}{\partial c}$ , we can rewrite (A6) as, for  $c < 1$ :

$$\frac{\partial g_i^l(c)}{\partial c} = -\gamma_i \frac{\partial \epsilon_i(c)}{\partial t_i} \frac{\partial t_i(c)}{\partial c} \quad (\text{A6})$$

Deriving both sides of (6) with respect to  $c$ :

$$(1-c) \frac{\partial g_i^l(c)}{\partial c} - g_i^l(c) = (1-\epsilon_i(c)) k_i(c) \frac{\partial t_i(c)}{\partial c} \quad (\text{A7})$$

which we can rearrange using (A6) as:

$$\frac{\partial t_i(c)}{\partial c} = -\frac{\gamma_i(1 - \epsilon_i(c))}{(1 - \epsilon_i(c))k_i(c) + \gamma_i(1 - c)\frac{\partial \epsilon_i(c)}{\partial t_i}} < 0 \quad (\text{A8})$$

Finally, by multiplying both sides by  $\frac{1 - c}{t_i(c)}$  and simplifying, we obtain from the above expression:

$$\frac{1 - c}{t_i(c)} \frac{\partial t_i(c)}{\partial c} = -\frac{1}{1 - \epsilon_i(c) + \frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}} < 0 \quad (\text{A9})$$

We can rewrite (A6):

$$\frac{\partial g_i^l(c)}{\partial c} = -\frac{\gamma_i(1 - \epsilon(c))}{1 - c} \frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i(c)} \frac{1 - c}{t_i(c)} \frac{\partial t_i(c)}{\partial c} \quad (\text{A10})$$

Which simplifies into:

$$\frac{1 - c}{g_i^l(c)} \frac{\partial g_i^l(c)}{\partial c} = \frac{\frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}}{1 - \epsilon_i(c) + \frac{t_i(c)}{1 - \epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i}} > 0$$

### Proof of Proposition 3

With a quadratic production function, we have:

$$\frac{t_i(c)}{\epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i} = 1 + \epsilon_i(c)$$

so that:

$$\frac{1 - t_i(c)}{\epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i(c)} = \frac{1 + \epsilon_i(c)}{1 - \epsilon_i(c)} \epsilon_i(c)$$

Hence equation (A9) writes:

$$\frac{1 - c}{t_i(c)} \frac{\partial t_i(c)}{\partial c} = -\frac{1}{1 - \epsilon_i(c) + \frac{1 + \epsilon_i(c)}{1 - \epsilon_i(c)} \epsilon_i(c)} \quad (\text{A11})$$

In turn, we have:

$$\frac{1 - c}{\epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial c} = \frac{t_i(c)}{\epsilon_i(c)} \frac{\partial \epsilon_i(c)}{\partial t_i} \frac{1 - c}{t_i(c)} \frac{\partial t_i(c)}{\partial c} = -\frac{1 + \epsilon_i(c)}{1 - \epsilon_i(c) + \frac{1 + \epsilon_i(c)}{1 - \epsilon_i(c)} \epsilon_i(c)} = -\frac{1 - \epsilon_i^2(c)}{1 - \epsilon_i(c) + 2\epsilon_i^2(c)} \quad (\text{A12})$$

## Chapter II

# Tax competition and club formation

### 1 Introduction

Tax cooperation, defined as the common setting of tax rates or ranges of rates, is well-known to face numerous obstacles. First, countries must accept to band together with allies that potentially have different preferences and goals than their own. The benefits of cooperation have to outweigh the loss of independence. Then, in a world where factor mobility erodes taxable bases, cooperation remains partial if participating is not as attractive as holding out in the rest of the world and winning the tax competition game. The possibility to benefit from cooperation elsewhere while staying out might constrain the size of alliances, or even prevent their formation in the first place if no country is willing to give up what it could potentially gain by remaining an outsider, although there is a benefit in cooperating.

In particular, if there are asymmetries in size or factor endowment, some may prefer the tax competition equilibrium to cooperation although it is Pareto improving. For example, small regions can exploit factor mobility by setting relatively low taxes to attract a lot of base (Wilson, 1991; Bucovetsky, 1991), which can explain the existence of non-cooperating tax havens. Even leaving aside structural asymmetries among competitors, policy coordination itself leads to differences in tax levels and capital allocations. Difficulties to set-up

tax agreements such as the Common Consolidated Corporate Tax Base (CCCTB) in the EU illustrate how countries can be reluctant to cooperate if they fear ending up disadvantaged compared to other competitors. Hence, one may wonder what type of policy coordination may induce countries to join alliances in spite of tax competition, so that full cooperation is reached.

The contribution of this paper consists in including public good spillovers when analyzing the formation of tax cooperation zones. In a tax competition setting, cooperating players who set their rate in common lose tax base to the rest of the world. But if cooperating entails benefiting from spillovers on top of coordinating in taxes, then the net benefits of membership might be high enough to remove the incentives to remain a non-cooperating, low-tax player. Spillovers then take the form of side payments making up for the lost tax base. Provided spillovers are high enough, full cooperation may be reached. We connect our theoretical thinking to the financing of pan-European public goods such as single market of goods, security or defence as well as cross-border infrastructures. This analysis provides a rationale for complementing tax cooperation projects such as the CCCTB with common spending exhibiting high spillovers, such as a euro area budget to provide public goods at the European level.

In this paper, we adopt a standard model of tax competition where identical countries compete *à la Nash* over a mobile tax base, capital, taxed at the source to finance a public good. Tax competition distorts downwards the amount of tax revenue the government can raise since some capital flies away following a tax increase. We introduce the public good spillovers in the following way: as long as they do not cooperate, countries restrict the access of their public good to their respective household (in that sense these public goods have the feature of publicly provided private goods). Then, we make it possible for some countries to cooperate and benefit from a share of the others' public goods. We call this group of countries the club. Members can overcome tax competition by coordinating to set taxes and in return they benefit from a share of the others' public good through

cross-border spillovers.

Strong assumptions on functional forms are made to derive closed-form solutions for the tax equilibrium as in Bucovetsky (2009): the production function is quadratic and the utility is linear in the public good. However, the results described in this paper are representative of general mechanisms not driven by these assumptions. Through the inclusion of robustness checks, we show that our results are still valid with other more general functional forms.

Our work relates to two strands of literature. First, the tax competition literature.<sup>1</sup> Specifically, greater capital mobility raises the cost of the public good since a tax increase causes capital flight, conveying a positive externality on other jurisdictions. Competing governments cannot, without cooperation, achieve an efficient public good provision, which is the seminal result. It can also mean that taxation shifts to less mobile tax bases such as labor, or to the residence principle (Bucovetsky and Wilson, 1991). Moreover, an important branch of this literature investigates tax cooperation, with ambiguous welfare conclusions.<sup>2</sup> Konrad and Schjelderup (1999) show that a partial tax harmonization is beneficial not only for cooperating countries but also for countries outside the cooperation provided tax rates are strategic complements.<sup>3</sup> Peralta and van Ypersele (2005) present minimum capital tax and tax range as alternative forms of tax coordination policies, and find only the latter to be Pareto-improving. One should also mention matching grants, or side payments, as possible instruments to overcome tax competition (DePeter and Myers, 1994; Wildasin, 1989). Also, Burbidge et al. (1997) incorporate coalition formation in a tax competition model and show that when there are more than two regions, equilibrium can consist of partial cooperation with multiple federations. Our contribution on policy coordination among tax competitors is to consider that countries coordinating in taxes also grant access to others to a share of their own public good. In particular, we do so by studying the

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<sup>1</sup>Seminal models are presented by Zodrow and Mieszkowski (1986); Wildasin (1988). See Wilson (1999) for an overview.

<sup>2</sup>We refer the reader to Keen et al. (2012) for a review.

<sup>3</sup>This assumptions relies on empirical work, see Brueckner and Saavedra (2001); Devereux et al. (2008)

implications of including spillovers in terms of tax equilibrium and cooperation size.

The second strand of the literature connected to our work is that of club theory, which provides relevant insights regarding the nature of public goods we are analyzing.<sup>4</sup> A public good is considered pure when fully non-rival (each user of the good has access to its full amount regardless of how many others use it) and non-excludable (it is impossible to prevent any user from accessing it). A club good however is non-rival but excludable to non-member of the club providing it. First identified by Buchanan (1965) and Olson (1965), clubs are created to benefit from economies of scale and to share public goods. Club theory studies congestion costs or member heterogeneity as factors determining the size of unions. In this paper, the strength of tax competition and of spillovers in public good provision ultimately determine the size that the club can reach.

Our model accounts for externalities, spillovers and tax competition. First, we calculate equilibrium tax rates under autarky and then when there is capital mobility but no cooperation. Subsequently, we derive the equilibrium under partial cooperation where only a subset of countries is part of the club, and finally in a case of full cooperation where all countries participate. Although we adopt a set-up with symmetric countries, partial policy coordination induces asymmetries with high and low tax regions which are analogous to having size differences. Next, we show that an increase in the size of the club benefits all, incumbent and non-cooperating countries alike. Then, we analyze the stable club size, defined as the one at which no country prefers to join or leave the club, as a function of spillovers.

We contribute to the literature by presenting a partial tax coordination framework augmented with the possibility of public good spillovers. The standard result according to which outsiders' gains may be bigger than those of the coordinating subgroup if there is tax competition is reconsidered. We analyze the conditions for a club to emerge, and also for the last remaining country outside of the club to benefit from joining as well bringing the economy to full cooperation. We derive a condition for full cooperation to happen

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<sup>4</sup>See Sandler and Tschirhart (1980) and Sandler and Tschirhart (1997) for surveys of the literature.



according to which, in spite of tax competition, all countries participate because spillovers are high enough. We provide a numerical example to illustrate our model, as well as robustness checks where our assumptions on functional forms are modified.

The paper is organized as follows. Section 2 presents the model. In Section 3, we derive the tax equilibrium under different scenarios. Section 4 studies club formation. Section 5 concludes.

## 2 Model set-up

We adopt a model of international tax competition drawing on a set-up derived in Bucovetsky (2009), itself based on a seminal model of tax competition *à la* Zodrow and Mieszkowski (1986). Similar models have been presented in Peralta and van Ypersele (2005) or Keen et al. (2012). In this one-period model,  $n$  identical countries, equal in size, compete for capital that moves costlessly wherever the after-tax return is highest.<sup>5</sup>

Our take on the issue is to study how the standard tax competition framework evolves when a  $m$ -sized club of countries emerges among these  $n$  tax competitors, with  $1 \leq m \leq n$ . The club consists for its members in coordination to set a harmonized tax rate, while in return benefiting from spillovers in public good provision.<sup>6</sup> As long as  $1 < m < n$ , some countries remain outside of the club and cooperation remains partial. That aspect connects our analysis to the one of Konrad and Schjelderup (1999). We assume that there can be only one club at the same time, and leave the study of the co-existence of multiple clubs to further research. We also characterize the no cooperation case as a world where  $m = 1$ , while full cooperation happens at  $m = n$ .

Each country is inhabited by one representative immobile household receiving utility

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<sup>5</sup>Countries are supposed to compete in taxes, not expenditures. It is an important distinction as shown by Wildasin (1988).

<sup>6</sup>For studies on non cooperative tax policy in the presence of spillovers and the resulting free riding issues, see Bjorvatn and Schjelderup (2002).

from the consumption of a private good as well as a local public good financed through source-based taxation of capital. We consider in this paper a linear utility function, as in Peralta and van Ypersele (2005) or Bucovetsky (2009). Such a specification implies a constant marginal rate of substitution between private and public goods. Adopting a linear function for preferences in the public good means that the household's marginal utility of one additional unit of capital tax revenue is constant and does not decrease with the level of taxation. As argued by Bucovetsky (2009), such an assumption may not be an unrealistic approximation of the utility derived from CIT (corporate income tax, which is source-based taxation), if one considers that the government has access to other sources of distortionary taxation which it chooses optimally. In the end, the CIT tax may represent a small fraction of the overall government revenue, with little impact on the social value of resources raised by taxation. Hence, utility can be considered linear in the revenue from that tax.

While this restriction preserves the key findings of the tax competition literature, it allows in combination with a quadratic production function to derive closed-form solutions for equilibrium tax rates, capital allocation and after-tax return. However, we provide below numerical simulations with different assumptions on the utility and the production functions, to show that our results are robust to more general functional forms.

Each country is inhabited by one household so that all are equal in size, and all variables in the model are in per capita terms. Starting with a non-cooperating country, labelled with an  $s \in ]m; n]$ , preferences follow:

$$u_s(x_s, g_s; m) = x_s + (1 + \lambda)g_s, \forall s \in ]m; n] \quad (1)$$

where  $u_s$  denotes the utility of the representative household in a country  $s$ , while  $x_s$  and  $g_s$  denote the consumption of the private and the public good, respectively. Like in Bucovetsky (2009), we assume the marginal cost of public funds to exceed one: the constant marginal rate of substitution is  $1 + \lambda > 1$ , which represents the marginal utility of each additional unit of the public good.

We now consider a country in the cooperating club, labelled  $c \in [1, m]$ . Inside the club, local public spending creates cross-border spillovers. Positive spillovers are measured with parameter  $0 < \beta < 1$ : the household enjoys the public good of his country,  $g_c$ , plus a share  $\beta$  of all public goods from the  $(m - 1)$  other members of the club. Club membership is a condition for access to spillovers. By symmetry of the club countries, and as those are equal in size, it follows that the total amount of available public good reads  $[1 + \beta(m - 1)]g_c$ , so that the utility of a resident inside the club  $u_c$  follows:

$$u_c(x_c, g_c; m) = x_c + (1 + \lambda)[1 + \beta(m - 1)]g_c, \forall c \in [1; m] \quad (2)$$

where  $x_c$  represents consumption of the private good. For illustration purposes, security can be thought as an example for the type of public good we are considering, as mentioned above. When there is cooperation to share spending on intelligence services or border guards, public spending in one country generates positive spillovers for the other members as security is improved for the whole club. Another example can be cooperative tertiary education programs: spending on universities in one country creates positive spillovers for the other members as skilled labor is mobile.

The immobile household supplies inelastically some domestic, fixed factor (normalized to unity) such as labor or land. As is common in the literature, this factor is untaxed and we only study taxation of the mobile production factor, capital. The homogeneous private good  $x_i$  is produced using both capital and labor according to the production function:

$$f(k_i) = \left(a - \frac{b}{2}k_i\right)k_i, \quad a, b > 0 \quad (3)$$

where we assume  $0 < k_i < \frac{a}{b}$ , with  $k_i$  the per capita amount of capital located in that country, with  $i \in [1; n]$ . Hence, the marginal product of capital reads  $f'(k_i) = a - bk_i > 0$ , while  $f''(k_i) = -b < 0$  ensures the existence of a tax equilibrium. This quadratic production function has been adopted by several noticeable papers on tax competition (Wilson, 1991; Bucovetsky, 1991; Peralta and van Ypersele, 2005).  $f$  is the same for all countries as technologies are the same.<sup>7</sup>

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<sup>7</sup>There is no public input in the production process. Including  $g_i$  as a production factor does not change

The public good  $g_i$ ,  $i \in [1, n]$ , is financed by taxing capital at the source according to the following budget constraint:

$$g_i = t_i k_i \quad (4)$$

where  $t_i$  denotes the tax rate set by the government of country  $i$ . For club countries, the tax rate  $t_c$  is set cooperatively while in the rest of the world, countries set their tax rate  $t_s$  non cooperatively.

Before tax rates are set, the representative household in each country is endowed with an equal amount of capital  $\bar{k}$ . Since capital is assumed perfectly mobile and households can move their endowment wherever the after-tax return is the highest, the allocation of capital is determined by an arbitrage condition:

$$\rho(t_1, \dots, t_n) = f'(k_i) - t_i \quad \forall i \in [1; n]$$

where  $\rho$  denotes the single after-tax return earned from the supply of this capital endowment. Given our specification for  $f$ , we can write the after-tax return as such:

$$\rho(t_1, \dots, t_n) = a - bk_i - t_i \quad \forall i \in [1; n] \quad (5)$$

It follows that the after-tax return is equalized across countries inside and outside of the club, such that  $\rho(t_c, t_s) = a - bk_c - t_c = a - bk_s - t_s, \forall c \in [1, m], \forall s \in [m+1, n]$ . Finally, the market clearing condition for capital means that its total utilization across the economy is at most equal to the total endowment:

$$n\bar{k} = \sum_{c=1}^m k_c + \sum_{s=m+1}^n k_s = mk_c + (n - m)k_s \quad (6)$$

As is common in the literature, when there is capital mobility, we will only study tax equilibria implying a positive after-tax return and no withdrawal of capital endowments, where the market clearing condition (6) holds with equality and (5) determines the allocation of capital for all competitors.<sup>8</sup> This rules out so-called excess supply regimes.

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the results qualitatively.

<sup>8</sup>Equilibrium is also unique, as demonstrated in Bucovetsky (2009).

Formally, tax rates do not exceed the marginal return of capital:

$$t_i < f'(k_i) \quad i \in [1, n]$$

In other words, the two following assumptions are imposed simultaneously to guarantee that  $\rho > 0$ :

$$\begin{cases} t_s < a - bk_s, & \forall s \in ]m, n] \\ t_c < a - bk_c, & \forall c \in [1, m] \end{cases} \quad (7)$$

If the government of country  $i$  raises its tax rate to increase public good provision, it triggers a capital outflow so that the arbitrage condition (5) is satisfied with a lower capital  $k_i$ . How much capital has to flow out to regain equilibrium after a tax hike depends on the elasticity of capital to the tax rate, and whether or not the country is part of the club.

Considering a non-participating country  $s$ , a rise in  $t_s$  triggers a capital outflow towards all other non-participating countries  $s' \in ]m, n]$  and all club countries  $c$ . Differentiating (5) and (6) with respect to a marginal tax hike  $t_s$  yields, after rearranging:<sup>9</sup>

$$\frac{\partial k_s}{\partial t_s} = -\frac{n-1}{nb} < 0 \quad (8)$$

$$\frac{\partial k_{s'}}{\partial t_s} = \frac{\partial k_c}{\partial t_s} = \frac{1}{nb} > 0 \quad (9)$$

$$\frac{\partial \rho}{\partial t_s} = -\frac{1}{n} < 0 \quad (10)$$

Base erosion is determined by  $b = -f''(k_i)$ . The higher  $b$ , the lower the capital outflow following an increase in  $t_s$  needed to restore the arbitrage condition.

Turning to club countries, the level of tax  $t_c$  is set cooperatively as a common tax rate, so a marginal rise leads to an outflow from the entire club to every non-cooperating country. After differentiating (5) and (6) with respect to  $t_c$  and rearranging we obtain:

$$\frac{\partial k_c}{\partial t_c} = -\frac{n-m}{nb} < 0 \quad (11)$$

$$\frac{\partial k_s}{\partial t_c} = \frac{m}{nb} > 0 \quad (12)$$

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<sup>9</sup>Complete calculations are deferred to the Appendix.

$$\frac{\partial \rho}{\partial t_c} = -\frac{m}{n} < 0 \quad (13)$$

From the perspective of club countries, tax coordination means that the capital outflow is lower than for non-cooperating ones, since they compete with  $n - m$  other countries instead of  $n - 1$ . Conversely, non-cooperative countries receive a higher amount of inflow than when there is no cooperation at all, since there is a tax increase in  $m$  countries simultaneously. Also, a marginal increase in  $t_c$  decreases the after-tax return by more than for a marginal increase in  $t_s$ .

Finally, private consumption for the representative household in country  $i$  is made of a wage or real estate rent earned from the supply of the fixed factor  $w_i = f(k_i) - f'(k_i)k_i$ , plus the after-tax return on capital endowment  $\rho \bar{k}$ . There is no saving in this static model so that all the disposable income is spent in consumption of the private good, that amounts in country  $i$  to:

$$x_i = \frac{1}{2}bk_i^2 + \rho \bar{k} \quad (14)$$

### 3 Tax equilibrium

In an autarkic environment without capital mobility, capital allocation is not determined by (5) and (6) anymore. Households utilize their endowment  $\bar{k}$  and the government can tax capital without triggering an outflow. In this case, the government can just convert units of private good into units of public goods, which increases the utility at the rate  $\lambda > 0$ . The social value of one additional unit of tax resources when one unit of private good is taxed away is then  $1 + \lambda > 1$ .

The absence of capital mobility and the linearity of the utility function yield a corner solution for the equilibrium tax rate in autarky. We specify that the government cannot set a tax rate so high that it would imply a negative after-tax return, which would mean that households provide their endowment at a loss, and as a result they might withhold capital.

Hence, the government sets a tax which drives the after-tax return to zero:

$$t^{aut} = f'(\bar{k}) = a - b\bar{k} \quad (15)$$

The corresponding utility amounts to:

$$u^{aut} = \frac{1}{2}b\bar{k}^2 + (1 + \lambda)t^{aut}\bar{k} = \frac{1}{2}b\bar{k}^2 + (1 + \lambda)(a - b\bar{k})\bar{k} \quad (16)$$

### 3.1 No cooperation

To study the tax equilibrium when there is capital mobility and countries compete in taxes, let us start with a setting of no cooperation at  $m = 1$ . In other words, all countries are non-cooperative. The government of country  $i \in [1, n]$  sets its tax rate  $t_i$  to fund  $g_i$  so as to maximize the utility of the representative household (1), subject to constraints for the public (4) and the private goods (14). Country  $i$  does so à la Nash by taking that of all other competitors as given. Given (8) and (10), as long as  $\rho > 0$ , the equilibrium tax rate solves the following first-order condition:

$$\frac{\partial u_i}{\partial t_i} = -\frac{n-1}{n}k_i - \frac{1}{n}\bar{k} + (1 + \lambda) \left[ k_i - \frac{n-1}{n} \frac{t_i}{b} \right] = 0 \quad (17)$$

Due to capital flight, the government transforms one unit of private good into less than one unit of public good,  $k_i - \frac{n-1}{n} \frac{t_i}{b}$  specifically. This distortion reduces the social benefit of taxation, which is the seminal result of the tax competition literature (Zodrow and Mieszkowski, 1986; Wildasin, 1988).

Using symmetry of all competitors in this case, we know that  $k_i = \bar{k}$  and note the equilibrium rate  $t_i = t^{nc}$ ,  $\forall i \in [1, n]$ . The first-order condition (17) can be rearranged to solve for  $t^{nc}$ :

$$t^{nc} = \frac{\frac{\lambda}{1+\lambda} b \bar{k}}{n} \quad (18)$$

The utility under no cooperation is then  $u^{nc}$  with:

$$u^{nc} = \frac{1}{2}b\bar{k}^2 + (1 + \lambda)t^{nc}\bar{k} = \frac{1}{2}b\bar{k}^2 + (1 + \lambda) \frac{\frac{\lambda}{1+\lambda} b \bar{k}}{n} \bar{k} \quad (19)$$

From the arbitrage condition (5), we have  $\rho = a - b\bar{k} - t^{nc}$ , or equivalently  $t^{nc} = t^{aut} - \rho$ . Since we only study cases where the after-tax return is positive i.e.  $\rho > 0$ , it must be that  $t^{aut} > t^{nc}$  so that the tax rate is lower under no cooperation than in autarky. From (16) and (19), we have:

$$u^{aut} - u^{nc} = (1 + \lambda)(t^{aut} - t^{nc})\bar{k} > 0$$

### 3.2 Partial cooperation

We now derive the tax equilibrium at a given  $m$  with  $1 < m < n$ . Let us start with the government of non-cooperative country  $s \in ]m, n]$ , which sets its tax rate by taking that of all other competitors as given. The equilibrium tax rate  $t_s$  solves the following first-order condition:

$$\frac{\partial u_s}{\partial t_s} = \frac{\partial x_s}{\partial t_s} + (1 + \lambda) \frac{\partial g_s}{\partial t_s} = 0 \quad (20)$$

Taking into account (4), (8), (10) and (14), the above condition reads:

$$-\frac{n-1}{n}k_s - \frac{1}{n}\bar{k} + (1 + \lambda) \left[ k_s - \frac{n-1}{n} \frac{t_s}{b} \right] = 0 \quad (21)$$

Next, club countries set their rate in common, taking that of all other outsiders as given. For club country  $c \in [1, m[$ , by deriving utility (2) with respect to  $t_c$ , we obtain:

$$\frac{\partial u_c}{\partial t_c} = \frac{\partial x_c}{\partial t_c} + (1 + \lambda)[1 + \beta(m-1)] \frac{\partial g_c}{\partial t_c} = 0 \quad (22)$$

Because of the spillovers, one unit of public good bring more utility inside the club than outside. Moreover, because taxes are set cooperatively, base erosion is lower than for countries outside of the club, as  $|\frac{\partial k_c}{\partial t_c}| < |\frac{\partial k_s}{\partial t_s}|$ , such that a marginal increase in the tax rate brings more units of public goods than outside the club. Using (4), (11), (13) and (14), we can write:

$$-\frac{n-m}{n}k_c - \frac{m}{n}\bar{k} + (1 + \Lambda(\beta)) \left[ k_c - \frac{n-m}{n} \frac{t_c}{b} \right] = 0 \quad (23)$$

where we define  $\Lambda(\beta) = \lambda + (1 + \lambda)\beta(m-1) > 0$  such that  $1 + \Lambda(\beta) = (1 + \lambda)[1 + \beta(m-1)] > 0$  represents the utility derived from one additional unit of public good inside the club.



As fully derived in the Appendix, these two first-order conditions yield the equilibrium tax rates for  $c$  and  $s$  countries, at a given  $m \in ]1, n[$ :

$$t_s = \left[ \lambda \left( 1 + \frac{2n-m}{n} \Lambda(\beta) \right) + \frac{m}{n} \left( \frac{1}{n} \Lambda(\beta) - \frac{m}{n} \lambda \right) \right] \frac{b\bar{k}}{\Gamma(\beta)} \quad (24)$$

$$t_c = \left[ \Lambda(\beta) \left( 1 + \frac{2n-1}{n} \lambda \right) + \frac{n-m}{n} \left( \frac{m}{n} \lambda - \frac{1}{n} \Lambda(\beta) \right) \right] \frac{b\bar{k}}{\Gamma(\beta)} \quad (25)$$

with  $\Gamma(\beta) > 0$  defined as:<sup>10</sup>

$$\Gamma(\beta) = \left( 1 + \frac{2n-1}{n} \lambda \right) \left( 1 + \frac{2n-m}{n} \Lambda(\beta) \right) - \frac{m}{n} \left[ \frac{m}{n} + \Lambda(\beta) \right] \left( 1 + \frac{2n-1}{n} \lambda \right) - \frac{n-m}{n} \left[ \frac{1}{n} + \lambda \right] \left( 1 + \frac{2n-m}{n} \Lambda(\beta) \right)$$

The tax differential between club and non-cooperative countries is always positive:<sup>11</sup>

$$t_c - t_s = \frac{m-1}{n} (1+\lambda) [\lambda + \beta(n-1 + \lambda(m-1))] \frac{b\bar{k}}{\Gamma(\beta)} > 0 \quad \forall m \in ]1, n[ \quad (26)$$

When  $\beta = 0$ , we obtain  $\Lambda(0) = \lambda$  such that the utility derived from one additional unit of taxation is the same for club and non-club countries. However,  $t_c - t_s$  is not equal to zero. Even without spillovers, there exists a positive differential equal to  $\frac{m-1}{n} (1+\lambda) \lambda \frac{b\bar{k}}{\Gamma(0)} > 0$  because club countries are still coordinating in taxes, resulting in a higher common tax than in the rest of the world.

When there are spillovers  $\beta > 0$  inside the club, we have  $\Lambda(\beta) > \lambda$ . In combination with the coordination in taxes which reduces base erosion, it follows that club countries set higher taxes than non-cooperating ones. The presence of spillovers widens the tax gap implied by the tax coordination.

Non club-countries do not benefit from public good spillovers, however, they win the tax competition game and attract capital from the club. From the arbitrage condition, we know that  $k_s > k_c$  such that club countries are capital exporters and non cooperative ones are capital importers. Hence, the club behaves as a "fortress" (Konrad and Schjelderup (1999)) of high taxes, such that our set-up fits into the partial tax competition literature.

<sup>10</sup>As shown in the Appendix, we have  $\Gamma(\beta) > 0$ .

<sup>11</sup>Proof is derived in the Appendix.

Let us note that this asymmetric outcome is not due to structural differences in size, capital endowment or technology since countries are identical. Instead, partial policy coordination yields the asymmetry here. However, this result is similar to having one big cooperating region (the club) setting a higher tax rate than the rest of the smaller, low-tax, non-cooperating regions.<sup>12</sup>

The tax differential is proportional to  $b$ : the higher  $b$ , the lower the capital outflow following a tax increase such that base erosion weakens. But according to (8) and (11), for the same increase in  $b$ , the outflow decreases relatively more for club countries than for non-club ones. This pushes the tax differential upwards. Moreover, for club countries, this reduced distortion when raising public revenue applies to a relatively higher amount of public good (augmented with spillovers) than for non-club countries, driving the differential even further up.

### 3.3 Full cooperation

A full cooperation scenario consists in the club including all countries such that  $m = n$ . In this special case, all members set their tax rate cooperatively so that tax competition is completely eliminated. In this sense, this case resembles the autarkic setting except for the spillovers. As argued in Bucovetsky (2009), countries can then raise the tax rate without distortion (as there is no base erosion anymore), transforming one unit of private good into one unit of public which is beneficial since  $\lambda > 0$ . However, raising the tax rate cannot be done indefinitely since it depresses the after-tax return. Hence the equilibrium tax rate under full cooperation is increased until  $\rho$  is driven to zero.

Since all cooperating countries are then identical and set in common the equilibrium rate  $t^{full}$ , they all utilize  $\bar{k}$ . From (5), and since under full cooperation,  $\rho = 0$ , we have:

$$t^{full} = a - b\bar{k} = t^{aut} \quad (27)$$

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<sup>12</sup>This is apparent when looking at the size of capital flows and the influence on the after-tax return that  $t_c$  and  $t_s$  have, through (8), (10), (11) and (13). This is analogous to Bucovetsky (1991) for example.

The utility amounts in this case to  $u^{full}$  with:

$$u^{full} = \frac{1}{2}b\bar{k}^2 + (1 + \Lambda(\beta))(a - b\bar{k})\bar{k} \quad (28)$$

In both autarky and the full cooperation settings, there is no base erosion but in the latter, spillovers augment the benefits of raising tax revenue. In autarky, one additional unit of public good raises the utility by  $1 + \lambda$ , while in full cooperation it is  $1 + \Lambda(\beta) > 1 + \lambda$ . As in both autarky and full cooperation cases  $\bar{k}$  allocates in each country, it follows that:

$$u^{full} > u^{aut}$$

In a setting when taxes can never be set so high that they imply a negative rate of return on capital, it must be that the utility in full cooperation is higher than in autarky, itself being higher than when there is no cooperation.

## 4 Club formation

Now that we described the tax equilibrium at  $m$  given, we spell out a definition for club stability in our model, close to that of Alesina et al. (2005a).

For a club to be stable, it must be that all members prefer to be part of the club and all non-members prefer to remain in the rest of the world. Hence an union forms only if at least some countries prefer to exit the rest of the world and ally. If all countries prefer cooperation, then full cooperation is reached. Otherwise, if at least some countries prefer to hold outside while some prefer to stay, then partial cooperation is the stable outcome.

### 4.1 How does the tax equilibrium evolve with $m$ ?

We now analyze the behavior of the tax equilibrium following a marginal increase in  $m$ .<sup>13</sup>

As shown in the Appendix where we defer formal expressions for the derivatives, all tax rates are increasing functions of  $m$ . Furthermore, club members increase their rate faster

<sup>13</sup>Although  $m$  represents a number of countries, we consider it as a continuous variable in this section, which does not change the results, as in Hoyt (1991).

than non-cooperating countries do when  $m$  increases, such that:

$$\frac{\partial t_c(m)}{\partial m} > \frac{\partial t_s(m)}{\partial m} > 0 \quad \forall m \in [1, n[$$

Intuitively, as one more member joins the club, one more country switches from low to high tax, and additional spillovers are brought to the club such that incumbent members increase the common tax rate further. Also, one more member means one less non-cooperating tax competitor, such that base erosion is further reduced for club countries, impacting positively  $t_c(m)$ .

As taxes are strategic complements in this model, the optimal response to an increase in  $t_c(m)$  for non-cooperating countries is to increase their own rate  $t_s(m)$ . But since  $t_c(m)$  rises faster than  $t_s(m)$  when  $m$  increases, non-cooperating countries attract more and more tax base from the club as it increases in size:  $\frac{\partial k_s(m)}{\partial m} > 0, \forall m \in [1, n[$ .

Next, we focus on the change in utility for non-cooperating countries following a marginal increase in  $m$ . Deriving the utility of the representative household (1) with respect to  $m$ , with  $m \in [1, n[$ , yields:

$$\frac{\partial u_s(m)}{\partial m} = bk_s \frac{\partial k_s(m)}{\partial m} + \bar{k} \frac{\partial \rho(m)}{\partial m} + (1 + \lambda) \left[ \frac{\partial t_s(m)}{\partial m} k_s(m) + t_s(m) \frac{\partial k_s(m)}{\partial m} \right] \quad (29)$$

Using the fact that  $\frac{\partial k_s(m)}{\partial m} = -\frac{1}{b} \left[ \frac{\partial \rho(m)}{\partial m} + \frac{\partial t_s(m)}{\partial m} \right]$ , we rearrange the expression above into:

$$\frac{\partial u_s(m)}{\partial m} = \underbrace{-\frac{\partial \rho(m)}{\partial m} (k_s(m) - \bar{k})}_{(a)>0} + \underbrace{\lambda k_s(m) \frac{\partial t_s(m)}{\partial m}}_{(b)>0} + \underbrace{(1 + \lambda) t_s(m) \frac{\partial k_s(m)}{\partial m}}_{(c)>0} > 0 \quad (30)$$

We decompose (30), starting with (a). We know that all tax rates increase with  $m$ . Hence, the after-tax return is decreasing when  $m$  rises. Non-cooperating countries are capital importers, so an increase in  $m$  lowers payment towards club countries which rent part of their capital. This effect has a positive impact on the utility of non-cooperating countries. Next, component (b) is positive since an increase in  $m$  increases the tax rate, so that there is additional public good provision. Finally, (c) is positive because while  $t_s(m)$  increases with  $m$ ,  $t_c(m)$  rises even higher so that the non-cooperative country attracts

more capital. In the end, with  $m$  increasing, a resident staying outside the club pays a lower after-tax return for the capital it imports, and has both higher private and public consumption. So it enjoys higher utility. Formally, as derived in the Appendix, we can rearrange (30) into:

$$\frac{\partial u_s(m)}{\partial m} = \frac{1}{b}(\bar{t}(m) + \lambda t_s(m)) \left[ t_c(m) - t_s(m) + \frac{m}{n} \frac{\partial t_c(m)}{\partial m} + \frac{n-m-1}{n} \frac{\partial t_s(m)}{\partial m} \right] > 0 \quad (31)$$

with  $\bar{t}(m)$  defined as the average tax rate, see equation (A5) in the Appendix.

**Proposition 1** The utility of residents outside the club strictly increases when the size of the club increases.

Proposition 1 means that non-cooperating countries benefit from having another country entering the club.

Turning to the utility of residents inside the club, we derivate (2) with respect to  $m \in [1; n[$ :

$$\begin{aligned} \frac{\partial u_c(m)}{\partial m} = & \underbrace{-\frac{\partial \rho(m)}{\partial m} (k_c(m) - \bar{k})}_{(a)<0} \underbrace{+\Lambda(\beta, m)k_c(m)}_{(b)>0} \frac{\partial t_c(m)}{\partial m} \\ & + \underbrace{(1+\lambda)[1+\beta(m-1)]t_c(m)}_{(c)<0} \frac{\partial k_c(m)}{\partial m} + \underbrace{(1+\lambda)\beta t_c(m)k_c(m)}_{(d)>0} \end{aligned} \quad (32)$$

When the club increases in size while cooperation is partial, its members receive additional spillovers and increase their common tax rate, which has a positive impact on  $u_c(m)$  through effects (b) and (d). However, when cooperation is partial at  $m < n$ , they also lose capital to the rest of the world and they receive a lower after-tax return from the capital they export, so that effects (a) and (c) decrease their utility. Hence, the overall impact of an increase in  $m$  on  $u_c(m)$  is unclear and expression (32) requires further rearrangement.

As shown in Appendix, equation (32) can be transformed into,  $\forall m \in [1, n[$ :

$$\frac{\partial u_c(m)}{\partial m} = \frac{1}{b}(\bar{t}(m) + \Lambda(\beta, m)t_c(m)) \left[ t_c(m) - t_s(m) + \frac{n-m}{n} \frac{\partial t_s(m)}{\partial m} \right] + (1+\lambda)\beta t_c(m)k_c(m) > 0 \quad (33)$$

An increase in the size of the club while in partial cooperation increases the utility of incumbents. This is not driven by our assumptions for the utility and the productions functions, as demonstrated by our robustness checks below.

To complete the analysis, we need to prove that the utility of members already in the club increases when the last country remaining outside enters it. To that effect, we demonstrate below that the discrete jump in the utility of a member country is positive when  $m$  reaches  $n$ .

First, the common tax rate increases from  $t_c(m)$  to the highest possible value  $t^{full}$ . Hence there is an increase in tax revenue which impacts positively the utility. Next, we know that  $k_c(m) < \bar{k}$  when  $m \in [1, n[$ . When  $m$  reaches  $n$ , the economy enters full cooperation and all countries have the same capital allocation  $\bar{k}$ . As club countries switch from being capital exporters with  $k_c < \bar{k}$  to enjoying the endowment  $\bar{k}$ , they benefit from more capital when the club reaches full cooperation than under partial cooperation. Next, we know that under partial cooperation, the after-tax return decreases in  $m$  which hurts club countries since they export capital. However, when there is full cooperation,  $k_c = \bar{k}$  so that club countries are not hurt anymore by  $\rho$  decreasing. Finally, the entry of an additional country brings more spillovers to the club, increasing the utility of its members further.

In the end, an increase in  $m$  that brings the club to full cooperation has a positive marginal effect on the utility of club countries. Indeed, both their common tax rate and their capital allocation increase, they enjoy more spillovers, and are not penalized by the decrease in the after-tax return. Including the last member out of the club is beneficial for those already inside.

It follows that the utility of club countries is strictly increasing in  $m$ ,  $\forall m \in [1, n]$ .

**Proposition 2** The utility of residents inside the club strictly increases when the club increases in size.

In our set-up, the emergence of the cooperation and its increase in size is beneficial for all countries, both inside and outside the club. However, full cooperation may not be reached with all countries joining the club, as some countries might, at one point, gain more by holding out outside of the club when another enters than joining as well.

## 4.2 When does a club emerge? Can full cooperation be reached?

We define the equilibrium club size as  $m^*$ . According to our definition of club stability, at this size, no country would rather enter or leave the cooperation zone.

Starting from no cooperation, for a club to emerge, at least some countries must prefer to ally than to remain in the rest of the world. And since club formation increases the utility of all countries, for a club to be formed, the benefit obtained by cooperating must outweigh the benefit obtained by holding outside while others cooperate. Otherwise, all countries would rather not cooperate.

Formally, we know that both  $u_c(m)$  and  $u_s(m)$  are continuous functions of  $m$  at  $m = 1$ , and  $u_c(1) = u_s(1) = u^{nc}$ . At  $m = 1$ , some non-cooperating countries prefer to cooperate if:

$$\frac{\partial u_c(1)}{\partial m} > \frac{\partial u_s(1)}{\partial m} \quad (34)$$

As proved in the Appendix, a necessary and sufficient condition for a club to be formed is:

$$\beta > \frac{1}{n^2} \frac{1 + \left[ n - 1 + \frac{2}{n} + \frac{3n-1}{n} \lambda \right] \frac{\frac{\lambda}{1+\lambda}}{n-1}}{\frac{n-1}{n} + \left( \frac{2n-1}{n} \lambda \right)^2 + \frac{4n-3}{n} \lambda} = A \quad (35)$$

If spillovers are lower than threshold  $A$ , then no club is formed since spillovers are not high enough to compensate for losing the tax competition. In this case, no cooperation is the stable equilibrium and  $m^* = 1$ . There are benefits in cooperating, but with low spillovers, not as much as staying in the rest of the world and letting others cooperate to remain a low-tax competitor. It follows that in the absence of spillovers, when  $\beta = 0$ , then there

can be no club formation.

If  $\beta > A$ , a club is formed and  $m^* > 1$ . The stable club size is reached at  $u_c(m^*) = u_s(m^*)$ . Both  $u_c(m)$  and  $u_s(m)$  are increasing functions of  $m$ . As long as  $u_c(m) > u_s(m)$ , the stable club size  $m^*$  is not reached since more countries prefer to join. As long as  $u_c(m) < u_s(m)$ , the club is not stable either as some member countries want to leave. At  $m^*$ , no club member prefers to leave since utility would be lower in the rest of the world at  $m < m^*$ , and no country wants to enter as utility would be lower inside the club at  $m > m^*$ .

It might be that all countries want to participate, such that full cooperation is the stable size and  $m^* = n$ . A necessary and sufficient condition for full cooperation to happen is that no country would rather hold out outside than entering into full cooperation.

We adopt the viewpoint of the last remaining non-cooperating country when  $m \rightarrow n$ , and label it with a  $S$ . At this point, the economy consists in one big region, the club, which approaches the size of  $n$ , and country  $S$  with a size approaching zero, resembling one last tax haven outside of the club. Recalling the expression we obtained for capital flows (11) as well as (13), we have, when  $m \rightarrow n$ ,  $\frac{\partial k_c}{\partial t_c} \rightarrow 0$  and  $\frac{\partial \rho}{\partial t_c} \rightarrow -1$ . The club approaches the size of one big cooperating region setting its tax rate with such market power that it decreases the after-tax return proportionally when increasing its tax, and taxes away private production without triggering an outflow. As stated before, we analyze an economy where the after-tax return cannot be negative, hence the tax rate is such that  $\rho \rightarrow 0$ .

Next, we note  $t_S$  and  $k_S$  the tax rate and the corresponding capital allocation of country  $S$ , such that the utility reads:

$$u_S = \frac{1}{2}bk_S^2 + (1 + \lambda)t_Sk_S \quad (36)$$

When  $m \rightarrow n$ , country  $S$  becomes infinitesimal with no influence on the after-tax return:  $\frac{\partial \rho}{\partial t_S} = 0$ . Then, we use the arbitrage condition (5) to obtain  $-b\frac{\partial k_S}{\partial t_S} - 1 = 0$ , or  $\frac{\partial k_S}{\partial t_S} = -\frac{1}{b} < 0$ . We derivate the utility function (36) with respect to  $t_S$  to obtain the



following first-order condition:

$$\frac{\partial u_S}{\partial t_S} = -k_S + (1 + \lambda) \left( k_S - \frac{t_S}{b} \right) = 0 \quad (37)$$

Rearranging the above expression yields  $t_S = \frac{\lambda}{1 + \lambda} b k_S$ . Together with  $k_S = \frac{a - t_S}{b}$  as the after-tax return is driven to zero, we derive the tax rate and capital allocation for country  $S$ :

$$t_S = \frac{a\lambda}{1 + 2\lambda} \quad (38)$$

$$k_S = \frac{a(1 + \lambda)}{b(1 + 2\lambda)} \quad (39)$$

This tax equilibrium characterizes an infinitesimal tax haven in the presence of a cooperation club whose size approaches  $n$  and drives  $\rho$  to zero. It follows that the utility this last country  $S$  obtains by holding out tends to:

$$u_S = \frac{[a(1 + \lambda)]^2}{2b(1 + 2\lambda)} \quad (40)$$

Country  $S$  enters the club if and only if the utility inside under full cooperation,  $u^{full}$ , is higher than the one obtained by remaining the last outsider,  $u_S$ , i.e. full cooperation happens if and only if:

$$u^{full} > u_S \quad (41)$$

Using (28) and (40), we rearrange the above condition (41) into:<sup>14</sup>

$$\beta > \frac{\frac{a^2(1 + \lambda)}{2b(1 + 2\lambda)} - \frac{\frac{1}{2}b\bar{k}^2}{1 + \lambda} - (a - b\bar{k})\bar{k}}{(a - b\bar{k})\bar{k}(n - 1)} = B \quad (42)$$

For full cooperation to happen, spillovers measured by  $\beta$  must be higher than term  $B$ . If  $\beta > B$ , then full cooperation is stable and  $m^* = n$ . If  $\beta < B$ , then cooperation is partial and  $m^* < n$ .

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<sup>14</sup>Steps to obtain expression (42) are developed in the Appendix.

**Proposition 3** Full cooperation happens if spillovers are strong enough to compensate for the benefit of holding out in terms of additional private and public goods.

This result brings a new take at the classic insight of the partial cooperation literature in a tax competition setting. The standard thinking is that although cooperation among a subset of jurisdictions benefits all, full cooperation might not happen if the benefits of holding out as a non-cooperative competitor exceed those of banding together. This is because of tax competition: attracting a lot of tax base from not cooperating might be strong enough of an incentive to remain an outsider.

In our model, cooperating countries also share provision of their public good through spillovers. If strong enough, these spillovers may outweigh the benefits of staying outside of the club, such that holding out does not yield the highest possible utility. Hence, it may be the case that full cooperation is reached even in the presence of tax competition.

$B$  is a decreasing function of  $n$ . The number of countries has no influence on the behavior of country  $S$ . Indeed, due to its infinitesimal size, country  $S$  sets its tax rate without any influence on the after-tax return, regardless of the number of competing countries. However, an increasing  $n$  means more spillovers inside the club under full cooperation. Hence, the higher the  $n$ , the easier it is to fulfill condition (42).

$B$  is also decreasing in the marginal cost of public funds  $\lambda$ , as shown in the Appendix. Holding outside of the club to remain a small low-tax country allows to attract a lot of tax base and to increase capital allocation. However, setting a low tax rate is less of an incentive for country  $S$  when  $\lambda$  increases. On the contrary, inside the club, a rise in  $\lambda$  means a higher utility derived from public good provision, augmented with spillovers, and without base erosion. Hence, an increase in the marginal cost of public funds makes it more attractive to join the club and reach full cooperation.

Moreover,  $B$  decreases in the capital endowment  $\bar{k}$ . Indeed,  $\bar{k}$  does not influence the tax equilibrium of country  $S$ . However, inside the club, a higher  $\bar{k}$  means more private good consumption, as well as more public good provision. As a result, it is more attractive to join the club for the last non-cooperating country when  $\bar{k}$  rises.

Finally, as shown in the Appendix,  $B$  is a decreasing function of  $b = -f''(k_i)$ . When  $b$  increases, base erosion weakens. We see from (38) that  $t_S$  is not impacted. But with a higher  $b$ , the arbitrage condition is consistent with a lower level of capital  $k_S$ . Indeed, since the capital inflow obtained by country  $S$  decreases in  $b$ , country  $S$  attracts less tax base by setting a lower tax rate. In other words, when  $b$  increases and base erosion is lower, there is less of an incentive to hold out and remain a low-tax setter. Hence, condition (42) is more easily met.

Conversely, a decreasing  $b$  characterizes a world where base erosion intensifies. As  $B$  increases, spillovers must be higher for full cooperation to be reached. From a policy perspective, to incentivize countries to join the club, incumbent members must share a higher degree of spillovers in public good provision when base erosion is high. Doing so is in the own interest of those incumbent members since they obtain a higher utility when all other countries are allies rather than when some hold out as competitors.

In the end, we have:

$$\begin{cases} m^* = 1 & \text{if } \beta < A \\ m^* = n & \text{if } \beta > B \\ 1 < m^* < n \text{ defined by } u_c(m^*) = u_s(m^*) & \text{otherwise} \end{cases}$$

We present numerical examples in the following subsection to illustrate our analysis of the stable club size.

### 4.3 Illustration and robustness checks

Whether the stable cooperation is partial or full, or whether a club exists at all depends on spillovers. If large enough, full cooperation might be stable. But when too low, it might be that spillovers do not provide the necessary incentives for at least some countries to join, and partial cooperation is the stable outcome. At most, it can be that spillovers are so low that no country wants to participate at all, and no cooperation is stable.

We borrow a classification from Alesina et al. (2005b) to identify public goods with different degrees of spillovers in the EU. One typical example of a policy area with high spillovers would be single market policies. Indeed, large benefits can be reaped from policies guaranteeing the proper functioning of the single market from goods, since those are highly mobile between countries.

Then, a policy domain with positive but lower spillovers would be international relations, including common defense and foreign policy. Club membership entails gains in terms of spillovers derived in this areas through border control or intelligence services for example, but limited to the extent that geo-political objectives are consistent among countries.

Finally, education or labor market policies can be identified as policy areas with low spillovers since labor is not particularly mobile, especially unskilled labor. Hence fewer benefits can be derived from spending on education or active labor market policies in cooperating countries compared to the other areas mentioned above.

We provide below numerical examples of these three possible cases (Figure 1): high, medium and low  $\beta$ .<sup>15</sup>

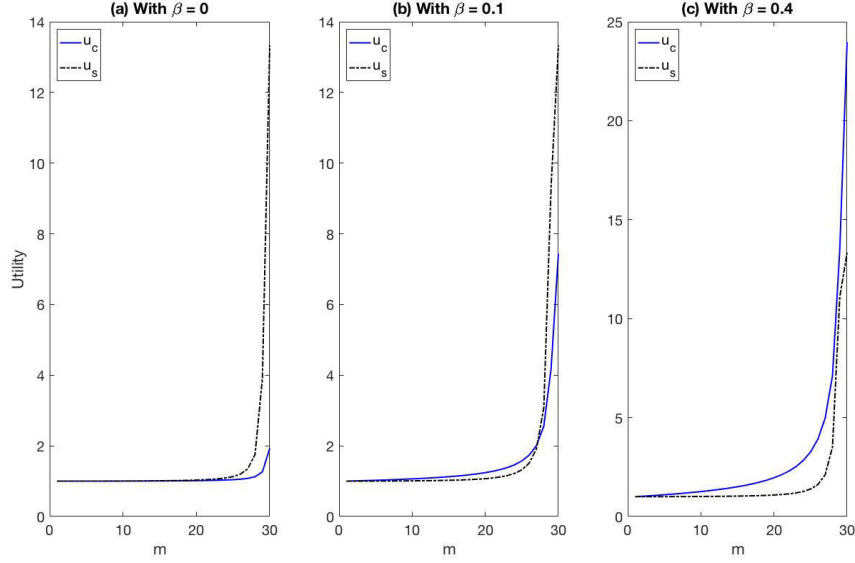
Considering our example with high spillovers (panel a), participating in a club to provide a single goods market is attractive enough for full cooperation to be stable, since utility inside the club is always higher than outside i.e.  $u_c(m) > u_s(m)$ ,  $\forall m \in [1, n]$ . Hence a club emerges and all countries prefer to join, which increases the utility of incumbents. Any club size  $m < n$  is unstable. We have  $m^* = n$ .

For the policy area with a positive but lower degree of spillovers such as defense (panel b),  $\beta$  is high enough for a club to emerge, but some countries prefer to hold outside such that partial cooperation is stable. Then  $1 < m^* < n$  is defined as the club size at which  $u_c(m^*) = u_s(m^*)$ .  $m < m^*$  is an unstable club size and some non-cooperating countries prefer to join since  $u_c(m) > u_s(m)$ , which increases  $m$ .  $m > m^*$  is also unstable since

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<sup>15</sup>We set  $\bar{k} = 1$ ,  $a = 1$ ,  $b = 0.05$ ,  $\lambda = 1$ ,  $n = 30$ . These values guarantee that the economy is outside an excess supply regime for all values of  $m \in [1, n]$ . The value for  $u_s(m)$  at  $m = n$  corresponds to the utility of the last remaining tax haven  $u_S$ .

**Figure 1:** Utilities as functions of  $m$



utility is higher in the rest of the world:  $u_c(m) < u_s(m)$ . Some incumbents leave which decreases  $m$ .

In our example, with the lowest spillovers (panel c), a club to provide common labor market policies does not emerge.  $\beta$  is too low such that all countries would rather hold in the rest of the world than form a club, as  $u_c(m) < u_s(m)$ ,  $\forall m \in [1, n]$ . Any club size  $m > 1$  is unstable, and instead  $m^* = 1$ .

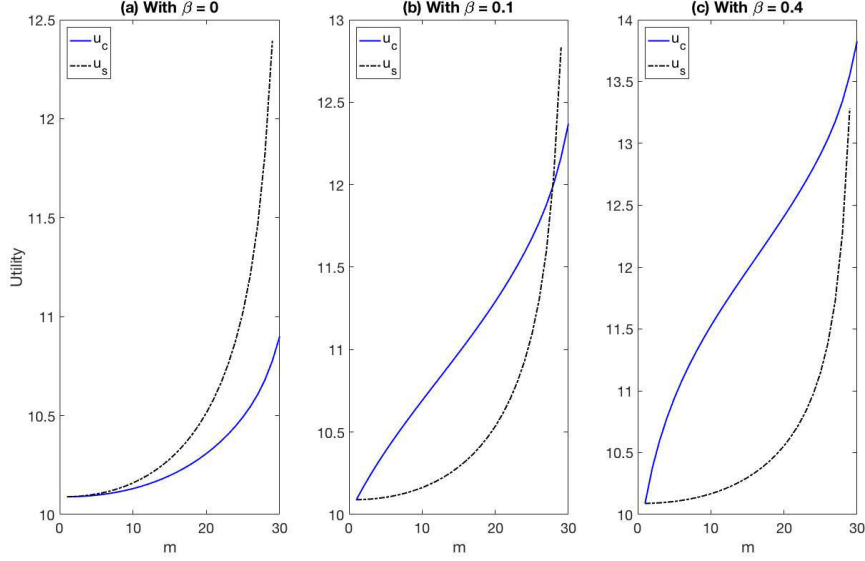
The reasoning exposed here is not limited to the specification we adopted for the production and the utility functions. Figures below provide robustness checks for our results. First, Figure 2 depicts our club formation model with the following iso-elastic utility functions for public goods:<sup>16</sup>

$$\tilde{u}_s(m) = x_s + \frac{g_s^{1-\gamma}}{1-\gamma} \quad \forall s \in ]m, n] \quad (43)$$

$$\tilde{u}_c(m) = x_c + \frac{[(1 + \Lambda(\beta, m))g_c]^{1-\gamma}}{1-\gamma} \quad \forall c \in [1, m] \quad (44)$$

<sup>16</sup>We set  $\bar{k} = 2$ ,  $a = 1$ ,  $b = 0.05$ ,  $\gamma = 0.9$ ,  $n = 30$ . These values guarantee that the economy is outside an excess supply regime for all values of  $m \in [1, n]$ .

**Figure 2:** Robustness check with iso-elastic utility function



with  $\gamma < 1$ . Those replace equations (1) and (2) respectively.

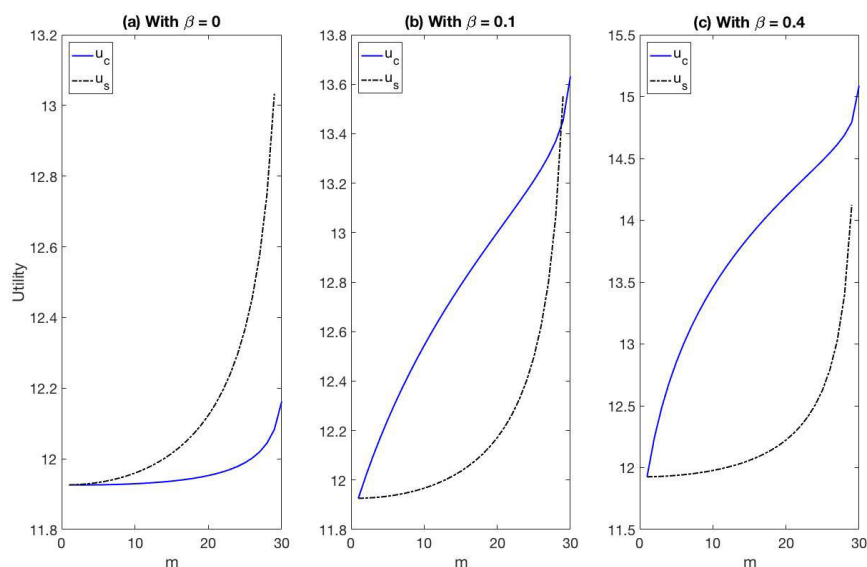
Then, we further amend our model by replacing the production function (3) with the following Cobb-Douglas function:

$$\tilde{f}(k_i) = k_i^\alpha \tag{45}$$

with  $0 < \alpha < 1$ , such that  $f'(k_i) = \alpha k_i^{\alpha-1} > 0$ ,  $f''(k_i) = \alpha(\alpha - 1)k_i^{\alpha-2} < 0$ , and  $f'''(k_i) = \alpha(\alpha - 1)(\alpha - 2)k_i^{\alpha-3} > 0$ . Figure 3 presents our model with equations (43), (44) and (45).<sup>17</sup>

According to these robustness checks, our model is representative of general mechanisms as results are not driven by our specifications for utility and production functions (1), (2) and (3). Concavity of the utility or production functions does not alter the analysis: stability of the club size depends on the strength of spillovers. Cooperating entails losing capital to the rest of the world, so that benefits in sharing public good determine whether partial or full cooperation can be stable equilibria, or none at all.

<sup>17</sup>We set  $\bar{k} = 10$ ,  $\alpha = 0.5$ ,  $\gamma = 0.9$ ,  $n = 30$ . These values guarantee that the economy is outside an excess supply regime for all values of  $m \in [1, n]$ .

**Figure 3:** Robustness check with iso-elastic utility and Cobb-Douglas production functions

## 5 Conclusion

The present paper extends the standard model of partial cooperation among identical tax competitors with the possibility of exploiting spillovers in public good provision. Cooperating countries are then part of a club which sets higher taxes than in the rest of the world.

By adopting assumptions for production and utility, we calculate the tax equilibrium as a function of the club size. Subsequently, we show how an increase in the number of cooperating countries increases the utility of all, those already members of the club as well as those staying outside. Numerical simulations show that this is still valid with more general utility and production functions.

Whether or not the economy reaches full cooperation is unclear in the literature: benefits obtained by holding out and winning the tax competition game can outweigh that of entering the cooperation. Then, tax competition and the possibility of free riding policy coordination elsewhere may provide an explanation for tax havens or the difficulty to achieve full tax cooperation among groups of countries, the EU for example.

The contribution of this paper is to present a type of policy coordination which consists between cooperating countries in granting access to a share of local public spending, on top of coordinating in taxes. Our model suggests that, if these spillovers in public good provision are sufficient, cooperation entry may be attractive enough for all countries to give up the benefits of remaining a low-tax outsider, such that tax competition is eliminated. We also show that the stronger tax competition is, the higher spillovers must be for full cooperation to be reached.

It is more likely that all countries are incentivized to participate, reaching full cooperation, if taxes are coordinated to share public goods whose provision exhibits high spillovers. In the context of economic integration among countries which are also tax competitors, this builds the case for the set-up of common taxes to finance public goods with a high degree of spillovers, such as, for European countries, area-wide security, defence or international relations policies.



## 6 Appendix

### Calculating capital flows

Differentiating (5) and (6) with respect to a marginal tax hike  $t_s$  yields,  $\forall c \in [1, m]$ ,  $s \in [m, n]$ ,  $s' \in [m, n]$ ,  $s \neq s'$ :

$$\frac{\partial \rho}{\partial t_s} = -b \frac{\partial k_s}{\partial t_s} - 1 = -b \frac{\partial k_{s'}}{\partial t_s} = -b \frac{\partial k_c}{\partial t_s} \quad (\text{A1})$$

$$m \frac{\partial k_c}{\partial t_s} + (n - m - 1) \frac{\partial k_{s'}}{\partial t_s} + \frac{\partial k_s}{\partial t_s} = 0 \quad (\text{A2})$$

Using (A1), we know that  $\frac{\partial k_s}{\partial t_s} = -\frac{1}{b} \left[ 1 + \frac{\partial \rho}{\partial t_s} \right]$  and  $\frac{\partial k_{s'}}{\partial t_s} = \frac{\partial k_c}{\partial t_s} = -\frac{1}{b} \frac{\partial \rho}{\partial t_s}$ . Replacing these expressions into (A2), we can write  $\frac{\partial \rho}{\partial t_s} = -\frac{1}{n}$ , and it follows that  $\frac{\partial k_s}{\partial t_s} = -\frac{n-1}{nb}$  and  $\frac{\partial k_{s'}}{\partial t_s} = \frac{\partial k_c}{\partial t_s} = \frac{1}{nb}$ .

Keeping in mind that club countries set their tax rate cooperatively, we repeat with  $t_c$  to obtain:

$$\frac{\partial \rho}{\partial t_c} = -b \frac{\partial k_c}{\partial t_c} - 1 = -b \frac{\partial k_s}{\partial t_c} \quad (\text{A3})$$

$$m \frac{\partial k_c}{\partial t_c} + (n - m) \frac{\partial k_s}{\partial t_c} = 0 \quad (\text{A4})$$

From (A3), we have  $\frac{\partial k_c}{\partial t_c} = -\frac{1}{b} \left[ 1 + \frac{\partial \rho}{\partial t_c} \right]$  and  $\frac{\partial k_s}{\partial t_c} = -\frac{1}{b} \frac{\partial \rho}{\partial t_c}$ . Using these expressions together with (A4), we obtain  $\frac{\partial \rho}{\partial t_c} = -\frac{m}{n}$  and then  $\frac{\partial k_c}{\partial t_c} = -\frac{n-m}{nb}$  and  $\frac{\partial k_s}{\partial t_c} = \frac{m}{nb}$ .

### Finding $t_c$ and $t_s$ for $1 < m < n$

Let us first define the average tax rate for the economy at a given  $m$ :

$$\bar{t} = \frac{mt_c + (n - m)t_s}{n} \quad (\text{A5})$$

To proceed, we use the fact that for  $\rho > 0$ , (5) holds for the  $m$  club and the  $n - m$  non-cooperating countries. Summing yields:

$$m\rho + (n - m)\rho = n\rho = na - b[mk_c + (n - m)k_s] - [mt_c + (n - m)t_s] \quad (\text{A6})$$

Dividing by  $n$  while using the market clearing equation (6) and the definition for  $\bar{t}$  (A5), we obtain:

$$\rho = a - b\bar{k} - \bar{t} \quad (\text{A7})$$

Next, combining (5) and (A7), it follows that:

$$k_s - \bar{k} = \frac{\bar{t} - t_s}{b} \quad (\text{A8})$$

Hence, if the tax rate of a non-cooperative countries is lower than the average tax rate, it is a capital importer as it implies  $k_s > \bar{k}$ . (A8) determines the allocation of capital for a country outside the club.

After rearranging the first-order condition (21) and using (A8), we obtain:

$$t_s = \frac{\lambda b\bar{k} + \left(\frac{1}{n} + \lambda\right)\bar{t}}{1 + \frac{2n-1}{n}\lambda} \quad (\text{A9})$$

Conversly, using (5) and (A7), we know that:

$$k_c - \bar{k} = \frac{\bar{t} - t_c}{b} \quad (\text{A10})$$

If a club countries set their tax rate higher than average, then they export capital. Using this expression yields the equilibrium tax rate for the club:

$$t_c = \frac{\Lambda(\beta)b\bar{k} + \left[\frac{m}{n} + \Lambda(\beta)\right]\bar{t}}{1 + \frac{2n-m}{n}\Lambda(\beta)} \quad (\text{A11})$$

To obtain a solution for  $t_c$  and  $t_s$ , we calculate the equilibrium average tax rate as a function of the club size  $m$ , when  $1 \leq m < n$ , by plugging expressions for  $t_c$  (A11) and  $t_s$  (A9) into expression (A5):

$$\bar{t} = \left[ \frac{m}{n}\Lambda(\beta) \left(1 + \frac{2n-1}{n}\lambda\right) + \frac{n-m}{n}\lambda \left(1 + \frac{2n-m}{n}\Lambda(\beta)\right) \right] \frac{b\bar{k}}{\Gamma(\beta)} \quad (\text{A12})$$

We name

$$\Gamma(\beta) = \left(1 + \frac{2n-1}{n}\lambda\right) \left(1 + \frac{2n-m}{n}\Lambda(\beta)\right) - \frac{m}{n} \left[\frac{m}{n} + \Lambda(\beta)\right] \left(1 + \frac{2n-1}{n}\lambda\right) - \frac{n-m}{n} \left[\frac{1}{n} + \lambda\right] \left(1 + \frac{2n-m}{n}\Lambda(\beta)\right)$$

the denominator of  $\bar{t}$ . From (A5), we can write:

$$\bar{t} = \frac{\frac{m}{n}\Lambda(\beta)b\bar{k} + \frac{m}{n}\left[\frac{m}{n} + \Lambda(\beta)\right]\bar{t}}{1 + \frac{2n-m}{n}\Lambda(\beta)} + \frac{\frac{n-m}{n}\lambda b\bar{k} + \frac{n-m}{n}\left(\frac{1}{n} + \lambda\right)\bar{t}}{1 + \frac{2n-1}{n}\lambda} > \frac{\frac{m}{n}\left[\frac{m}{n} + \Lambda(\beta)\right]\bar{t}}{1 + \frac{2n-m}{n}\Lambda(\beta)} + \frac{\frac{n-m}{n}\left(\frac{1}{n} + \lambda\right)\bar{t}}{1 + \frac{2n-1}{n}\lambda} \quad (\text{A13})$$

Dividing both sides by  $\bar{t}$ , the above expression returns:

$$1 - \frac{\frac{m}{n}\left[\frac{m}{n} + \Lambda(\beta)\right]}{1 + \frac{2n-m}{n}\Lambda(\beta)} - \frac{\frac{n-m}{n}\left(\frac{1}{n} + \lambda\right)}{1 + \frac{2n-1}{n}\lambda} > 0$$

such that  $\forall m \in ]1, n[, \Gamma(\beta) > 0$ .

Finally, we plug (A12) into (A9) and (A11) to get:

$$t_s = \left[ \lambda \left( 1 + \frac{2n-m}{n}\Lambda(\beta) \right) + \frac{m}{n} \left( \frac{1}{n}\Lambda(\beta) - \frac{m}{n}\lambda \right) \right] \frac{b\bar{k}}{\Gamma(\beta)} \quad (24)$$

$$t_c = \left[ \Lambda(\beta) \left( 1 + \frac{2n-1}{n}\lambda \right) + \frac{n-m}{n} \left( \frac{m}{n}\lambda - \frac{1}{n}\Lambda(\beta) \right) \right] \frac{b\bar{k}}{\Gamma(\beta)} \quad (25)$$

**Calculating the tax differential  $t_c - t_s$  for  $1 < m < n$**

We use expressions for  $t_c$  (25) and  $t_s$  (24) to calculate  $\forall m \in ]1, n[$ :

$$\begin{aligned} t_c - t_s &= \left[ \Lambda(\beta) - \lambda + \left( \frac{2n-1}{n} - \frac{2n-m}{n} \right) \Lambda(\beta)\lambda + \frac{m}{n}\lambda - \frac{1}{n}\Lambda(\beta) \right] \frac{b\bar{k}}{\Gamma(\beta)} \\ &= \left[ (1 + \lambda)\beta(m-1) + \frac{m-1}{n}\lambda\Lambda(\beta) + \frac{m-1}{n}\lambda - \frac{m-1}{n}(1 + \lambda)\beta \right] \frac{b\bar{k}}{\Gamma(\beta)} \\ &= \left[ \frac{n-1}{n}(1 + \lambda)\beta(m-1) + \frac{m-1}{n}\lambda(1 + \lambda)[1 + \beta(m-1)] \right] \frac{b\bar{k}}{\Gamma(\beta)} \\ &= \frac{m-1}{n}(1 + \lambda)[\lambda + \beta(n-1 + \lambda(m-1))] \frac{b\bar{k}}{\Gamma(\beta)} \end{aligned} \quad (26)$$

**Proving**  $\frac{\partial \bar{t}(m)}{\partial m} > 0$  and  $\frac{\partial t_c(m)}{\partial m} > \frac{\partial t_s(m)}{\partial m}$

We first derive  $t_c(m)$  and  $t_s(m)$  with respect to  $m$  using their expression (A11) and (A9).

Starting with non-cooperating countries, we have:

$$\frac{\partial t_s(m)}{\partial m} = \frac{\frac{1}{n} + \lambda}{1 + \frac{2n-1}{n}\lambda} \frac{\partial \bar{t}(m)}{\partial m} \quad (\text{A14})$$

The marginal change in the tax rate of a cooperating country when the club increases in size (when it is not the joining member) is proportional to that of the average tax rate.

Continuing with  $t_c(m)$ :

$$\frac{\partial t_c(m)}{\partial m} = I(m) + \frac{\frac{m}{n} + \Lambda(m, \beta)}{1 + \frac{2n-m}{n}\Lambda(m, \beta)} \frac{\partial \bar{t}(m)}{\partial m} \quad (\text{A15})$$

with

$$I(m) = \frac{[\frac{1}{n} + (1 + \lambda)\beta] b\bar{k} + [\frac{1}{n} (1 + \frac{2n-m}{n}\lambda) + \frac{1}{n} (\frac{m}{n} + \lambda) + (\frac{n-2}{n} + \frac{m-1}{n} + \frac{m}{n^2})] \bar{t}(m)}{[1 + \frac{2n-m}{n}\Lambda(m, \beta)]^2} > 0 \quad (\text{A16})$$

Next, we derive (A5) with respect to  $m$ :

$$\frac{\partial \bar{t}(m)}{\partial m} = t_c(m) - t_s(m) + \frac{m}{n} \frac{\partial t_c(m)}{\partial m} + \frac{n-m}{n} \frac{\partial t_s(m)}{\partial m} \quad (\text{A17})$$

Plugging (A14) and (A15) into (A17) yields:

$$\frac{\partial \bar{t}(m)}{\partial m} = (t_c(m) - t_s(m) + I(m)) \left[ 1 - \frac{\frac{m}{n} [\frac{m}{n} + \Lambda(\beta)]}{1 + \frac{2n-m}{n}\Lambda(\beta)} - \frac{\frac{n-m}{n} (\frac{1}{n} + \lambda)}{1 + \frac{2n-1}{n}\lambda} \right]^{-1} \quad (\text{A18})$$

We know that the denominator of the above expression is positive, as well as  $t_c(m) > t_s(m)$ , and finally that  $I(m) > 0$ . Hence  $\frac{\partial \bar{t}(m)}{\partial m} > 0, \forall m \in [1, n[$ . The average tax rate is an increasing function of the club size  $m$ .

Using (A14) and (A15), we deduce from the above expression that equilibrium tax rates for both club and non-cooperating countries are increasing functions of  $m$ .

It follows that:

$$\frac{\partial t_c(m)}{\partial m} - \frac{\partial t_s(m)}{\partial m} = I(m) + \left[ \frac{\frac{m}{n} + \Lambda(m, \beta)}{1 + \frac{2n-m}{n}\Lambda(m, \beta)} - \frac{\frac{1}{n} + \lambda}{1 + \frac{2n-1}{n}\lambda} \right] \frac{\partial \bar{t}(m)}{\partial m} \quad (\text{A19})$$

We have:

$$\left[ \frac{\frac{m}{n} + \Lambda(m, \beta)}{1 + \frac{2n-m}{n}\Lambda(m, \beta)} - \frac{\frac{1}{n} + \lambda}{1 + \frac{2n-1}{n}\lambda} \right] = \left( \frac{m-1}{n} \right) \frac{1 + \lambda\Lambda(m, \beta) + (1+\lambda)\beta(n+m-2) + 2\lambda}{(1 + \frac{2n-m}{n}\Lambda(m, \beta))(1 + \frac{2n-1}{n}\lambda)} > 0$$

Such that  $\frac{\partial t_c(m)}{\partial m} > \frac{\partial t_s(m)}{\partial m}$ .

### Proof of Proposition 1

We can rearrange the first-order condition for  $t_s(m)$  (21) into:

$$k_s(m) - (1+\lambda) \left[ k_s(m) - \frac{t_s(m)}{b} \right] = \frac{1}{n} \left[ k_s(m) - \bar{k} + (1+\lambda) \frac{t_s(m)}{b} \right] \quad (\text{A20})$$

We use  $\frac{\partial k_s(m)}{\partial m} = -\frac{1}{b} \left[ \frac{\partial t_s(m)}{\partial m} - \frac{\partial \bar{t}(m)}{\partial m} \right]$  and  $\frac{\partial \rho(m)}{\partial m} = -\frac{\partial \bar{t}(m)}{\partial m}$  to rearrange (30) as such:

$$\frac{\partial u_s(m)}{\partial m} = \frac{\partial \bar{t}(m)}{\partial m} \left[ k_s(m) - \bar{k} + (1+\lambda) \frac{t_s(m)}{b} \right] + \left[ \lambda k_s(m) - (1+\lambda) \frac{t_s(m)}{b} \right] \frac{\partial t_s(m)}{\partial m} \quad (\text{A21})$$

Since  $k_s(m) - (1+\lambda) \left[ k_s(m) - \frac{t_s(m)}{b} \right] = - \left[ \lambda k_s(m) - (1+\lambda) \frac{t_s(m)}{b} \right]$ , we can rewrite (A21) using (A20) as:

$$\frac{\partial u_s(m)}{\partial m} = \left[ k_s(m) - \bar{k} + (1+\lambda) \frac{t_s(m)}{b} \right] \left[ \frac{\partial \bar{t}(m)}{\partial m} - \frac{1}{n} \frac{\partial t_s(m)}{\partial m} \right] \quad (\text{A22})$$

Finally, we know from (A8) that  $k_s(m) - \bar{k} = \frac{\bar{t}(m) - t_s(m)}{b}$  and from (A17) that  $\frac{\partial \bar{t}(m)}{\partial m} - \frac{1}{n} \frac{\partial t_s(m)}{\partial m} = t_c(m) - t_s(m) + \frac{m}{n} \frac{\partial t_c(m)}{\partial m} + \frac{n-m-1}{n} \frac{\partial t_s(m)}{\partial m}$ . Hence we can transform (A22) into:

$$\frac{\partial u_s(m)}{\partial m} = \frac{1}{b} (\bar{t}(m) + \lambda t_s(m)) \left[ t_c(m) - t_s(m) + \frac{m}{n} \frac{\partial t_c(m)}{\partial m} + \frac{n-m-1}{n} \frac{\partial t_s(m)}{\partial m} \right] > 0$$

### Proof of Proposition 2

We adopt the same reasoning from  $\frac{\partial u_c(m)}{\partial m}$ . We rearrange the first-order condition for  $t_c(m)$  (23) into:

$$k_c(m) - (1 + \Lambda(m, \beta)) \left[ k_c(m) - \frac{t_c(m)}{b} \right] = \frac{m}{n} \left[ k_c(m) - \bar{k} + (1 + \Lambda(m, \beta)) \frac{t_c(m)}{b} \right] \quad (\text{A23})$$

Using  $\frac{\partial k_c(m)}{\partial m} = -\frac{1}{b} \left[ \frac{\partial t_c(m)}{\partial m} - \frac{\partial \bar{t}(m)}{\partial m} \right]$ , we can rewrite (32) as:

$$\begin{aligned} \frac{\partial u_c(m)}{\partial m} &= \frac{\partial \bar{t}(m)}{\partial m} \left[ k_c(m) - \bar{k} + (1 + \Lambda(m, \beta)) \frac{t_c(m)}{b} \right] + \\ &\quad \left[ \Lambda(m, \beta) k_c(m) - (1 + \Lambda(m, \beta)) \frac{t_c(m)}{b} \right] \frac{\partial t_c(m)}{\partial m} + (1 + \lambda) \beta t_c(m) k_c(m) \end{aligned} \quad (\text{A24})$$

As  $k_c(m) - (1 + \Lambda(m, \beta)) \left[ k_c(m) - \frac{t_c(m)}{b} \right] = \left[ \Lambda(m, \beta) k_c(m) - (1 + \Lambda(m, \beta)) \frac{t_c(m)}{b} \right]$ , we can combine (A23) and (A24) to obtain:

$$\frac{\partial u_c(m)}{\partial m} = \left[ k_c(m) - \bar{k} + (1 + \Lambda(m, \beta)) \frac{t_c(m)}{b} \right] \left[ \frac{\partial \bar{t}(m)}{\partial m} - \frac{m}{n} \frac{\partial t_c(m)}{\partial m} \right] + (1 + \lambda) \beta t_c(m) k_c(m) \quad (\text{A25})$$

From (A8), we know that  $k_c(m) - \bar{k} = \frac{\bar{t}(m) - t_c(m)}{b}$  and from (A17) that  $\frac{\partial \bar{t}(m)}{\partial m} - \frac{m}{n} \frac{\partial t_c(m)}{\partial m} = t_c(m) - t_s(m) + \frac{n-m}{n} \frac{\partial t_s(m)}{\partial m}$ . We can transform (A25) into:

$$\frac{\partial u_c(m)}{\partial m} = \frac{1}{b} (\bar{t}(m) + \Lambda(m, \beta) t_c(m)) \left[ t_c(m) - t_s(m) + \frac{n-m}{n} \frac{\partial t_s(m)}{\partial m} \right] + (1 + \lambda) \beta t_c(m) k_c(m) > 0$$

## Calculating A

We calculate the derivative of  $u_c(m)$  and  $u_s(m)$  at  $m = 1$  using (31) and (33):

$$\begin{aligned} \frac{\partial u_c(1)}{\partial m} &= \frac{1}{b} (1 + \lambda) t^{nc} \frac{n-1}{n} \frac{\partial t_c(1)}{\partial m} + (1 + \lambda) t^{nc} \beta \bar{k} \\ \frac{\partial u_s(1)}{\partial m} &= \frac{1}{b} (1 + \lambda) t^{nc} \left[ \frac{1}{n} \frac{\partial t_c(1)}{\partial m} + \frac{n-2}{n} \frac{\partial t_s(1)}{\partial m} \right] \end{aligned}$$

We obtain:

$$\frac{\partial u_c(1)}{\partial m} > \frac{\partial u_s(1)}{\partial m} \Leftrightarrow \beta > \frac{1}{nb\bar{k}} \left[ \frac{\partial t_c(1)}{\partial m} - \frac{\partial t_s(1)}{\partial m} \right] = \frac{1}{nb\bar{k}} I(1) \quad (\text{A26})$$

Using the expression (A16) for  $I(m)$ ,  $I(1)$  reads:

$$I(1) = \frac{\left[ \frac{1}{n} + (1 + \lambda) \beta \right] b\bar{k} + \frac{1}{n} \left[ n - 1 + \frac{2}{n} + \frac{3n-1}{n} \lambda \right] t^{nc}}{\left( 1 + \frac{2n-1}{n} \lambda \right)^2}$$

We arrange the inequality (A26) into:

$$\beta > \frac{1}{n^2} \frac{1 + \left[ n - 1 + \frac{2}{n} + \frac{3n-1}{n} \lambda \right] \frac{\lambda}{\frac{1+\lambda}{n-1}}}{\frac{n-1}{n} + \left( \frac{2n-1}{n} \lambda \right)^2 + \frac{4n-3}{n} \lambda} = A$$

### Proof of Proposition 3

We use definitions for the utility under full cooperation (28) and the utility of country  $S$  (40) to rearrange the condition (41):

$$\begin{aligned} u^{full} > u_S &\Leftrightarrow \frac{1}{2} b \bar{k}^2 + [1 + \beta(n-1)](1+\lambda)(a - b\bar{k})\bar{k} > \frac{[a(1+\lambda)]^2}{2b(1+2\lambda)} \\ &\Leftrightarrow [1 + \beta(n-1)] > \frac{\frac{a^2(1+\lambda)}{2b(1+2\lambda)} - \frac{\frac{1}{2} b \bar{k}^2}{1+\lambda}}{(a - b\bar{k})\bar{k}} \\ &\Leftrightarrow \beta > \frac{\frac{a^2(1+\lambda)}{2b(1+2\lambda)} - \frac{\frac{1}{2} b \bar{k}^2}{1+\lambda} - (a - b\bar{k})\bar{k}}{(a - b\bar{k})\bar{k}(n-1)} \end{aligned}$$

**Proving**  $\frac{\partial B}{\partial b} < 0$

We derivate  $B$  with respect to  $b$ :

$$\begin{aligned}
\frac{\partial B}{\partial b} &= \frac{\left[ -\frac{a^2(1+\lambda)}{2b^2(1+2\lambda)} - \frac{\frac{1}{2}\bar{k}^2}{1+\lambda} + \bar{k}^2 \right] (a - b\bar{k})\bar{k} + \left[ \frac{a^2(1+\lambda)}{2b(1+2\lambda)} - \frac{\frac{1}{2}b\bar{k}^2}{1+\lambda} - (a - b\bar{k})\bar{k} \right] \bar{k}^2}{[(a - b\bar{k})\bar{k}]^2 (n-1)} \\
&= \frac{\left[ -\frac{a^2(1+\lambda)}{2b^2(1+2\lambda)} - \frac{\frac{1}{2}\bar{k}^2}{1+\lambda} \right] (a - b\bar{k}) + \left[ \frac{a^2(1+\lambda)}{2b(1+2\lambda)} - \frac{\frac{1}{2}b\bar{k}^2}{1+\lambda} \right] \bar{k}}{[a - b\bar{k}]^2 \bar{k}(n-1)} \\
&= \frac{-\frac{a^2(1+\lambda)}{2b^2(1+2\lambda)}(a - b\bar{k}) - \frac{\frac{1}{2}\bar{k}^2}{1+\lambda}a + \frac{a^2(1+\lambda)}{2b(1+2\lambda)}\bar{k}}{[a - b\bar{k}]^2 \bar{k}(n-1)} \\
&= -\frac{\frac{a^2(1+\lambda)}{2b^2(1+2\lambda)}(a - 2b\bar{k}) + \frac{\frac{1}{2}\bar{k}^2}{1+\lambda}a}{[a - b\bar{k}]^2 \bar{k}(n-1)} < 0
\end{aligned}$$

The values of  $a$ ,  $b$  and  $\bar{k}$  must be that it is never beneficial for households to withdraw their capital endowment. We have:

$$\frac{\partial u^{full}}{\partial \bar{k}} = (a - b\bar{k}) + \lambda(a - 2b\bar{k})$$

To ensure that it is never beneficial for households to withhold some of their endowment i.e.  $\frac{\partial u^{full}}{\partial \bar{k}} > 0$ , it must be that:

$$a - 2b\bar{k} > 0 \tag{A27}$$

An analogous assumption is made in Bucovetsky (2009). Under the assumption (A27), we know that the above expression is negative. Hence  $B$  is a decreasing function of  $b$ .



**Proving**  $\frac{\partial B}{\partial \lambda} < 0$

We derivate  $B$  with respect to  $b$ :

$$\begin{aligned}
\frac{\partial B}{\partial \lambda} &= \frac{-\frac{a^2}{2b(1+2\lambda)^2} + \frac{\frac{1}{2}b\bar{k}^2}{(1+\lambda)^2}}{(a-b\bar{k})\bar{k}(n-1)} \\
&= -\frac{[a(1+\lambda)]^2 - [b\bar{k}(1+2\lambda)]^2}{(a-b\bar{k})\bar{k}(n-1)2b(1+\lambda)^2(1+2\lambda)^2} \\
&= -\frac{[a(1+\lambda) - b\bar{k}(1+2\lambda)][a(1+\lambda) + b\bar{k}(1+2\lambda)]}{(a-b\bar{k})\bar{k}(n-1)2b(1+\lambda)^2(1+2\lambda)^2} \\
&= -\frac{[a - b\bar{k} + \lambda(a - 2b\bar{k})][a(1+\lambda) + b\bar{k}(1+2\lambda)]}{(a-b\bar{k})\bar{k}(n-1)2b(1+\lambda)^2(1+2\lambda)^2} < 0
\end{aligned}$$

Again, under the assumption (A27), we know that the above expression is negative. Hence  $B$  is a decreasing function of  $\lambda$ .

**Proving**  $\frac{\partial B}{\partial \bar{k}} < 0$

$B$  can be written as such :

$$B = \frac{\frac{a^2(1+\lambda)}{2b(1+2\lambda)} - \frac{\frac{1}{2}b\bar{k}^2}{1+\lambda}}{(a-b\bar{k})\bar{k}(n-1)} - \frac{1}{n-1}$$

Then we derivate the above expression with respect to  $\bar{k}$ :

$$\begin{aligned}
\frac{\partial B}{\partial \bar{k}} &= \frac{-\frac{\frac{1}{2}b\bar{k}}{1+\lambda}(a-b\bar{k})\bar{k} + \frac{\frac{1}{2}b\bar{k}^2}{1+\lambda}(a-2b\bar{k})}{[(a-b\bar{k})\bar{k}]^2(n-1)} \\
&= -\frac{\frac{\frac{1}{2}(b\bar{k})^2}{1+\lambda}}{[(a-b\bar{k})\bar{k}]^2(n-1)} < 0
\end{aligned}$$

## Chapter III

# Unemployment insurance union

### 1 Introduction

A monetary union of heterogeneous members needs mechanisms to deal with asymmetric shocks (Mundell, 1961a; McKinnon, 1963; Kenen, 1969). For example, factor mobility, price and wage flexibility or a common budget that allows for macroeconomic stabilization and risk-sharing among member countries. In Europe, although labour mobility strongly increased during the crisis, it might still be too low to adjust quickly to idiosyncratic shocks.<sup>1</sup> Also, wage flexibility can be an ineffective stabilization channel if wage cuts do not translate into price decreases, yielding no competitiveness gains.<sup>2</sup>

This observation calls for some sort of fiscal capacity at the European level where a common budget could transfer funds from booming to busting regions in the event of idiosyncratic shocks. While in normal times national fiscal stabilizers bring enough stabilization, in bad times fiscal policy can be pro-cyclical in some countries due to the fiscal rules in place and the loss of market access to issue debt. Hence transferring part of the existing fiscal stabilizers to a supranational level can be considered as a way to improve

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<sup>1</sup>See Beyer and Smets (2015).

<sup>2</sup>This is the case if the monetary policy is stuck at the zero lower bound and prices are sticky. See a recent study by Gali and Monacelli (2015).

stabilization and risk-sharing. Bringing fiscal federalism to the euro area is not a new idea, dating back to the MacDougall report (1977) and more recently in the Four presidents report (2012). But what form should it take?

A European unemployment insurance scheme has gained increased attention as a new and ambitious common fiscal instrument which could be used for cross-country temporary transfers.<sup>3</sup> Part of the national stabilizers composing unemployment insurance schemes (labor taxes paid by workers and benefits paid to the unemployed) would be transferred to the central level. This mechanism offers several advantages. It would react automatically to overall economic conditions, as unemployment is closely linked to activity. The mechanism would deliver stabilization without lag. Then, it is counter-cyclical, acting as a stabilizer: decreasing taxes and increasing benefits mitigate the recessive effects of a shock. Finally, although this is outside the scope of the paper, it would offer material solidarity to the workers in the euro area.

However, there are significant caveats. First, as in any risk-sharing arrangement, moral hazard issues arise. National governments may be disincentivized to implement policies that reduce structural unemployment if they know that they will receive transfers in the event of shocks. Second, Europe is characterized by highly heterogeneous unemployment insurance schemes in terms of replacement rates, eligibility criteria and entitlement durations. Setting up a common regime that respects national characteristics is then an issue. Third, permanent transfers, where more efficient countries finance less efficient ones over the cycle must be ruled out. Otherwise, the scheme is not one of stabilization but one of redistribution.

In this paper, we build a two-country New-Keynesian DSGE model with job market frictions. The union is composed of two asymmetric members, where goods are imperfect substitutes and are traded across countries. Labour is immobile between countries while financial markets are incomplete, because some households have access to financial markets

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<sup>3</sup>See Artus et al. (2013); Beblavý et al. (2015); Bénassy-Quéré et al. (2016); Dullien and Fichtner (2013).

while some are constrained. Workers flow in and out of employment, and we distinguish between short and long term unemployment in order to mimic the situation on European labour markets. A benchmark consisting of national unemployment agencies only is set as a reference for calibration. The calibrated version of our model is able to replicate key facts of the euro area core and periphery data. It matches the empirically observed volatility of consumption, wages and unemployment dynamics.

Then, as a second scenario, we plug a European Unemployment Insurance (EUI) into existing national agencies which remain active, so that unemployment insurance is multi-layered. The EUI is financed by lump sum taxes on households and provides benefits to the unemployed across the economy. We consider rules so that transfers only happen when countries deviate from their steady-state equilibrium. Finally, we create two more scenarios where the EUI can issue debt on international financial markets to finance the transfers, one scenario with shared debt and the other with country-specific debt compartments. We compare these scenarios to analyze the stabilization potential of the scheme.

We present three main ideas as contributions to the literature. First, we propose a design for the EUI that plugs into existing national systems, such that it does not require a change in the way national governments choose to insure their unemployed workers, both in terms of benefits and entitlement duration. Second, we show that the EUI is able to stabilize the economy only if it can issue debt. Third, we show that the scheme can improve stabilization while avoiding permanent transfers through country-specific accounts towards the fund.

The paper is structured as follows: Section 2 reviews the literature on fiscal capacity and unemployment insurance in search and matching models. Section 3 describes the theoretical model, while Section 4 introduces the EUI design. Section 5 discusses the baseline calibration. The model results are presented in Section 6. Finally, Section 7 concludes.

## 2 Literature review

This paper draws mainly on two strands of literature. The first deals with risk-sharing in federal systems while the second focuses on optimal unemployment insurance in frictional labour markets.

The issue of risk-sharing among members of different provinces or countries has been widely investigated. In a seminal paper, Asdrubali et al. (1996) find that 75% of the shocks to per-capita state gross product in the US from 1963 to 1990 are smoothed, including 13% through the federal budget, 23% through credit markets and 39% through capital markets. Later, Sørensen and Yosha (1998) show that for European and OECD countries, only 43% of country-specific shocks to GDP from 1966 to 1990 are smoothed, half by government spending and half by private savings. Afonso and Furceri (2008) conduct an analysis on EU-25 countries and show that only 37% of the shocks to GDP from 1998 to 2005 are smoothed, with the largest part provided by social benefits. More recently, Furceri and Zdzienicka (2015) find that risk-sharing mechanisms in the Eurozone are ineffective (only 30% of the shocks are smoothed) compared to the U.S. and Germany (75% and 80% respectively). They also point out that the degree of risk-sharing among Eurozone countries is lower in recession, precisely when needed the most. Finally, they suggest that a supranational scheme, such as a centralized transfer mechanism based on automatic rules, amounting to between 1.5 and 2.5% of total GNP would significantly improve stabilization.

The importance of common fiscal tools as alternative risk-sharing mechanisms roots in the theory of optimal currency areas (Mundell, 1961a; Kenen, 1969). Farhi and Werning (2017) show that sharing a currency implies significant uninsurable effects due to nominal rigidities, hence that fiscal unions organizing transfers are inherent to viable monetary unions. Evers (2012) studies different federal transfer rules to redistribute funds automatically in the event of an asymmetric shock. In the analysis, rules targeting consumption spending and labour income gaps are the most effective at increasing welfare. Engler and Voigts (2013) back this analysis by showing first that the implementation of a common currency by member countries with no labour migration, incomplete financial markets

and partial integration in trade (hence with weak private risk-sharing channels) strongly increases consumption and employment volatility. Then, a transfer system between members reduces this volatility, in a more effective way than national fiscal stabilization policies when these are hampered by Ricardian equivalence effects and rising risk-premia.

A European unemployment insurance (EUI) system as a cross-country transfer scheme has been given increased attention. Moyen et al. (2016) analyze the welfare effects of an EUI with a DSGE model. They find that, in case of negative country-specific productivity shocks, the EUI makes the replacement rate more counter-cyclical because of international risk-sharing. Apart from this working paper, most studies on EUI consist in empirical simulations aimed at providing a rough assessment of the potential stabilization gains and transfers (Beblavý et al., 2017; Dolls et al., 2018). For example, Dolls et al. (2015) present a hypothetical EUI based on counterfactual simulations of European data from 2000 to 2013. Their common scheme replaces part of the national insurance policies with a 50% replacement rate, 12 months entitlement duration and a broad coverage ratio. They find a sizable stabilization gains of 12% for households, however some countries are net contributors or debtors to the scheme. Lellouch and Sode (2014), using the same characteristics for the common system while adding claw-backs, also find counter-cyclical net transfers amount from -0.6% to 1.4% of GDP.

An unemployment agency faces a trade-off between the provision of insurance and incentive effects. In Baily (1978)'s framework, the optimal level of insurance increases with workers' risk-aversion but decreases with the elasticity of search effort with respect to benefits. Chetty (2008) decomposes the effect of unemployment benefits between liquidity and moral hazard effects: an increase in benefits allows to uphold consumption while unemployed but also reduces search effort, increasing the unemployment duration.

Moreover, when there are search frictions on labor markets, matching unfilled vacancies from firms with unemployed workers is modeled as a costly process. This is due to positive between-group externalities and negative within-group congestion effects: when a firm posts a vacancy, it increases workers' probability to find a job but it is harder for firms to

have their vacancy filled. Conversely, when an additional worker looks for a job, workers' chances to exit unemployment are decreased but firms' probability to fill their vacancy are improved. The social optimum, characterized by the right 'blend' of positive externalities and congestion effects, is reached when the bargaining power of the worker equals the elasticity of the matching function with respect to unemployment (Hosios, 1990). Depending on how far from this condition the labour market settles, a benefit policy can address some of the frictions by affecting the outside option for the worker.

In a dynamic setting, the topic of whether benefits should be increased, decreased or kept constant over the unemployment duration has gained attention.<sup>4</sup> For example, Hopenhayn and Nicolini (1997, 2009) build the case for a tapering profile of benefits over time, with benefits decreasing with the length of the spell. As for their time sequencing over the cycle i.e. should they be increased or not in bad times, Kroft and Notowidigdo (2011) find that the moral hazard cost of insurance is lower in times of high unemployment while the consumption-smoothing effect is acyclical. This suggests that optimal benefits should be counter-cyclical. Similarly, Landais et al. (2013) highlight that in recessions, the elasticity of unemployment with respect to benefits is lower so that the moral hazard effect is reduced. Mitman and Rabinovich (2015a) show that optimal state-contingent unemployment benefits would smooth cyclical fluctuations and deliver substantial welfare gains. Albertini and Fairise (2013a) investigate the optimal unemployment scheme under real wage rigidities and show that unemployment benefits schemes reduce welfare costs resulting in inefficient separations. In a subsequent paper, Albertini and Poirier (2015a) use a New Keynesian model to study the effect of the US unemployment benefit extension on the labour market under a zero lower bound. They find evidence of wage and inflationary pressure resulting from the benefit extension which reduces unemployment at the ZLB. While most of the papers focus on an optimal unemployment insurance scheme for the US, Moyen and Stähler (2014a) also include Europe. They show that the issue of time-sequencing for the entitlement duration of benefits depends on the relation mentioned above between the bargaining power of the worker and the matching elasticity. Namely,

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<sup>4</sup>See Fredriksson and Holmlund (2006) for a review.

in the US unemployment is too low in bad times relative to the Hosios condition (as the bargaining power is relatively low), hence benefit duration should be increased in recessions while it is the opposite in Europe.

While most existing studies rely on counter-factual analysis and simulations, we present an original DSGE model of multi-layered unemployment insurance in the presence of search and matching frictions, implementing transfer rules and claw-backs which prevent permanent transfers. Once calibrated, we are able to assess quantitatively the stabilization gains offered by the system while considering different types of shocks.

### 3 Model

We construct a two-country dynamic stochastic general equilibrium model with search and matching frictions, as well as national and supranational fiscal policies.<sup>5</sup> The structure of both economies is symmetric: all equations are derived for the Home economy and analogously apply to the Foreign economy. If needed, we denote Foreign variables with an asterisk. Each country consists of households, firms and a national government. We name the first country Home, inhabited by  $\omega$  households and the second Foreign, inhabited by  $(1 - \omega)$  so that the size of the union is normalized to one. A baseline model (called Scenario 1) with national governments only is presented in this section. In order to analyze the possible outcomes of a union-wide unemployment insurance, a supranational layer of government is introduced in the next section.

In both countries, there is a continuum of households including a fixed portion  $\mu \in [0, 1]$  with no access to financial markets. In each period, these household members, referred to as Rule-of-Thumb (denoted in this paper with a  $R$ ), are restricted to consume their total disposable income.<sup>6</sup> Members of the remaining households, the optimizers (denoted with

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<sup>5</sup>Our model builds on standard features from Ljungqvist and Sargent (2007), Mitman and Rabinovich (2015a), Moyen and Stähler (2014a) and Moyen et al. (2016).

<sup>6</sup>In the literature those households are called Non-Ricardian, Rule-of-Thumb or financially constrained



an  $O$ ), are able to pool their income against idiosyncratic risk through their access to financial markets. Therefore, they are able to smooth consumption optimally over time.

Each household consists of a continuum of members who can either be employed or be unemployed in the domestic country. Labor is immobile: labor mobility is ruled out as a channel of risk-sharing in the model. Employed members supply labor and earn a wage determined in bilateral Nash bargaining. Unemployed members can either be short- or long-term unemployed. In short-term unemployment, the member is entitled to premium benefits that last for a duration set by the national government. Once premium benefits expire, the worker flows to long-term unemployment and gets a minimum of social assistance. Each household consumes an aggregate consumption good which is produced by Home or Foreign firms. These firms post vacancies to workers in frictional labor markets and are subject to hiring costs. Firms and workers separate at an exogenous rate. The national government issues bonds and collects taxes used to finance the unemployment benefits, social assistance and public expenditures. We introduce imperfect financial integration by assuming that asset markets are incomplete and governments in each country issue risk-free bonds denominated in the same currency.<sup>7</sup>

### 3.1 Labor markets

The labor markets in both countries are subject to search and matching frictions. In order to form a new employment relationship, unemployed workers at the end of last period  $u_{t-1}$  search in the domestic labor market for a job. We assume a constant search effort and a fixed number of hours worked, and all unemployed workers search for a job.<sup>8</sup> We are aware that search effort is an important issue to include in an analysis of unemployment insurance. However, as developed below, we are studying a common insurance scheme activated only during recessions, and as pointed by several studies (see Albertini and Poirier (2015b) for example), the adverse effects of unemployment insurance on job search incentives are reduced in times of crisis. Also, the design for the common scheme presented in this paper

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households.

<sup>7</sup>See Melitz and Ghironi (2005).

<sup>8</sup>We abstract from job-to-job transition, as this issue is not relevant for our research question.

is conceived to keep the overall amount of insurance unaltered.

Firms do not discriminate between household types and post the same vacancies for both. Also, since both types of households face the same probabilities of changing unemployment status, aggregate and household specific labor market variables are the same so we can drop household-type indices.

The number of matches  $m_t$  is given by a Cobb-Douglas matching function:

$$m_t = \kappa^m v_t^{1-\eta} (u_{t-1})^\eta \quad (1)$$

where  $0 < \kappa^m < 1$  measures the matching efficiency capturing structural factors, while  $u_t$  is the aggregate unemployment rate at the end of date  $t$  and  $v_t$  denotes vacancies posted by firms.  $0 < \eta < 1$  is the matching elasticity with respect to unemployment. Because the total labor force is normalized to one, the number of total employed workers is  $n_t = 1 - u_t$  and can be interpreted as aggregate employment rate. The law of motion for employment writes:

$$n_t = (1 - s_t)n_{t-1} + m_t \quad (2)$$

where matches are dispersed at the separation rate  $s_t \in [0, 1]$ . Recent evidence suggests that separation fluctuations are an important factor for employment over the cycle.<sup>9</sup> We follow Christoffel et al. (2009a) by including separation rate changes via a an AR-1 process with mean  $s$  and defined by:

$$\log(s_t) = \rho_s \log(s_{t-1}) + (1 - \rho_s) \log s + \epsilon_{s,t} \quad (3)$$

with persistence parameter  $0 < \rho_s < 1$  and white noise process  $\epsilon_{s,t}$  with zero mean and constant variance  $\sigma_s^2$ .

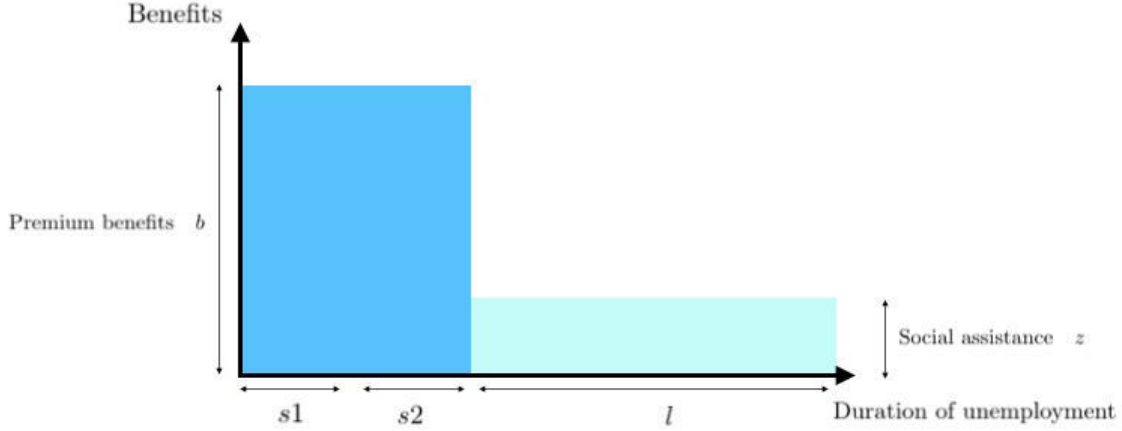
We define the labor market tightness in efficiency units as  $\theta_t \equiv \frac{v_t}{u_{t-1}}$ . The characteristics of the Cobb-Douglas matching function implies that firms fill their posted vacancies

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<sup>9</sup>For example, Fujita and Ramey (2012) find that the separations are countercyclical and contribute to a large part of fluctuations in unemployment in the US.

with probability  $q_t \equiv \frac{m_t}{v_t} = \kappa^m \theta_t^{-\eta}$ . Symmetrically, workers find a job with the probability  $f_t \equiv \frac{m_t}{u_{t-1}} = \kappa^m \theta_t^{1-\eta} = \theta_t q_t$ .

Then, the aggregate unemployment rate  $u_t$  can be distinguished between the short-term  $u_t^s$  and the long-term unemployment rates  $u_t^l$ . Short-term unemployed workers get premium benefits denoted with  $b$ .<sup>10</sup> To allow for multi-layered unemployment insurance, defined further on, we split the overall short-term unemployment into two consecutive segments:  $u_t^s = u_t^{s1} + u_t^{s2}$  for a total of three possible unemployment status ( $s1, s2, l$ ). Unemployed in tiers 1 and 2 receive premium benefits  $b$ . The point of splitting short-term unemployment into two segments will become apparent in the next section. Long-term unemployed receive social assistance  $z < b$ .<sup>11</sup> The tiered benefit system is illustrated in Figure 1.



**Figure 1:** Baseline case

Short-term unemployed in the first segment at time  $t$  are those who were already in

<sup>10</sup>We abstract from eligibility criteria in our analysis although they are highly heterogeneous across countries and would therefore be an issue in designing a common unemployment insurance scheme. We assume that workers who become unemployed are immediately eligible to premium benefits once their match separates. Hence, the coverage ratio is 1 for both countries.

<sup>11</sup>Including both premium benefits and social assistance allows us to capture that most unemployment insurance schemes feature decreasing benefits over the spell of unemployment, with premium benefits eventually decreasing to a lower amount of insurance past some entitlement duration.

this pool at  $t - 1$  excluding those who find a job or move to the second segment. We also add workers employed last period whose match separates:

$$u_t^{s1} = (1 - f_t - \phi^{s1})u_{t-1}^{s1} + s_t n_{t-1} \quad (4)$$

where  $0 < \phi^{s1} < 1$  is equal in both countries and measures the fixed entitlement duration for tier 1 benefits  $b$ .<sup>12</sup> With probability  $\phi^{s1}$ , the unemployed moves out of the first segment to the second, switching from unemployment status  $s1$  to  $s2$ .

Accordingly, the pool in the second segment of short-term unemployment consists of those who were in this pool last period, excluding those who find a job or lose their eligibility to tier 2 benefits  $b$ , as well as those flowing from the first segment:

$$u_t^{s2} = (1 - f_t - \phi^{s2})u_{t-1}^{s2} + \phi^{s1}u_{t-1}^{s1} \quad (5)$$

where  $0 < \phi^{s2} < 1$  is the probability that an unemployed worker eligible for tier 2 benefits becomes ineligible in the next period, moving to long term unemployment. He switches from unemployment status  $s2$  to  $l$ .

Finally, long-term unemployment amounts to the long-term unemployed from last period minus those who find a job plus those who flow from the second pillar of the insurance system:

$$u_t^l = (1 - f_t)u_{t-1}^l + \phi^{s2}u_{t-1}^{s2} \quad (6)$$

A long-term unemployed regains eligibility for premium benefits only if he finds a job with probability  $f_t$ . We assume that all unemployed face the same job finding rate  $f_t$  regardless of which unemployment pillar they are in.

The aggregate employment and unemployment rates are weighted sums of household-specific rates  $n_t = (1 - \mu)n_t^O + \mu n_t^R$ ,  $u_t = (1 - \mu)u_t^O + \mu u_t^R$ ,  $u_t^{s1} = (1 - \mu)u_t^{s1,O} + \mu u_t^{s1,R}$ ,  $u_t^{s2} = (1 - \mu)u_t^{s2,O} + \mu u_t^{s2,R}$  and  $u_t^l = (1 - \mu)u_t^{l,O} + \mu u_t^{l,R}$ .

<sup>12</sup>Hence the entitlement duration for the tier 1 benefits is  $\frac{1}{\phi^{s1}}$ .

### 3.2 Households

Optimizing households maximize the expected lifetime utility:

$$E_0 \sum_{t=0}^{\infty} \left( \prod_{i=0}^t \beta_i \right) u(c_t^O, c_{t-1}^O) \quad (7)$$

where  $E_0$  denotes the expectation formed in period 0 and  $\beta$  represents a discount factor shock, with  $\beta$  in the steady-state. The discount factor shock follows an autoregressive process with mean  $\beta$ , defined as such:

$$\log \beta_t = \rho^\beta \log \beta_{t-1} + (1 - \rho^\beta) \log \beta + \epsilon_t^\beta \quad (8)$$

where  $\rho^\beta$  is a persistence parameters between 0 and 1 and  $\epsilon_t^\beta$  is a white noise process with zero mean and constant variance  $(\sigma^\beta)^2$ .

$c_t^i$  denotes consumption of a basket made of Home and Foreign products which are imperfect substitutes. The instantaneous utility function is assumed to be CRRA-utility  $u(c_t^O, c_{t-1}^O) = \frac{(c_t^O - h c_{t-1}^O)^{1-\gamma}}{1-\gamma}$  where  $\gamma$  is the elasticity of substitution,  $\gamma \neq 1$ , and  $h \in [0, 1]$  is a consumption habit parameter. Optimizing households face the following budget constraint:

$$c_t^O + j_t^O + \frac{H_{t+1}^O}{P_t} = (1 + i_t) \frac{H_t^O}{P_t} + w_t n_t^O + b_t u_t^O - \tau_t + r_t^k k_t^O + \Pi_t^O - \Phi_t^a \quad (9)$$

There exists a private insurance market but only the  $1 - \mu$  optimizing households have access to it. We assume that workers from optimizing households pool their labor income in order to insure each other and consume the same average consumption level (Andolfatto, 1996; Merz, 1995). Namely, they can save and borrow through nominal bond holdings of government debt, where  $H_t^O$  denotes per Home optimizing household holdings of bonds. These bonds pay  $i_t$ , the same risk-free rate for the two countries forming the monetary union. Hence, governments face no frictions when accessing financial markets.

Optimizers also rent capital, which depreciates at rate  $\delta$ , to firms at the real rate  $r_t^k$ . Per optimizer investment follows:

$$j_t^O = k_{t+1}^O - (1 - \delta)k_t^O \quad (10)$$

where  $k_t^O$  denotes per optimizer capital. The household is subjected to real portfolio adjustment costs  $\Phi_t^a$ , with:

$$\Phi_t^a(H_{t+1}^O, k_t^O) = \frac{\kappa^H}{2} \left( \frac{H_{t+1}^O}{P_{t+1}} - \frac{\bar{H}^O}{\bar{P}} \right)^2 + \frac{\kappa^k}{2} (k_t^O - \bar{k}^O)^2,$$

where  $\kappa^H > 0$  and  $\kappa^k > 0$  are the adjustment cost parameters assigned to bond holdings and capital stock respectively.  $\bar{H}^O$  and  $\bar{k}^O$  denote the steady-state levels of bond holdings and capital respectively. Optimizers also pay lump-sum real taxes  $\tau_t$ . Finally, they own the firms from which they receive real profits  $\Pi_t^O$ .

The employed members of both households earn real labor income  $w_t$ , while the unemployed receive real social benefits according to their unemployment status. Short-term unemployed receive premium benefits  $b$  while long-term ones receive social assistance  $z$ . We can write the average benefit from unemployment insurance as:

$$b_t = \frac{u_t^{s1} + u_t^{s2}}{u_t^i} b + \frac{u_t^l}{u_t} z.$$

Note that although benefits and social assistance are parameters, the average benefit is time-dependent since unemployed workers flow between unemployment tiers around the cycle, and benefits vary across these tiers.

The instantaneous utility function of RoT households, who only consume their current disposable income, writes:

$$u(c_t^R, c_{t-1}^R) = \frac{(c_t^R - hc_{t-1}^R)^{1-\gamma}}{1-\gamma} \quad (11)$$

The  $\mu$  RoT consumers also pool their income. So there is risk-sharing within the type- $R$  household, but without access to financial markets its members are not able to save and borrow against their idiosyncratic income risk. Therefore, their budget constraint in real terms determines the consumption level in each period:

$$c_t^R = w_t n_t^R + b_t u_t^R - \tau_t \quad (12)$$

The disposable income of a RoT household consists of the labor income and the unemployment benefits net of taxes.

The Home consumption basket  $c_t^i$  of household type  $i$  is a CES aggregate of the Foreign and Home produced goods:

$$c_t^i = [\psi(c_{H,t}^i)^\sigma + (1 - \psi)(c_{F,t}^i)^\sigma]^\frac{1}{\sigma} \quad (13)$$

where  $c_{H,t}$  is the amount of Home produced good consumed in the Home country and  $c_{F,t}$  the amount of Foreign produced good consumed at Home, hence imported.<sup>13</sup> Then,  $0 < \psi < 1$  is the degree of home bias in the domestic economy and  $\sigma > 0$  governs the elasticity of substitution between the Home and the Foreign goods. We define  $p_t^H$  as the price of the Home produced good and  $p_t^F$  as the price of the Foreign produced good. By solving the utility-maximization problem of the household we can write the relative demand function for the Home good as well as  $P_t$ , the Home consumer price index (CPI), as follows:

$$\frac{c_{H,t}^i}{c_{F,t}^i} = \left( \frac{\psi}{1 - \psi} \frac{p_t^F}{p_t^H} \right)^\frac{1}{1-\sigma}, \quad P_t = \left( \psi^\frac{1}{1-\sigma} (p_t^H)^\frac{\sigma}{\sigma-1} + (1 - \psi)^\frac{1}{1-\sigma} (p_t^F)^\frac{\sigma}{\sigma-1} \right)^\frac{\sigma-1}{\sigma}. \quad (14)$$

Optimizing households maximize their lifetime utility (7) taking as given their type-specific budget constraint (9) and the laws of motion for employment (2) and unemployment (4), (5), (6). The first-order conditions for the optimizing households with respect to the choice variables consumption, capital accumulation and bond holding of country,  $\{c_t^O, k_t^O, H_{t+1}^O\}$  imply:

$$\lambda_t^O = (c_t^O - hc_{t-1}^O)^{-\gamma} - \beta h(E_t c_{t+1}^O - hc_t^O)^{-\gamma}, \quad (15)$$

$$\lambda_t^O = \beta(1 + r_t^k - \delta)\lambda_{t+1}^O, \quad (16)$$

$$\lambda_t^O \left[ 1 + \kappa^a \left( \frac{H_{t+1}^O}{P_{t+1}} - \frac{\bar{H}^O}{\bar{P}} \right) \right] = E_t \lambda_{t+1}^O \frac{\beta(1 + i_{t+1})}{\Pi_{t+1}}. \quad (17)$$

where  $\Pi_t = \frac{P_t}{P_{t-1}}$  denotes CPI inflation. Marginal utility for the RoT households writes:

$$\lambda_t^R = (c_t^R - hc_{t-1}^R)^{-\gamma} - \beta h(E_t c_{t+1}^R - hc_t^R)^{-\gamma} \quad (18)$$

<sup>13</sup>Conversely,  $c_{H,t}^*$  denotes the amount of Home produced good consumed in the Foreign country, hence exported by Home, and  $c_{F,t}^*$  the amount of Foreign produced good consumed in the Foreign country.

Similarly to aggregation of employment, aggregate consumption, profits, bonds, investment and capital accumulation is a weighted average of their type-specific values.

$$c_t = (1 - \mu)c_t^O + \mu c_t^R, \quad c_{H,t} = (1 - \mu)c_{H,t}^O + \mu c_{H,t}^R, \quad c_{F,t} = (1 - \mu)c_{F,t}^O + \mu c_{F,t}^R,$$

$$\Pi_t = (1 - \mu)\Pi_t^O, \quad k_t = (1 - \mu)k_t^O, \quad H_t = (1 - \mu)H_t^O,$$

### 3.3 Firms

In each country, the production process is separated in two stages. There is a continuum of intermediate firms indexed by  $j$  producing an intermediate good in a monopolistically competitive market using capital and labor as input factors. Then, retail firms operate in a perfectly competitive environment and produce the final good used for consumption. The final good is a composite of the intermediate good  $y_t(j)$ , with the following production function:

$$y_t \equiv \left( \frac{1}{\omega} \int_0^\omega y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}}$$

where  $\epsilon > 1$  denotes the elasticity of substitution between intermediate goods.

Expenditure minimizing subject to the CES-aggregate yields demand functions for intermediate inputs as well as the composite producer price index:

$$y_t(j) = \left( \frac{p_t(j)}{p_t^H} \right)^{-\epsilon} y_t \quad (19)$$

$$p_t^H = \left( \frac{1}{\omega} \int_0^\omega p_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \quad (20)$$

where  $p_t(j)$  denotes the intermediate input price for the corresponding firm.

The intermediate firm  $j$  has quadratic price adjustment costs and uses the following Cobb-Douglas production function:

$$y_t(j) = a_t k_t^\alpha(j) n_t^{1-\alpha}(j) \quad (21)$$

with  $0 < \alpha < 1$ .  $a_t$  is the country-specific productivity with mean  $a$ . Let us note that there is no productivity growth in the model. The logarithm of  $a_t$  follows an AR(1) process:

$$\log(a_t) = \rho_a \log(a_{t-1}) + (1 - \rho_a)a + \epsilon_{a,t} \quad (22)$$



with persistence parameter  $0 < \rho_a < 1$  and white noise process  $\epsilon_{a,t}$  with zero mean and constant variance  $\sigma_a^2$ . Since each firm  $j$  can decide about the vacancies for a given vacancy filling rate, the law of motion of firm-level employment can be written as:

$$n_t(j) = (1 - s_t)n_{t-1}(j) + q_t v_t(j), \quad (23)$$

Profits of intermediary firms write:

$$\Delta_t(j) = \frac{p_t(j)}{p_t^H} y_t(j) - w_t n_t(j) - r_t^k k_t(j) - \kappa_t^v v_t(j) - \Phi_t^\pi(j) \quad (24)$$

where  $\kappa^v$  is the cost paid for every posted vacancy by the firm, linear with respect to the number of vacancies posted. Each firm  $j$  maximizes its present value of discounted profit flows subject to the intermediate good demand function (19), the production function (21) and the law of motion for employment (23). Firms discount profits with the time-varying discount factor  $\beta_{t+1} \frac{\lambda_{t+1}^O}{\lambda_t^O}$  because they are owned by the optimizing households.

Nominal rigidities are introduced through quadratic real price adjustment costs that intermediate firms face, denoted by  $\Phi_t^\pi(j) = \frac{\kappa^\pi}{2} (\pi_t(j) - 1)^2 y_t(j)$ .  $\kappa^\pi > 0$  is a price adjustment cost parameter and the producer price inflation is defined as  $\pi_t(j) = \frac{p_t(j)}{p_{t-1}(j)}$ .

Capital demand of the firm satisfies  $r_t^k = mc_t(j) \alpha \frac{y_t(j)}{k_t(j)}$ , where  $mc_t$  denotes the Lagrange multiplier on equation (19) in the program, in other words the marginal costs of the firms. As all firms choose the same price, employment and number of vacancies, index  $j$  cancels and the corresponding first-order conditions for those variables are, respectively:

$$\frac{\kappa_t^v}{q_t} = \mathcal{F}_t, \quad (25)$$

$$\mathcal{F}_t = mc_t (1 - \alpha) \frac{y_t}{n_t} - w_t + E_t (1 - s_{t+1}) \beta_{t+1} \frac{\lambda_{t+1}^O}{\lambda_t^O} \mathcal{F}_{t+1}, \quad (26)$$

$$\pi_t (\pi_t - 1) = \frac{1 - \epsilon}{\kappa^\pi} + \frac{\epsilon}{\kappa^\pi} mc_t + E_t \beta_{t+1} \frac{\lambda_{t+1}^O}{\lambda_t^O} \pi_{t+1} (\pi_{t+1} - 1) \frac{y_{t+1}}{y_t}, \quad (27)$$

where  $\mathcal{F}_t$  is the Lagrangian multiplier on the law of employment i.e. the marginal value of a filled job for the firm. Equation (25) is the free entry condition for vacancy posting: at equilibrium the average cost of posting a vacancy equals the marginal value of having it filled,  $\mathcal{F}_t$ . In turn, according to equation (26), this marginal value of vacancy filling

equals the marginal product of an additional worker minus the wage he receives, plus the continuation value of this filled job for next period provided the match does not separate. Equation (27) describes the New Keynesian Phillips curve with the marginal cost  $mc_t$  for each firm. It states that an increase in producer price inflation is the result of increasing input costs, or raising inflation or real growth expectations.

Combining equations (25) and (26) gives the job creation condition:

$$\frac{\kappa^v}{q_t} = mc_t(1 - \alpha) \frac{y_t}{n_t} - w_t + E_t \beta_{t+1} \frac{\lambda_{t+1}^O}{\lambda_t^O} \left\{ (1 - s_{t+1}) \frac{\kappa_{t+1}^v}{q_{t+1}} \right\}, \quad (28)$$

which is an arbitrage condition for job creation stating that firms increase vacancies until the benefit from employing an additional worker is equal to the cost of posting a vacancy.

Finally, we perform aggregation of firm-specific shares for the capital stock, employment and vacancies:  $\int_0^1 k_t(j) dj = k_t$ ,  $\int_0^1 n_t(j) dj = n_t$  and  $\int_0^1 v_t(j) dj = v_t$ .

### 3.4 Nash bargaining

The firm and newly hired workers determine the wage according to a Nash bargaining solution. Wage bargaining is centralized for both household types and all unemployment stages, which means that the obtained bargained wage may differ over the cycle from what would have resulted from a household-specific bargaining. Indeed, marginal utility of employment differs between unemployed in the different unemployment tiers, and members of the two household types do not have the same discount rates. See Moyen and Stähler (2014a) for a detailed analysis of this issue.

The Nash bargaining solution splits the overall surplus of a match in order to maximize the Nash product given by

$$\max_{w_t} (\mathcal{H}_t)^\zeta (\mathcal{F}_t)^{1-\zeta} \quad (29)$$

where  $0 < \zeta < 1$  represents the bargaining power of the worker.  $\mathcal{H}_t$  denotes the marginal surplus of a match for the worker and  $\mathcal{F}_t$  the marginal surplus of a filled vacancy for firms.  $\mathcal{F}_t$  is given by equation (28), while  $\mathcal{H}_t$  is the marginal surplus of working net of the marginal

surplus of being unemployed for an average household member:

$$\mathcal{H}_t = (1 - \mu)(\mathcal{W}_t^O - \mathcal{U}_t^O) + \mu(\mathcal{W}_t^R - \mathcal{U}_t^R) \quad (30)$$

where

$$\mathcal{W}_t^i = w_t + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} \left\{ (1 - s_{t+1}) \mathcal{W}_{t+1}^i + s_{t+1} \mathcal{U}_{t+1}^{s1,i} \right\} \quad (31)$$

$$\mathcal{U}_t^{s1,i} = b + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} \left\{ (1 - f_{t+1} - \phi^{s1}) \mathcal{U}_{t+1}^{s1,i} + \phi^{s1} \mathcal{U}_{t+1}^{s2,i} + f_{t+1} \mathcal{W}_{t+1}^i \right\} \quad (32)$$

$$\mathcal{U}_t^{s2,i} = b + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} \left\{ (1 - f_{t+1} - \phi^{s2}) \mathcal{U}_{t+1}^{s2,i} + \phi^{s2} \mathcal{U}_{t+1}^{l,i} + f_{t+1} \mathcal{W}_{t+1}^i \right\} \quad (33)$$

$$\mathcal{U}_t^{l,i} = z + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} \left\{ (1 - f_{t+1}) \mathcal{U}_{t+1}^{l,i} + f_{t+1} \mathcal{W}_{t+1}^i \right\} \quad (34)$$

are, respectively, the per household member marginal utility of employment, of short-term unemployment in the first and second segments and of long-term unemployment. These value functions are obtained through derivation of (7) taking into account the household-type specific budget constraint ((9) or (12)) as well as labor market laws of motions (equations (2) to (6)). The corresponding average marginal utility of unemployment writes:

$$\mathcal{U}_t^i = \frac{u_t^{s1,i}}{u_t^i} \mathcal{U}_t^{s1,i} + \frac{u_t^{s2,i}}{u_t^i} \mathcal{U}_t^{s2,i} + \frac{u_t^{l,i}}{u_t^i} \mathcal{U}_t^{l,i} \quad (35)$$

Hence the difference between (31) and (35) follows:

$$\begin{aligned} \mathcal{W}_t^i - \mathcal{U}_t^i &= w_t - b_t + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} \left\{ \mathcal{W}_{t+1}^i - \mathcal{U}_{t+1}^i + s_{t+1} \left( \mathcal{U}_{t+1}^{s1,i} - \mathcal{W}_{t+1}^i \right) - f_{t+1} \left( \mathcal{W}_{t+1}^i - \mathcal{U}_{t+1}^i \right) \right. \\ &\quad \left. - \phi^{s1} \frac{u_{t+1}^{s1,i}}{u_{t+1}^i} \left( \mathcal{U}_{t+1}^{s2,i} - \mathcal{U}_{t+1}^{s1,i} \right) - \phi^{s2} \frac{u_{t+1}^{s2,i}}{u_{t+1}^i} \left( \mathcal{U}_{t+1}^{l,i} - \mathcal{U}_{t+1}^{s2,i} \right) - \frac{u_{t+1}^{l,i}}{u_{t+1}^i} \mathcal{U}_{t+1}^{l,i} \right\} \quad (36) \end{aligned}$$

The first two terms represent the wage that the worker obtains when hired net of the average benefit he or she loses from exiting the unemployment pool. The third term is a continuation value that accounts for the fact that the worker may or may not change employment status in the future. This term includes the marginal value of staying employed in the next period, plus the marginal value of flowing into the first segment of unemployed times the probability of match separation. The last elements account for the fact that next period the newly hired worker will not switch to employment again (since the worker

cannot lose his or her job and find a new one the same period), or  $s1$  and  $l$  unemployment status (since, if dismissed, he/she will join  $s1$  first). We denote this third term by  $cv_t^i$ . Aggregating over the two household types, we can use equation (36) to rewrite (30) as:

$$\mathcal{H}_t = w_t - b_t + E_t cv_{t+1} \quad (37)$$

where  $cv_t = (1 - \mu)cv_t^O + \mu cv_t^R$ . Maximization of (29) with respect to the wage yields the wage bargaining rule:

$$\mathcal{H}_t = \frac{\zeta}{1 - \zeta} \mathcal{F}_t \quad (38)$$

By inserting the marginal value of a filled job (28) and the net marginal surplus of becoming an employed worker (37) into the wage bargaining rule (38), we finally get the Nash-bargaining wage equation:

$$w_t = \zeta \underbrace{\left[ mc_t(1 - \alpha) \frac{y_t}{n_t} + E_t \beta_{t+1} \frac{\lambda_{t+1}^O}{\lambda_t^O} \left\{ (1 - s_{t+1}) \frac{\kappa_{t+1}^v}{q_{t+1}} \right\} \right]}_{\text{surplus from match}} + (1 - \zeta) \underbrace{[b_t - E_t cv_{t+1}]}_{\text{outside option}} \quad (39)$$

The above equation shows that the worker obtains a fraction that the firm gets from a match plus a share of the outside option  $b_t - E_t cv_{t+1}$ , depending on its bargaining power. This outside option depends on the benefit policy net of the continuation value included in the net marginal utility of becoming employed.

However, following Hall (2005), we introduce some real wage rigidity on top of search and matching frictions to better reproduce cyclical variations in employment and vacancies, addressing a typical issue of search and matching models known as the Shimer puzzle (Shimer, 2005).<sup>14</sup> We implement a wage norm to prevent instantaneous wage adjustments to economic shocks. As in Albertini and Fairise (2013b), the wage norm is set as the steady-state wage, and the real wage in our model follows a weighted average of the Nash-bargaining  $\tilde{w}_t$  and norm  $\bar{w}$  wage levels, with a rigidity parameter  $0 < v < 1$ :

$$w_t = (1 - v)\tilde{w}_t + v\bar{w} \quad (40)$$

<sup>14</sup>The Shimer puzzle refers to the inability of standard search and matching models to account for the fluctuations in the unemployment rate observed in the data.

### 3.5 Monetary policy

The central bank stabilizes price inflation and the output gap through the following rule:<sup>15</sup>

$$i_t = \varphi_i i_{t-1} + (1 - \varphi_i) \left[ \log \frac{\overline{\Pi}^{cb}}{\beta} + \varphi_\pi \log \Pi_t^U + \varphi_y \log \frac{y_t^U}{\bar{y}^U} \right] \quad (41)$$

where  $y_t^U = \omega y_t + (1 - \omega)y_t^*$  is the average real output of both countries.  $\overline{\Pi}^{cb}$  is the inflation target of the central bank.  $\Pi_t^U = \omega \Pi_t + (1 - \omega)\Pi_t^*$  is the average price inflation rate measured as the weighted average of country-specific inflation rates. Finally,  $\varphi_i$ ,  $\varphi_\pi$  and  $\varphi_y$  are positive parameters measuring the weighting of the central bank for interest rate smoothing, as well as average price inflation and output growth targeting.

### 3.6 National governments

Governments each run an unemployment agency. A national insurance policy at time  $t$  consists of a set  $(b, \phi^{s2})$ .  $b$  are premium benefits for the first and second segments of short-term unemployment.  $\phi^{s2}$  relates to the entitlement duration for premium benefits.

The government can issue debt  $D_t$  bought by optimizing households across the union. We assume that the national tax  $\tau_t$  follows a counter-cyclical ad-hoc fiscal rule. The government reduces the lump-sum tax compared to steady-state if output or real debt levels are underneath their steady-state values,  $\bar{y}$  and  $\frac{\bar{D}}{\bar{P}}$ :

$$\tau_t = \bar{\tau} + \phi_y (y_t - \bar{y}) + \phi_d \left( \frac{D_t}{P_t} - \frac{\bar{D}}{\bar{P}} \right) \quad (42)$$

where  $\phi_y, \phi_d > 0$  are weighting parameter for the two target variables.

The budget constraint for the national government writes:

$$\tau_t + \frac{D_{t+1}}{P_t} = g_t + b(u_t^{s1} + u_t^{s2}) + zu_t^l + (1 + i_t) \frac{D_t}{P_t} + (1 - \mu)\Phi_t^a + \Phi_t^\pi \quad (43)$$

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<sup>15</sup>Since the central bank follows a stabilization rule, defined below, based on an interest rate rather than a monetary aggregate, we ignore money in the model by assuming that money is separable from consumption in the utility function of the households. We study an economy sometimes referred as cashless economy, where money is used as the numeraire but is neutral.

where  $g$  is an exogenous government expenditure.  $b(u_t^{s1} + u_t^{s2}) + zu_t^l$  are the total social benefits of the national entity. As a modeling trick, we also assume that the government rebates portfolio adjustment costs to optimizing households  $(1 - \mu)\Phi_t^a$  to neutralize their effect on the cycle. The government also rebates price adjustment costs  $\Phi_t^\pi$  borne by intermediate firms, owned by optimizers, also in order to neutralize their effect on the cycle.

### 3.7 Goods and financial trade

Produced goods can be either used domestically or exported to the other economy. For Home, the nominal trade balance is defined as the difference between exports and imports:

$$TB_t \equiv (1 - \omega)p_t^H c_{H,t}^* - \omega p_t^F c_{F,t} \quad (44)$$

Financial market equilibrium reads:

$$\omega H_t + (1 - \omega)H_t^* = \omega D_t + (1 - \omega)D_t^* \quad (45)$$

The current account balance is defined as the sum of the trade balance and interests paid or received on net savings for the country  $H_t - D_t$ :

$$CA_t = TB_t + \omega i_t(H_t - D_t) + \omega T r_t \quad (46)$$

The balance of payments is equal to zero and can be expressed as:

$$bop_t \equiv 0 = \omega[(H_{t+1} - H_t) - (D_{t+1} - D_t)] - CA_t \quad (47)$$

which shows that the financial account must be equal to the opposite current account balance.

## 4 Design of the European unemployment insurance

### 4.1 European benefits and taxes

We now introduce the EUI as a supranational government. The EUI provides part of the premium benefits that short-term unemployed workers are entitled to, when a shock hits, and finances them with taxes as well as, depending on the scenario, debt issuance.

The challenge when designing the EUI is to establish a base European insurance common to both countries, which plugs into existing national policies without altering the overall amount of benefits distributed or the total entitlement duration. A major source of concern in the debate over EUI is that the scheme would conflict with countries' preferences on how they choose to insure their workers, especially considering the high heterogeneity in national systems.

In our model, the scheme is active over the first segment of short term unemployment to provide part of real premium benefits  $b$ . The scheme disburses European benefits  $b^e$  for unemployed workers in the first segment  $s1$ . In every period  $t$ , unemployed switch to purely national premium benefit, the second segment  $s2$ , with probability  $\phi^{s1}$ . First, targeting short term unemployed only allows us to dodge moral hazard issues. Second, the national agency can extend the base European insurance along two dimensions: it can keep insuring short term unemployed with premium benefits for a longer period through the second segment  $s2$ , and it can top-up the European benefits with extra national premium benefits in the first pillar  $b^n = b - b^e$ .<sup>16</sup> Tier 1 benefits are then made of European benefits  $b^e$  as well as a national top-up  $b^n$  such that  $b^e + b^n = b$ . National governments can extend premium benefits over the second segment, and the overall amount of benefits is unaltered. Hence we designed a European segment that can be extended at the national level to respect each country's preferences in terms of insurance and reproduce the insurance level of the baseline. Our two-tiered structure for premium benefits allows for the European insurance to be integrated into national ones sequentially and simultaneously, without altering the overall amount of premium benefits  $b$  or their duration  $\phi^{s2}$ . The EUI plugs into the existing agencies which remain active so that unemployment insurance is multi-layered. The EUI is represented in figure 2.

The supranational insurance entity sets a benefit policy  $(b^e, b^{e*}, \phi^{s1})$  and can impose

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<sup>16</sup>The national government sets its policies taking  $(b^e, \phi^{s1})$  as given, which are set by the supranational entity.

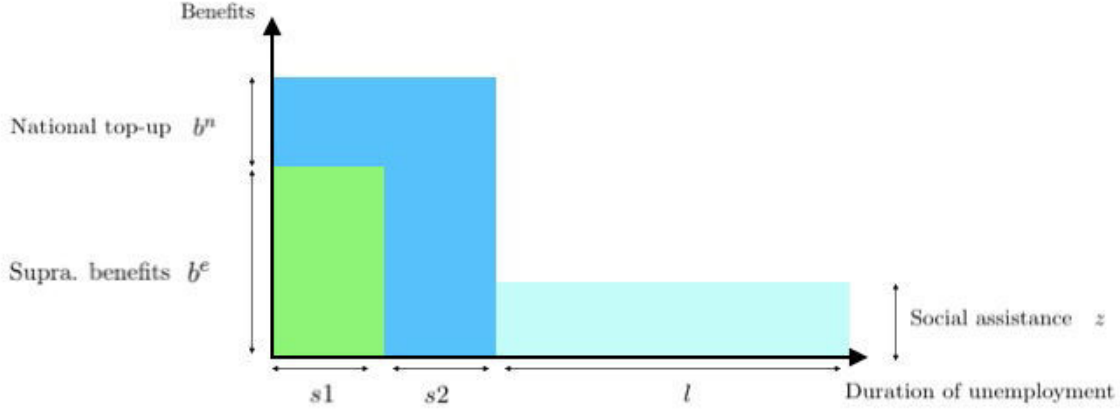


Figure 2: EUI

lump-sum taxes  $(\tau_t^e, \tau_t^{e*})$  to disburse unemployment benefits in the Home or in the Foreign economy.<sup>17</sup> Net transfers to the EUI are defined as the difference between what the country receives in terms of benefits from the fund and what it contributes in terms of taxes. Hence per capita real net transfers write:

$$T\tau_t = b^e u_t^{s1} - \tau_t^e \quad (48)$$

The amount of European benefits is pinned down to deviations of output relative to the steady-state, according to the following rule:

$$b^e u_t^{s1} = \phi_y^E (y_t - \bar{y}) \quad (49)$$

with  $\phi_y^E < 0$  so that the above rule sets a positive amount of European benefits  $b^e$  when a negative shock hits and output drops in one country. The amount of support in the form of benefits is proportional to the size of shock, and is null at the steady-state. Hence, the EUI is only active over the cycle, and not at the steady-state.

Compared to the baseline, taxes charged to the households are now made of a national part  $\tau_t^n$  and a European one  $\tau_t^e$ , so that  $\tau_t = \tau_t^n + \tau_t^e$ . Hence, we update the debt rule (42)

<sup>17</sup>As in the status quo case, we focus on constant policy instrument i.e. constant benefits and entitlement duration over the cycle.



and the budget constraint (43) of the national government :

$$\tau_t^n + \frac{D_{t+1}}{P_t} = g_t + b^n u_t^{s1} + b u_t^{s2} + z u_t^l + (1 + i_t) \frac{D_t}{P_t} + (1 - \mu) \Phi_t^a + \Phi_t^\pi \quad (50)$$

$$\tau_t^n = \bar{\tau}^n + \phi_y (y_t - \bar{y}) + \phi_d \left( \frac{D_t}{P_t} - \frac{\bar{D}}{\bar{P}} \right) \quad (51)$$

## 4.2 EUI scenarios

We now present three different scenarios for the functioning of the EUI, summarized in Table 1.

**Scenario 2: EUI without debt issuance** When the EUI cannot issue debt, its budget constraint reads in nominal terms:

$$\omega P_t b^e u_t^{s1} + (1 - \omega) P_t^* b^{e*} u_t^{s1*} = \omega P_t \tau_t^e + (1 - \omega) P_t^* \tau_t^{e*}$$

Using the definition of net transfers (48), the above budget constraint (52) can be written

$$\omega P_t T r_t + (1 - \omega) P_t^* T r_t^* = 0 \quad (52)$$

In this scenario, we are left with one degree of freedom to set European taxes so that the budget constraint of the EUI (52) balances. We use this degree of freedom to define a uniform tax rate charged to both countries to finance the overall amount of European benefits every period:<sup>18</sup>

$$\tau_t^e = \tau_t^{e*} = \tau_t^u \quad (53)$$

### Scenario 3: EUI with shared debt issuance

In this scenario, the EUI runs the same policy as scenario 2 but can issue debt  $D_t^E$ . It pays the risk-free rate of the union  $i_t$  and is bought by optimizing households across the

<sup>18</sup>Alternatively, the one degree of freedom to design taxes could be used to define a transfer rule which, in combination with the budget constraint (52), would set  $\tau_t^e$  and  $\tau_t^{e*}$  in every period. This rule would be equivalent to equation (53).

Scenarios	EUI	Debt issuance	Shared debt
Baseline	1	No	No
EUI without debt issuance	2	Yes	No
EUI with shared debt issuance	3	Yes	Yes
EUI with debt issuance and debt compartments	4	Yes	Yes

**Table 1:** Scenarios

union. The budget constraint of the EUI now writes:

$$\omega P_t T r_t + (1 - \omega) P_t^* T r_t^* + (1 + i_t) D_t^E = D_{t+1}^E \quad (54)$$

With the European debt variable  $D_t^E$ , we are left with two degrees of freedom to design European taxes. The following fiscal rules, or claw-backs, imply an increase in European taxes when the fund issues debt:<sup>19</sup>

$$\tau_t^e = \phi_d^E \left( \frac{D_t^E}{P_t} - \frac{\overline{D^E}}{\overline{P}} \right) \quad (55)$$

where  $\phi_d^E > 0$  measure the strength of the claw-back for the target variable, the debt issued by the fund.

In this scenario, taxes increase in both countries when the fund issues debt to provide transfers to at least one of the two. This provides fiscal risk-sharing to the union. Indeed, when an asymmetric shock hits one country, the European debt is reimbursed by both union members. In this sense, there is a form of permanent transfers since the country receiving the net transfers will not repay the totality of the support it received.

The parameter  $\phi_d^E > 0$  is used to provide stabilization through the EUI. In this scenario, households pay part of their taxes to the national government according to (42), and another part to the European government according to (55). By setting a lower coefficient

<sup>19</sup>Compared to scenario 2, we take out equation (53) and have one additional endogenous variable which is the European debt. This gives us two more degrees of freedom to design the insurance, corresponding to the Home and Foreign fiscal rules at the European level.

on the European rule, we allow for a relatively more accomodative fiscal policy at the European level than at the national one to finance premium benefits:

$$\phi_d^E < \phi_d \quad (56)$$

Assuming that repayment of the European debt would happen at a lower rate than the national one is understandable if one consider that unemployment benefits only represent a small fraction of the overall national budgets. Hence, national fiscal policy would be more strict than the one at the European level which only comprises unemployment benefits.

#### Scenario 4: EUI with debt issuance and debt compartments

This setting is identical to the previous, but here each country has an account with respect to the fund and we can keep track of which country receives positive transfers: this is familiar a set-up to European countries and resembles the functioning of structural funds for example. Each country has a compartmentalized debtor or creditor nominal position with respect to the EUI, which follows for Home and Foreign respectively:

$$D_{t+1}^{E,H} = P_t T r_t + (1 + i_t) D_t^{E,H} \quad (57)$$

$$D_{t+1}^{E,F} = P_t^* T r_t^* + (1 + i_t) D_t^{E,F} \quad (58)$$

As stated in the results section, these accounts towards the fund prevent permanent transfers, meaning that no country can be a permanent creditor or debtor. Indeed, the provision of transfers and their reimbursement are circumvented to each country-specific account without affecting the other country.

The following fiscal rules, or claw-backs, imply an increase in European tax for a country when it receives positive transfers:

$$\tau_t^e = \phi_d^E \left( \frac{D_t^{E,H}}{P_t} - \frac{\overline{D^{E,H}}}{\overline{P}} \right) \quad (59)$$

where  $\phi_d^E > 0$  measure the strength of the claw-back for the target variable, the country-specific nominal position towards the fund. This fiscal rule (59) replaces (55) from the

previous scenario. Hence, there is no increase in European tax for a country that does not receive transfers. As such, permanent transfers are completely eliminated.

To finance the transfers when a country draws on its account, the fund issues debt  $D_t^E$  so that:

$$D_t^E = \omega D_t^{E,H} + (1 - \omega) D_t^{E,F} \quad (60)$$

such that the budget constraint of the EUI can be written as in (54).

Finally, we update the financial market equilibrium (45) as well as the current account (46) equations:

$$\omega H_t + (1 - \omega) H_t^* = \omega D_t + (1 - \omega) D_t^* + D_t^E \quad (61)$$

$$CA_t = TB_t + \omega i_t (H_t - D_t) + \omega Tr_t \quad (62)$$

## 5 Calibration

### 5.1 Euro area calibration

The calibration of the baseline scenario developed in Section 3 follows the literature on open economy DSGE models with search and matching as well as empirical observations.<sup>20</sup> Calibration is reported in table 3 in the Appendix, as well as data references. We calibrate the model on annual data from 1995 to 2017 for the core (Austria, Belgium, Finland, France, Germany, Luxemburg and Netherlands) and the periphery (Spain, Greece, Ireland, Italy and Portugal) of the euro area. We set the relative country size equal to  $\omega = 0.6$  in order to match relative total population. We set the steady-state discount factor to  $\beta = \beta^* = 0.994$  and the central bank's inflation target to  $\overline{\Pi}^{cb} = 1.005$ , consistent with an annualized interest rate of four percent. The partial production elasticity of capital  $\alpha$  is set to the conventional value one third and the quarterly depreciation rate of physical capital is  $\delta = \delta^* = 0.025$ . We assume the degree of home bias to be  $\psi = 0.75$  in the core economy and  $\psi^* = 1 - \psi = 0.25$  in order to match the shares of exports and imports

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<sup>20</sup>See e.g. Christoffel et al. (2009a), Mitman and Rabinovich (2015a), Albertini and Fairise (2013a), Moyen and Stähler (2014a).

on GDP. We normalize steady-state per capita output in the Core to  $\bar{y} = 1$ , while it is lower in the Periphery, equal to  $\bar{y}^* = 0.77$ . The price adjustment cost parameter of the intermediary firms is set to  $\kappa^\pi = \kappa^{\pi^*} = 17.6$  and the elasticity of substitution between intermediary inputs to  $\epsilon = \epsilon^* = 10$ . We obtain a Phillips curve analogous to price rigidities à la Calvo with an average price duration of two quarters. Risk aversion and consumption habit are set to standard values  $\gamma = \gamma^* = 1.5$  and  $h = h^* = 0.7$  respectively. So that the elasticity of substitution between goods approaches 3.4, we have  $\sigma = \sigma^* = 0.744$  (Corbo and Osbat, 2013). Following the empirical literature (Campbell and Mankiw, 1989), we set the share of RoT households in the Core and the Periphery to a half such that  $\lambda = \lambda^* = 0.5$ .

Turning to labor market characteristics, the matching elasticity and the wage bargaining power are the same and equal in both regions  $\eta = \zeta = \eta^* = \zeta^* = 0.5$ , such that the Hosios condition holds. Steady-state employment, job finding and vacancies filling probabilities are targeted to compute matching efficiency, separation rate and steady-state vacancies. We set  $\bar{n} = 0.92$ ,  $\bar{f} = 0.3$  and  $\bar{q} = 0.71$  for the Core and  $\bar{n}^* = 0.894$ ,  $\bar{f}^* = 0.29$  and  $\bar{q}^* = 0.73$  for the Periphery. The Core steady-state ratio of vacancies over unemployed workers is higher i.e. we have  $\bar{\theta} > \bar{\theta}^*$ . Core labor market is more efficient than Periphery labor market, with higher matching efficiency ( $\kappa^m = 0.4615$  against  $\kappa^{m^*} = 0.4601$ ) and lower vacancy cost as a share of GDP ( $\frac{\kappa^v \bar{v}}{\bar{y}} = 1.31\%$  against  $\frac{\kappa^{v^*} \bar{v}^*}{\bar{y}^*} = 3.62\%$ ). Separation rates are at  $s = 2.61\%$  and  $s^* = 3.44\%$ . The wage rigidity parameter is set at 0.92 in both countries to address the Shimer puzzle.

To match the data, steady-state real debt ratios are targeted at 69.4% of GDP for the core and 95% of GDP for the periphery, while government expenditures are targeted at 22% of GDP for the core and 20% of GDP for the periphery. Regarding insurance policies, premium unemployment benefits and social assistance are higher in Core than in the Periphery, with  $b = 0.48$ ,  $b^* = 0.33$ ,  $z = 0.44$  and  $z^* = 0.13$ . These values are set to match observed short and long-term replacement rates. We set  $\phi^{s1} = \phi^{s1^*} = 0.5$ , so that supranational benefits expire after 2 quarters. Then, the Home national government

extends premium benefits for 4 more quaters, with  $\phi^{s2} = 0.25$  while the Foreign government extends them for 2 quarters, with  $\phi^{s2*} = 0.5$ .

Coefficient on the Taylor rule for inflation stabilization is  $\varphi_\pi = 1.5$  and we allow for some degree of output stabilization as well with  $\varphi_y = 0.2$ . Interest rate smoothing is set at  $\varphi_i = 0.8$ . Coefficients on output and debt stabilization for the national tax rule are equal to  $\phi_y = \phi_y^* = 0.8$  and  $\phi_d = \phi_d^* = 0.5$  respectively. Accordingly, an increase in GDP by 1% increases the national tax by 0.8% while an increase in national real debt by 1% increases the tax by 0.5%. Turning to policy parameters of the supranational layer, we set  $\phi_y^E = \phi_y^{E*} = 1$ . Hence, for example, a 1% drop in output translates into support in the form of premium benefits from the fund of 1% of GDP. For the scenarios with debt issuance, coefficients on the fiscal claw-backs are  $\phi_d^E = \phi_d^{E*} = 0.05$ , hence a tenth of the national debt rule.

In order to get the characteristics of the technology shock, we calculated the cyclical component of the Solow residual from the production function. We than estimated the autoregressive parameter by applying the underlying AR(1) process. The persistence parameter for the discount factor shock is set to standard value of 0.9. The persistence parameters for the separation rate is taken from Christoffel et al. (2009a). Then variances for these shocks are defined to target observed volatility in output, consumption and unemployment rate.

## 5.2 Model steady-state and second moments

Finally, we assess the quality of the model by comparing the theoretical business cycle statistics of the calibrated model with the empirical facts presented in Table 2. We have three shocks in total: a productivity shock (supply), a discount factor shock (demand) and a separation rate shock (labor market shock). We draw country-specific shocks from their distributions and simulate 1000 periods to extract the standard deviations conditional on all shocks.

Appart from targeted output and government expenditure ratios, the model manages

				<b>Steady-state</b>		
		Model (Data)		Model (Data)		
		Core		Periphery		
Gross domestic product						
Output*	$y$	1		0.77(0.77)		
Consumption ratio	$\bar{c}/\bar{y}$	0.57(0.53)		0.55(0.59)		
Investment ratio	$\bar{j}/\bar{y}$	0.24(0.22)		0.24(0.21)		
Government expenditure ratio*	$\bar{g}/\bar{y}$	0.22(0.22)		0.2(0.2)		
Labor market						
		Core		Periphery		
Unemployment rate*	$\bar{u}$	0.08(0.08)		0.11(0.11)		
Labor share	$\bar{w}\bar{n}/\bar{y}$	0.59(0.52)		0.56(0.43)		
Government						
		Core		Periphery		
Real government debt*	$\bar{D}/(\bar{P}\bar{y})$	0.69(0.69)		0.95(0.95)		
Short-term replacement rate	$\bar{b}/\bar{w}$	75.2%(76.5%)		68.3%(67.4%)		
Long-term replacement rate	$\bar{z}/\bar{w}$	69%(68.6%)		26.9%(27.1%)		
				<b>Relative std. dev. to output</b>		
		Model (Data)		Model (Data)		
		Core		Periphery		
Consumption	$\sigma(c)/\sigma(y)$	0.74(0.69)		0.98(0.94)		
Unemployment rate	$\sigma(u)/\sigma(y)$	0.33(0.34)		0.51(0.51)		
Real wage	$\sigma(w)/\sigma(y)$	0.29(0.29)		0.4(0.41)		

*Model refers to the baseline calibration. The table compares steady-state and second moments from the model (quarterly statistics) with empirical observations (annual data). Items with an asterix are targeted.*

**Table 2:** Model steady-state and second moments

to match consumption and investment ratios for the core and the periphery. Short and long-term replacement rates are also close to the data. However, we note that the labor share in % of GDP is a bit too elevated in the periphery compared to the data.

Table 2 also depicts the empirical standard deviations for euro area core and periphery over the period 1995-2017. The model matches the relative standard deviations to output observed in the data quite well, for consumption, wages and the unemployment rate. In particular, the right signs and order of magnitude are captured.

## 6 Results

We implement a negative supply shock by decreasing Foreign productivity by 1%, and compare the different scenarios. Impulse responses functions are reported in Figures 3, 4 and 5 in the Appendix.

### 6.1 Impulse response functions : baseline

Let us first analyze the behavior of the economy in the baseline (Scenario 1, solid black lines in the figures), without transfers.

The shock increases the cost of production in the Foreign economy, and leads to a decrease in output, consumption and wages. As a consequence of lower marginal value from job creation, firms reduce their vacancy posting. Given their bargaining power workers have to reduce their wage claim and employment decreases. The drop in productivity affects the inter-temporal revenue of optimizers who own the firms, and they decrease their consumption. Decreasing wages, combined to increasing unemployment reduces the current disposable income of RoT households. In the short-run, this is partly offset by the stabilization delivered at the national level, through a tax cut. After 4 quarters, the consumption of RoT households decreases.

Furthermore, Foreign firms become less productive than their Home counterparts and the relative price (terms of trade) of Foreign goods increases. Therefore, on impact, Home and Foreign consumers substitute away from Foreign production and the Foreign trade



balance deteriorates.

As the shock hits, both short and long-term unemployment increase but short-term relatively more while it reverses in the medium term. Indeed, reduced vacancies and matches lead to a relatively higher pool of short-term unemployed, as workers flow there before long-term unemployment. As the long-term unemployment pool increases, the average benefit also diminishes since social assistance is lower than premium benefits, a point also made in Moyen and Stähler (2014a).

Moreover, due to the increase of social benefits receipts and the counter-cyclical component of the fiscal rule, the government issues debt. Then, through the fiscal rule, the government increases taxes in subsequent periods such that debt converges to zero.

Also, the increase in the price of Foreign goods generates inflation, which feeds into the rising union inflation rate. As a result, the central bank increases its interest rate. In the Home country, where there is no shock, the real interest rate increases for optimizing households, who decrease their consumption but only mildly. Overall, this asymmetric shock leaves the Home economy broadly unchanged but with the recession in the periphery, union consumption decreases.

## 6.2 Impulse response functions : EUI

In the following subsection, we compare the status quo set-up (scenario 1) with the unemployment insurance union scenarios: without debt issuance (scenario 2), with shared debt issuance (scenario 3) and finally with debt issuance and debt compartements (scenario 4). We do so by implementing the negative productivity shock in the Foreign economy of 1%.

The recession in the Foreign economy triggers transfers from the supranational scheme. According to (49), the scheme provides a portion of premium benefits to unemployed members of households in Tier 1 short-term unemployment. The Foreign national government tops-up the amount with national support, so that the overall amount is unchanged compared to the baseline. The national government also extends premium benefits beyond

expiration of European ones, according to our calibration, and the overall entitlement duration is unaltered. European benefits relieve part of the fiscal pressure on the national government. As a result, the national fiscal policy is made more counter-cyclical, which supports the current disposable income of Foreign RoT households.

In scenario 2 (insurance union without debt issuance, crossed blue lines in the figures), these positive transfers flowing from the scheme are financed in part through taxation of the Home economy, not hit by the shock. Indeed, as the scheme cannot issue debt, transfers have to be financed by the households of the other country. As  $\tau_t^u$  increases, Home RoT households reduce their consumption. In the end, in scenario 2, the EUI organizes cross-country transfers which support Foreign consumption effectively. However, this transfer policy is made at the expense of Home households: Home consumption decreases.

At the scale of the union, comparing scenarios 1 and 2, the EUI without debt does worse to deal with the shock than when there are not transfers, in the short-run. We observe the reverse after 4 quarters, where union consumption does not drop as much as in the baseline, but only with a small difference. In this scenario, transfers do not happen at the steady-state, but they are permanent in the sense that the Foreign economy does not reimburse Home for the support its households finance.

Let us now analyze scenario 3 (EUI with shared debt, red starred lines in the figure), where the EUI is entitled to borrow in financial markets, with the same negative productivity shock in the Foreign economy. Debt issued by the scheme is repaid by all households in the union. European benefits flow from the scheme to support households, with a positive effect on Foreign RoT households' consumption. Indeed, transfers make the national tax policy more counter-cyclical, just as in scenario 2. However, now that the EUI can issue debt, European fiscal claw-backs (55) ensure a gradual rise in taxation to stabilize the common debt, with a less strict rule than at the national level. This improves the consumption of RoT households in the Foreign economy.

Compared to the previous scenario, transfers to Foreign households are only in part

financed through taxation of Home, and mainly through debt issuance by the scheme. Hence, European taxes and negative transfers are only imposed gradually on the Home economy. As a result, consumption of Home RoT households is not as depressed. We note that the reaction of Home optimizers is negligible due to consumption smoothing.

Debt issuance allows the scheme to finance premium benefits in a more counter-cyclical way. Debt is repaid through less strict clawbacks than the national ones. Also, Home households do not bear as much cost for the transfers as in the scenario 1. In the end, the EUI is effective at stabilizing union consumption. The recession is postponed compared to the baseline and consumption does not drop by as much. However, some permanent transfers subsist in this scenario. Indeed, the European debt is in part reimbursed by Home households.

Finally, in scenario 4 (EUI with debt issuance and debt compartments, green circled lines in the figures), we look at the same negative shock in the case of a common scheme that issues debt which is not shared.

Transfers are provided to Foreign households in the same fashion than in scenarios 2 and 3, however now the European clawback (59) is more strict than in scenario 3 when debt was shared, since Home households do not participate in the debt repayment of the scheme. As a result, for the same amount of European debt, more taxes are levied on the Foreign economy and the European tax on Foreign households rises faster. While the consumption of optimizers is broadly unaffected, that of RoT households is not as stabilized as in scenario 3, but still more than 1 or 2.

The Foreign fiscal claw-back (55) ensures that taxation rises progressively in Foreign to close its debtor position towards the fund (58). However, taxes rise at a slower pace than the national debt rule, as we impose (56). Part of premium benefits are now financed by the EUI, which conducts a more accommodative fiscal policy than the national government. As a result, the consumption of RoT households is supported compared to the baseline. In a case (not shown) where the European and national claw-backs are identical, i.e.  $\phi_d^E = \phi_d$ , the baseline and scenario 4 would be identical as well.

In scenario 4, the Home economy is mostly unaffected, as transfers and debt repayment only include the Foreign economy. Through debt compartments, permanent transfers are completely avoided as Home households do not have to bear the financing of transfers disbursed to Foreign. In the end, comparing scenario 3 and 4 in terms of union consumption, the EUI deliver the same amount of stabilization. When looking at the country scale, in scenario 4, Foreign consumption is lower but this is compensated by a higher consumption in Home.

We note that the differences between scenarios are due to the presence of RoT households that break Ricardian equivalence. Across all scenarios, the consumption of optimizing households faces less variations than that of RoT ones across the different scenarios because optimizers smooth consumption. The differences we observe are mostly linked to the variation reactions of the central bank which affect the real interest rate they face.

By relieving some of the pressure put on national public governments to finance premium benefits, the EUI delivers stabilization in the union due to the presence of RoT households. But this is only true if the scheme can issue debt. If it cannot (scenario 2), transfers have to be financed through taxation of the Home economy, and overall consumption drops by more in the short run compared to the baseline. If it can issue debt (scenario 3), the scheme can organize transfers that increase overall stabilization compared to the baseline. If the debt is issued through country-specific accounts (scenario 4), permanent transfers are avoided while maintaining the same level of stabilization as in scenario 3. Contrary to common belief, debt issuance is then, designed as such, a tool allowing to avoid permanent cross-country shifts of income.

Finally, we remind the reader that the scheme steps in only when shocks hit to provide unemployment benefits directly to the households, without altering the overall amount of benefits or entitlement duration. Thus, its interventions do not require any labor market convergence and countries remain free to insure their unemployed workers as they like.

## 7 Conclusion

This paper studies the effects of implementing an unemployment insurance union between two countries sharing a currency. Our New-Keynesian DSGE model includes job market frictions as well as imperfect risk-sharing channels, such as incomplete financial markets, home bias in trade, and immobile labor. We calibrate the model to the euro area core and periphery, and include typical supply, demand and labour market shocks. Then, we compare, in terms of stabilization in reaction to a negative supply shock, the status quo situation (where unemployment insurance is only national) to EUI scenarios.

Our paper addresses three key issues in the debate on European unemployment insurance: heterogeneity in national social policies, debt issuance and permanent transfers. First, regarding cross-country differences in social policy, the multi-layered design allows for participating countries to remain free in insuring their unemployed workers as they like, in terms of benefit amount and entitlement duration. The EUI is built to plug into existing unemployment systems, heterogenous across countries, as a common base so that transfers do not affect country-specific characteristics.

Second, our paper tackles the issue of debt issuance. If the scheme cannot borrow, transfers are permanent and ineffective: contributions have to be raised in one country to support the other. Apart from political difficulties, the system without debt issuance would also be unable to smooth area-wide shock. Indeed, it would imply transfers from a country in a bad economic situation towards a country in an even worse one. In our model, the EUI without debt issuance cannot improve stabilization in the short term.

Third, if debt issuance is allowed, the EUI can be designed to prevent permanent transfers. Country-specific accounts towards the fund combined to fiscal claw-backs insure that transfers, positive or negative, target only the country activating the fund. At the same time, through a more accomodative claw-back at the European level compared to the national debt rule, stabilization is enhanced. As such, the EUI can acheive as much stabilization as when the debt issued is shared by both union members.

Finally, we note that our model could be expanded to include institutional moral hazard

effects. Endogenizing the optimal benefit policies of the national governments could help us determine if countries would change how they insure their workers when the EUI supports them.

## 8 Appendix

### Data description

**Country coverage:** Core includes Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands. Periphery includes Greece, Ireland, Italy, Portugal and Spain.

**Population** Total population, annual data, 1995-2017, OECD National Accounts, 2018.

**Output:** Gross domestic product (expenditure approach) at 2010 market prices, annual data, 1995-2017, OECD National Accounts, 2018.

**Consumption:** Final consumption expenditure of households at 2010 prices, annual data, 1995-2017, OECD National Accounts, 2018.

**Investment:** Gross fixed capital formation at 2010 prices, OECD National Accounts, 2018.

**Government expenditure:** Final consumption expenditure of general government at 2010 prices, annual data, 1995-2017, OECD National Accounts, 2018.

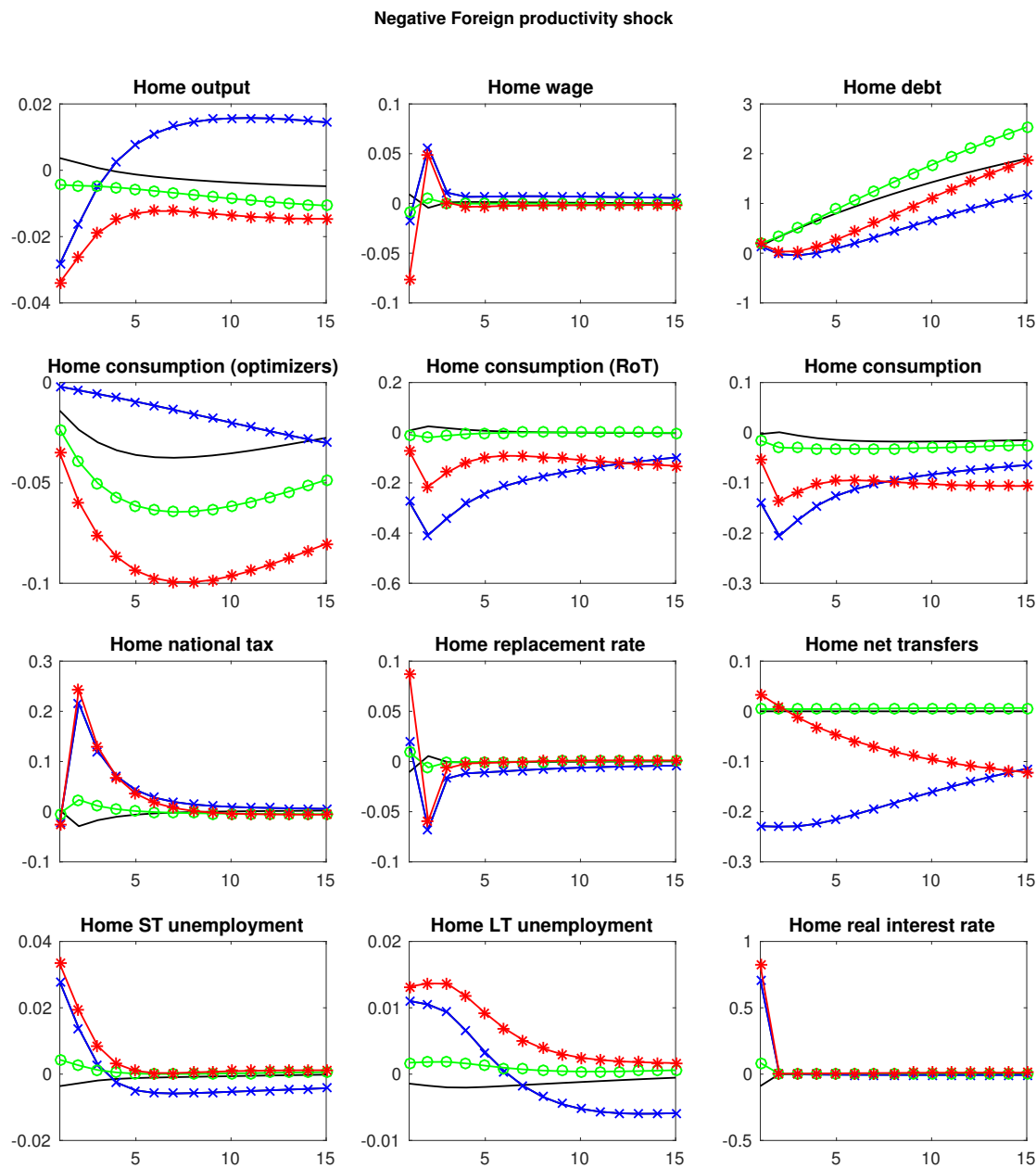
**Unemployment rate:** Unemployment rate (age 15 to 64), annual data, 1995-2017, OECD Labor Force Statistics database, 2018. Core and Periphery averages are computed using population weights.

**Real wages:** Average annual wages, deflator GDP, annual data, 1995-2017, OECD Labor Force Survey database, 2018. Core and Periphery averages are computed using population weights.

**Government debt:** Gross general government debt, Maastricht definition, deflator GDP, annual data, 1995-2017, OECD National accounts, 2018.

**Replacement rate:** Initial replacement rate for short-term unemployment replacement rate, long term replacement rate for long-term unemployment replacement rate, level of pre-unemployment income of 67% of the average production worker wage, average of single person household and married couple with one earner household, annual data, 2001-2016, OECD SOCX database, 2018. Core and Periphery averages are computed using population weights. Methodology and calibration is similar to Christoffel et al. (2009a).

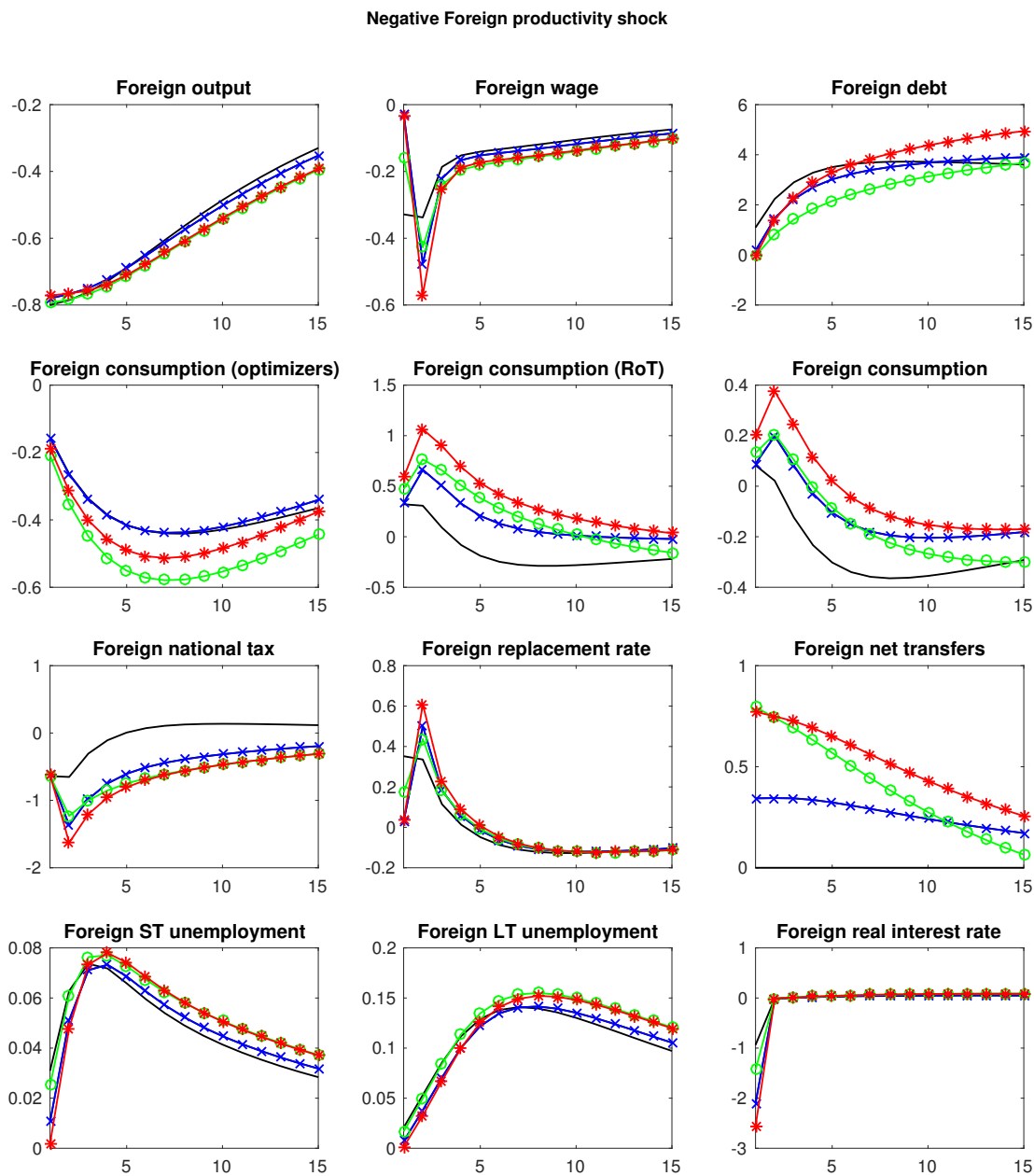
Figure 3: Home variables



Periods are quarters. Black solid lines: status quo (scenario 1); Crossed blue lines: EUI without debt issuance (scenario 2); Starred red lines: EUI with shared debt (scenario 3); Circled green lines: EUI with debt issuance and debt compartments (scenario 4). Results for output, consumption, tax, debt, wage and trade balance are in % deviation from the steady-state. Results for interest rate, replacement rate, and employment rate are in ppt change from steady-state. Transfers are in level.

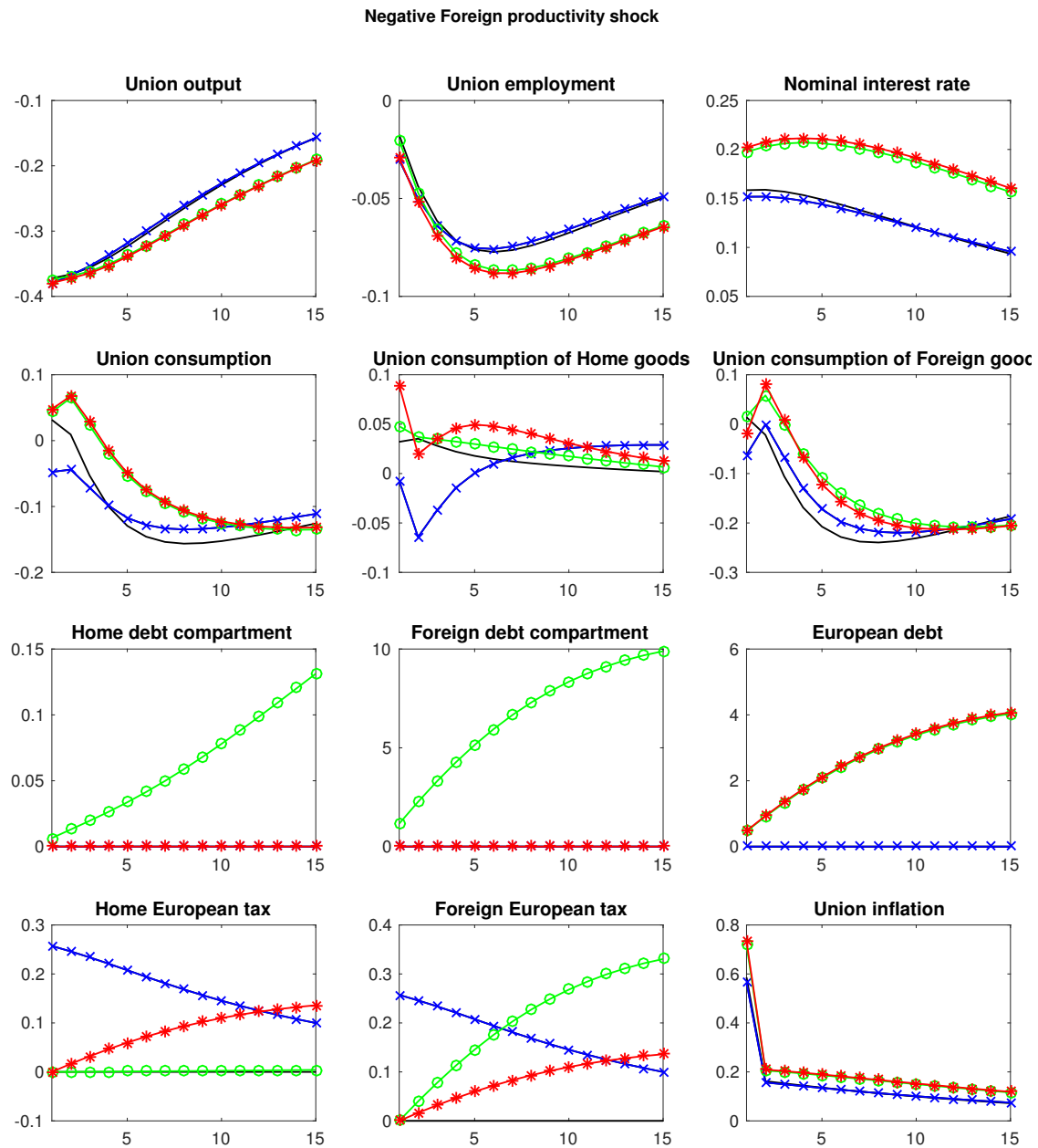


Figure 4: Foreign variables



Periods are quarters. Black solid lines: status quo (scenario 1); Crossed blue lines: EUI without debt issuance (scenario 2); Starred red lines: EUI with shared debt (scenario 3); Circled green lines: EUI with debt issuance and debt compartments (scenario 4). Results for output, consumption, tax, debt, wage and trade balance are in % deviation from the steady-state. Results for interest rate, replacement rate, and employment rate are in ppt change from steady-state. Transfers are in level.

Figure 5: Union variables



Periods are quarters. Black solid lines: status quo (scenario 1); Crossed blue lines: EUI without debt issuance (scenario 2); Starred red lines: EUI with shared debt (scenario 3); Circled green lines: EUI with debt issuance and debt compartments (scenario 4). Results for output, consumption, tax, debt, wage and trade balance are in % deviation from the steady-state. Results for interest rate, replacement rate, and employment rate are in ppt change from steady-state. Transfers are in level.

Structural parameters		Core	Periphery	Target/Source
Economic size	$n$	0.6	0.4	Relative total population
Time preference	$\beta$		0.994	4.4% annual nominal interest rate
Inflation target	$\overline{\Pi}^{cb}$		1.005	2% annual inflation
Production elasticity	$\alpha$		$\frac{1}{3}$	
Depreciation rate	$\delta$		0.025	Investment share
Elasticity of substitution between goods	$\sigma$		0.744	3.9 European average (Corbo and Osbat, 2013)
Openness	$\psi$	0.75	0.25	Core/Periphery exports shares
Risk aversion	$\gamma$		1.5	
Consumption habit	$h$		0.7	
Share of RoT consumers	$\lambda$		0.5	Campbell and Mankiw (1989)
Productivity	$a$	0.5	0.43	Relative output
Portfolio adjustment costs	$\kappa^k$		0.001	
Bond holding adjustment costs	$\kappa^H$		0.01	
Price adjustment cost	$\kappa^\pi$		17.6	Average price duration: two quarters
Elasticity of substitution between inputs	$\epsilon$		10	Average price duration: two quarters
Labour market		Core	Periphery	Target/Source
Separation rate	$s$	0.0261	0.0487	Job finding probability
Matching efficiency	$\kappa^m$	0.4615	0.4601	Vacancy filling probability
Vacancy costs	$\kappa^v$	0.3883	0.6625	
Wage bargaining power	$\zeta$		0.5	Hosios condition
Substitution elasticity of matching	$\eta$		0.5	Hosios condition
Wage rigidity	$v$		0.92	Wage volatility
Governments		Core	Periphery	Target/Source
Government spending	$g$	0.22	0.2	Government spending data
Premium unemployment benefit	$b$	0.48	0.33	Short-term replacement rate data
Social assistance	$z$	0.44	0.13	Long-term replacement rate data
Premium benefits entitlement duration	$\phi^{s1}$	0.5	0.25	Entitlement duration data
Coefficient on output (national)	$\phi_y$		0.8	
Coefficient on debt (national)	$\phi_d$		0.5	
Support (supra-national)	$\phi_y^E$		1	
Fiscal clawback (supra-national)	$\phi_d^E$		0.025	
Taylor rule (inflation)	$\phi_y^E$		1.5	
Taylor rule (output)	$\phi_y$		0.2	
Taylor rule (smoothing)	$\phi_d^E$		0.8	
Shocks		Core	Periphery	Target/Source
Persistence productivity	$\rho_a$	0.96	0.9	
Persistence discount factor	$\rho_\beta$	0.9	0.9	
Persistence separation rate	$\rho_S$	0.75	0.75	
Volatility productivity	$\sigma_A$	0.017	0.02	Output volatility
Volatility discount factor	$\sigma_\beta$	0.009	0.018	Consumption volatility
Volatility separation rate	$\sigma_s$	0.04	0.15	Unemployment rate volatility

Table 3: Calibration

## Chapter IV

# Euro area unemployment insurance and the ZLB

### 1 Introduction

The euro area sovereign debt crisis has exposed important gaps in the architecture of the Economic and Monetary Union. The introduction of the euro did not lead to moderation of country-specific shocks and national fiscal policies in many countries remained excessively pro-cyclical, not providing sufficient fiscal buffers against country-specific shocks. In addition, the doom loop between banks and their sovereigns, together with strong financial linkages across countries, allowed country-specific shocks to turn into systemic ones. Considerable cross-country spillovers and contagion from country-specific shocks and policies underlined the lack of sufficient risk-sharing mechanisms, both private and public, in the euro area.

In a monetary union where member countries give up independent monetary policy and irrevocably fix the nominal exchange rates vis-à-vis the other members, the macroeconomic adjustment toolkit shrinks and other channels to mitigate crises become necessary to replace the missing policy instruments. Since cross-border labour mobility remains low, private risk sharing in Europe usually takes place through cross-border flows of capital and

credit. International capital flows lead to more geographically diversified portfolios that are less correlated with domestic income, while cross-border credit flows facilitate consumption smoothing in the aftermath of a country-specific shock. Despite recent progress with the banking and capital markets unions, financial intermediation in Europe is primarily bank based and financial markets remain fragmented along national lines. As a result of this fragmentation, the level of private risk-sharing compared to federations like the United States, Canada or Germany tends to be considerably lower and biased towards domestic credit, rather than capital flows (Allard et al., 2013). Moreover, the risk sharing through the bank lending channel tends to break down in period of crisis, exactly when needed the most (Furceri and Zdzienicka, 2015).

Public risk sharing, which usually takes place through taxes and transfers, is virtually non-existent at the euro area and the EU levels. Federal states typically allocate significant resources at the federal level, with regional spending just below 50% of the total (and some 75% in Canada). In comparison, the EU budget represents about 2% of member states total expenditure, while the ESM's lending capacity of EUR 500 billion represents about 10% of the euro area countries' combined budgets. These tools are much smaller than usual in federations and neither of them is specifically meant for macroeconomic stabilisation.

At the European level, a common fiscal stabilisation capacity may address both asymmetric and area-wide shocks. For country-specific shocks, the national budget stabilisers may be constrained by the lack of fiscal space or high marginal borrowing costs. Although area-wide shocks could, in principle, be stabilised through a more accommodative monetary policy stance, monetary policy can usefully be complemented with fiscal policy, especially at the zero lower bound. Moreover, weak economic growth in the euro area and especially the weak inflation suggests that nominal interest rates may stay close to zero for a prolonged period of time. Similarly, the global neutral rate may remain low, perhaps around 1%, in the medium to long term, reflecting wide-ranging shifts in saving and investment preferences, and making monetary policy more frequently constrained by the zero lower

bound (Rachel et al., 2017).

The idea of complementing the monetary union in Europe with some form of fiscal federalism can be traced back to the MacDougall Report suggesting a community budget of at least 2-2.5% of GDP and other measures, including a common unemployment fund (MacDougall, 1977). More recently, the Five Presidents Report highlighted the key characteristics for such a scheme: it should not lead to permanent transfers between countries, it should not undermine the incentives for sound fiscal policy-making at the national level, it should be consistent with the existing EU fiscal framework and it should not be an instrument for crisis management (Juncker et al., 2015). The fiscal stabilisation instrument would help increase the resilience of the euro area and make future interventions by the ESM less likely.

Our paper contributes to the literature by explicitly modeling the stabilisation gains from a euro area unemployment benefit scheme (EUBS) when nominal interest rates are at zero. In normal times, the European Central Bank reacts to the area-wide inflation rate, so its reaction to a negative demand shock is not strong enough to fully offset the crisis in a given country if the shock is asymmetric. At the zero lower bound, the amount of stabilisation that monetary policy can deliver is reduced further, as the central bank cannot decrease the area-wide nominal interest rate below zero. With constrained monetary policy, additional fiscal integration is likely to improve macroeconomic outcomes.

More specifically, the present paper assesses whether a euro area unemployment insurance scheme can improve stabilisation in the presence of asymmetric shocks and a zero lower bound (ZLB) on monetary policy. We build a two-country general equilibrium model (core and periphery) with job market frictions and calibrate it to match the most important macroeconomic characteristics of the euro area. We then simulate three scenarios: one without the constraint on monetary policy and without transfers, a second one where we introduce the zero lower bound constraint (ZLB), and finally a third where we implement

both the ZLB and the transfers. Our results suggest that the unemployment insurance scheme could mitigate about a fifth of the drop in the periphery output caused by a negative demand shock. For a shock that would bring its GDP down by -1.6% compared to the steady-state, at the ZLB, transfers would limit the fall in periphery GDP to -1.2% only. When the shock hits, transfers received would amount to about 1.2% of GDP. Combined with stabilization also happening in the core, the fall in union output would be reduced from -0.5% to -0.3% of GDP. The effectiveness of the EUBS stems from the presence in the economy of households cut from financial markets, unable to save or borrow. The impossibility for a significant share of consumers to access financial markets has been documented empirically by Campbell and Mankiw (1989). In our model, the EUBS mitigates the crisis as it distributes fiscal transfers to financially constrained households, raising their current disposable income. Hence our paper provides a rationale for a fiscal capacity supporting households directly when some of them face financial constraints.

Additionally, we study an alternative scenario where the periphery government is cut from financial markets and cannot issue debt. The negative shock is amplified as the government has to increase the national tax pro-cyclically to finance benefits due to the rise in unemployment. When activating the EUBS, 1.5% of GDP in transfers are distributed to households. Consumption is upheld as described above, which yields an additional benefit when the government is financially constrained.

The rest of the paper is structured as follows: Section 2 reviews the literature on risk sharing in a monetary union, the propagation of macroeconomic shocks at the ZLB and on unemployment insurance. Section 3 presents the building blocks of the model while Section 4 discussed the calibration. Section 5 provides the results of model simulations and discusses the stabilisation gains from the common unemployment benefits scheme. Section 6 outlines several avenues for future work and concludes.

## 2 Related literature

Joining a monetary union brings both benefits, such as reduction in trade costs and elimination of exchange rate risk, and costs, mainly in terms of imperfect macroeconomic stabilisation (Mundell, 1961b; Kenen, 1969). The cost-benefit assessment of a shared currency may be endogenous to the past steps toward economic integration (Frankel and Rose, 1998). Although the degree of business cycle synchronisation may increase as the track record of economic integration lengthens, the loss of independent monetary policy and nominal exchange rate flexibility is likely to be costly even after a long period of trade integration, especially if not accompanied by increased labour mobility and other risk sharing mechanisms (Bayoumi et al., 1994).

The literature on risk sharing usually distinguishes between public risk sharing in the form of taxes and transfers, and private risk sharing, either in the form of cross-border borrowing and lending (savings channel) or international portfolio diversification (capital market channel). The empirical studies of the risk sharing channels in federal systems show important heterogeneity among countries. For the United States, Asdrubali et al. (1996) find that between 1963 and 1990 some 75% of the shocks to per capita state gross product are smoothed, mainly through capital and credit markets, at 39% and 23% respectively, while fiscal transfers from the federal budget only smooth out 13% of the output shocks. For European countries, less than a half of the GDP shocks between 1966 and 1990 were smoothed, roughly one half by fiscal transfers and another half by private savings (Sørensen and Yosha, 1998).<sup>1</sup> Further studies of European Union countries confirmed that only 30% to 40% of GDP shocks are smoothed, mainly by social benefits (Afonso and Furceri, 2008). If anything, risk sharing in the euro area seems to have deteriorated in the aftermath of the financial crisis when more than 70% of shocks remained unsmoothed (Milano and Reichlin, 2017; ECB, 2017). Still, the financial assistance instruments introduced during the European sovereign debt crisis probably increased the euro areas risk sharing capacity

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<sup>1</sup>In the study of Sørensen and Yosha (1998), European countries included in the sample are Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands and the United Kingdom.



(Cimadomo et al., 2017).

The importance of public risk sharing channels, such as a common fiscal stabilisation function, is still being disputed but the arguments in support seem stronger in a monetary union. Private risk sharing may not be enough when agents insufficiently internalise the social benefits from international risk sharing, while the reality of incomplete financial markets makes the case for public risk sharing arrangement even stronger (Farhi and Werning, 2017). A similar rationale for a common fiscal instrument is the existence of spillovers from fiscal policy in one country to other countries in a monetary union (Alcidi et al., 2016).

European unemployment insurance system as a cross-country temporary transfer scheme has been given increased attention (Dullien, 2014; Beblavý et al., 2017; Dolls et al., 2018). Unemployment benefits can be effective at upholding consumption as they quickly replace lost income and react shiftily to the cycle, and they also target households with a high propensity to consume. In the case of asymmetric shocks, governments may become liquidity constrained or face spiking marginal borrowing costs in times of sovereign stress. Furthermore, the current system of European fiscal rules does not provide strong incentives to cut deficits or, as in case of Ireland and Spain, to sustain large surpluses in good times (Dullien, 2017). According to Allard et al. (2013), with pay-outs limited to asymmetric temporary shocks to GDP, a euro area rainy-day stabilisation fund created in 1999 could have raised the overall level of income shock smoothing to 80% (roughly, the level in Germany), at the cost of annual contributions ranging from 1.5 to 2.5% of GNP. Moreover, in the case of common negative shocks, the stabilisation properties of the unemployment insurance scheme may usefully be enhanced by the ability to issue debt. An unemployment insurance scheme with borrowing capacity and annual average total payments of 0.1% of euro area GDP can provide smoothing of shocks comparable to that provided by federal budgets (Carnot et al., 2017).

As far as they have implications for price stability, common shocks in a monetary

union would normally be stabilised by monetary policy. However, in periods when it is constrained by the zero lower bound, coordinated fiscal support may be an important part of the policy mix. Even if unconventional monetary policy provides additional accommodation, the effectiveness of unconventional measures may be limited and have distributional consequences (Orphanides, 2017). Fiscal policy measures that stimulate aggregate demand, such as a temporary increase in government spending, are associated with higher multipliers in recession and at the zero lower bound (Auerbach and Gorodnichenko, 2012; Eggertsson, 2011), although the magnitude of the effect seems to be reduced when the expectations about monetary policy are more forward-looking (Swanson and Williams, 2014; Hills and Nakata, 2014).

In general, an unemployment insurance scheme faces a trade-off between the provision of insurance and negative effects on incentives. In a dynamic setting, Hopenhayn and Nicolini (2009) argue for a benefit policy which takes into account the length of past unemployment spells. In particular, benefits should be tapered over time and decrease with the length of the unemployment spell to increase the cost of job search. Moreover, there is an argument in favor of countercyclical benefits i.e. benefits increasing in bad times, since the moral hazard costs of insurance tend to be lower in times of high unemployment (Kroft and Notowidigdo, 2011; Landais et al., 2013). With direct relevance for our paper, the presence of the zero lower bound constraint seems to modify the labour market dynamics (Albertini and Poirier, 2015b). The inflationary pressure induced by the extension of unemployment benefits in the U.S. in 2008 when nominal interest rates were close to zero, has reduced the real interest rate and partly offset the negative job search and matching effects from higher wages, resulting in reduced unemployment rate.

### 3 Model

Our model is built as a general equilibrium set-up with price and labour market frictions. The model consists in a DSGE model including features and assumptions standard with respect to the literature on currency unions, for example from Galí and Monacelli (2008) or

Engler and Voigts (2013). We add a fiscal capacity with borrowing as the novelty for our paper, but apart from this innovation, the specification for the different sectors is typical and do not drive the results presented below.

The economy consists in a two-country monetary union: we label the first country the core and the second the periphery. Both countries have the same structure and only differ by the value of their parameters, so we only derive equations for the core economy and label periphery variables or parameters with a star when needed. Each country is inhabited by a continuum of households some with access to financial markets and others not, by final and intermediate-sector firms, and by a government in the form of an unemployment agency. Monetary policy is set by a common central bank, with a ZLB constraint. We add to this standard modelling a supra-national entity in the form of a European unemployment insurance scheme. Variables related to the supranational layer are labelled with an  $e$ .

### 3.1 Labor markets

Workers flow in and out of unemployment, with labour markets being subject to search and matching frictions à la Mortensen and Pissarides (1999). As both household types, defined below, face the same probability of being hired (firms do not discriminate across household types), we do not need to specify household-specific labour market variables. In period  $t$ , firms post vacancies  $v_t$  at a cost and all workers who ended the last period unemployed  $u_{t-1}$  search for a job. Firms and searching workers are matched according to the following Cobb-Douglas matching function:

$$m_t = \kappa^m u_{t-1}^\eta (v_t)^{1-\eta} \quad (1)$$

where  $0 < \kappa^m < 1$  represents the matching efficiency and  $0 < \eta < 1$  denotes the matching elasticity with respect to unemployment.

Normalizing total labour force to one, the employment rate at the end of period  $t$  is equal to  $n_t = 1 - u_t$ . We assume for simplicity constant search effort, fixed number of

working hours and no discouraged workers. Defining labour market tightness as  $\theta_t = \frac{v_t}{u_{t-1}}$ , the job finding rate for workers writes  $f_t = \frac{m_t}{u_{t-1}} = \kappa^m \theta_t^{1-\eta}$  and the vacancy filling rate for firms writes  $q_t = \frac{m_t}{v_t} = \kappa^m \theta_t^{-\eta}$ .

Finally, workers are separated each period at the exogenous rate  $0 < s < 1$ . It follows that the number of employed workers in period  $t$  is equal to those employed at the end of last period, minus those who are separated, plus the new matches for the current period. Hence the law of motion for employment writes:

$$n_t = (1 - s)n_{t-1} + m_t, \quad (2)$$

We assume no labour mobility across countries, shutting down this channel of international risk-sharing.

### 3.2 Households

The core and the periphery are inhabited by a mass  $\omega$  and  $1 - \omega$  of households respectively, with  $0 < \omega < 1$ , so that the total size of the union is normalized to one.

In line with the large family approach, each household is made of a continuum of members, either employed or unemployed, who pool their income to self-insure against unemployment risk. Following Galí et al. (2007), a fraction  $\mu \in [0, 1]$  of these households, labelled with an  $r$  for “Rule-of-thumb”, is cut from financial markets and cannot trade in bonds to smooth consumption. The other fraction  $(1 - \mu) \in [0, 1]$  is made of households able to save and borrow for consumption-smoothing purposes, labelled with an  $o$  for Optimizers. Hence, there exists some degree of private risk-sharing between the two countries, as some households can access credit markets to face idiosyncratic shocks. However, private risk-sharing is imperfect: first, because the bonds available to the households are non-contingent with respect to the state of the economy and, second, because a significant fraction of households do not have access to financial markets.

By choosing a sequence  $\{c_t^o, H_{t+1}^o\}_{t=0}^\infty$ , where  $c_t^o$  and  $H_{t+1}^o$  denote per optimizing household consumption and end-of-year holdings of nominal bonds respectively, each optimizing household maximizes the following lifetime utility :

$$E_0 \sum_{t=0}^{\infty} \left( \prod_{i=0}^t \beta_i \right) \frac{(c_t^o)^{1-\gamma}}{1-\gamma} \quad (3)$$

where  $E_0$  is the expectation operator at time  $t$  and  $\beta_i$  represents a discount factor shock, with  $\beta$  in the steady-state. The discount factor shock follows an autoregressive process with mean  $\beta$ , defined as such:

$$\log \beta_t = \rho^\beta \log \beta_{t-1} + (1 - \rho^\beta) \log \beta + \epsilon_t^\beta \quad (4)$$

where  $\rho^\beta$  is a persistence parameters between 0 and 1 and  $\epsilon_t^\beta$  is a white noise process with zero mean and constant variance  $(\sigma^\beta)^2$ .

Optimizers are subject to the following budget constraint written in real terms, per optimizing household:

$$c_t^o + \frac{H_{t+1}^o}{P_t} = (1 + i_t) \frac{H_t^o}{P_t} + w_t n_t + b u_t + \frac{Tr_t}{P_t} - \tau_t + \Delta_t^o \quad (5)$$

Among the household members,  $n_t$  employed receive real wage  $w_t$  from their supply of labour in the production process while  $u_t$  unemployed at the end of  $t$  receive real unemployment benefits  $b$ . We only consider a constant benefit policy: real per unemployed benefits are treated as a parameter.  $i_t$  is the nominal union-wide interest rate set by the central bank, and  $P_t$  the core consumer price index (CPI). Moreover, optimizing households receive real profits  $\Delta_t^o$  as they own the firms, and they also pay lump-sum taxes  $\tau_t$ . Finally, they receive nominal transfers from the European unemployment insurance scheme,  $Tr_t$  defined below.

Members of Rule-of-thumb households also pool their income, but they do not have access to financial markets to insure themselves against shocks. They just consume their current disposable income, made of wage and unemployment benefits net of taxes, plus transfers. Hence per RoT household consumption  $c_t^r$  follows the budget constraint:

$$c_t^r = w_t n_t + b u_t - \tau_t + \frac{Tr_t}{P_t} \quad (6)$$

Households derive utility from the consumption of a basket of domestic and foreign-produced goods, taking the form of CES aggregate of imperfect substitutes:

$$c_t^i = \left[ \Psi (c_t^{i,c})^\sigma + (1 - \Psi) (c_t^{i,p})^\sigma \right]^{\frac{1}{\sigma}} \quad (7)$$

with  $i \in o, r$  where  $c_t^{i,c}$  and  $c_t^{i,p}$  denote consumption of final core and periphery goods respectively by core households,  $0 < \Psi < 1$  the degree of home bias (the relative valuation of core products for the core consumption basket) and  $\sigma > 0$  the inverse elasticity of substitution between core and periphery goods. Trade is a channel of cross-country risk-sharing as households can switch expenditure between the two goods in reaction to price changes, but an imperfect one as the two goods are imperfect substitutes with some degree of home bias. Expressions for CPI as well as consumption shares in the basket read:

$$P_t = \left[ \Psi^{\frac{1}{1-\sigma}} (p_t^c)^{\frac{\sigma}{\sigma-1}} + (1 - \Psi)^{\frac{1}{1-\sigma}} (p_t^p)^{\frac{\sigma}{\sigma-1}} \right]^{\frac{\sigma-1}{\sigma}} \quad (8)$$

$$\frac{c_t^{i,c}}{c_t} = \Psi^{\frac{1}{1-\sigma}} \left( \frac{p_t^c}{P_t} \right)^{\frac{1}{\sigma-1}} \quad (9)$$

$$\frac{c_t^{i,p}}{c_t} = (1 - \Psi)^{\frac{1}{1-\sigma}} \left( \frac{p_t^p}{P_t} \right)^{\frac{1}{\sigma-1}} \quad (10)$$

where  $p_t^c$  and  $p_t^p$  are the prices of the final core and periphery goods respectively.

At optimum, optimizing household consumption is determined by the following Euler equation:

$$\lambda_t^o = E_t \beta_{t+1} \lambda_{t+1}^o \frac{1 + i_{t+1}}{\Pi_{t+1}} \quad (11)$$

where  $\Pi_t = \frac{P_t}{P_{t-1}}$  is the gross rate of CPI inflation and  $\lambda_t^o = (c_t^o)^{-\sigma}$  the marginal utility for optimizing households. Similarly, marginal utility for RoT consumers writes  $\lambda_t^r = (c_t^r)^{-\sigma}$ .

Finally, we can write the marginal value of having an unemployed member turning employed (hence the marginal value of a match for the worker) in type- $i$  household as:

$$W_t^i = w_t - b + E_t \beta_{t+1} \frac{\lambda_{t+1}^i}{\lambda_t^i} (1 - s - f_{t+1}) W_{t+1}^i \quad (12)$$

Marginal value  $W_t^i$  is made of two terms. First, the real wage net of unemployment benefits that this member is no longer eligible to. The second term is a continuation value made of that same marginal value of a match one period ahead  $W_{t+1}^i$ , discounted, and corrected for  $s$  in case the match separates and for  $f_{t+1}$  since the same match cannot be formed next period.

### 3.3 Firms

The production side comprises an intermediate and a final good sector. A representative firm in the final good sector operates a frictionless technology by bundling a variety of intermediate products, so that final good production follows:

$$y_t = \left( \int_0^1 y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \quad (13)$$

where  $y_t(j)$  represents the demand for intermediate input from firm  $j$  in the intermediate sector, and  $\epsilon > 1$  the elasticity of substitution between these intermediate inputs. All inputs are domestic without trade in intermediate goods. The maximization problem of the final good firm yields the relative demand for input  $j$  as well as the final good price as functions of intermediate price input  $p_t(j)$ :

$$\frac{y_t(j)}{y_t} = \left( \frac{p_t(j)}{p_t^c} \right)^{-\epsilon} \quad (14)$$

$$p_t^c = \int_0^1 p_t(j)^{1-\epsilon} dj \quad (15)$$

Firms in the intermediate sector use labour as input for production with the same productivity  $a_t$  following:

$$y_t(j) = a_t n_t(j) \quad (16)$$

where  $a_t$  is the country-specific aggregate technology shock, with  $a_t = a$  in the steady-state. The productivity shock follows an autoregressive process with mean  $a$ , defined as such:

$$\log a_t = \rho^a \log a_{t-1} + (1 - \rho^a) \log a + \epsilon_t^a \quad (17)$$

where  $\rho^a$  is a persistence parameters between 0 and 1 and  $\epsilon_t^a$  is a white noise process with zero mean and constant variance  $(\sigma^a)^2$ .

Intermediary firms face vacancy costs when they search for workers and quadratic price adjustment costs as in Rotemberg (1982), so that their profit function reads in real terms:

$$\Delta_t(j) = \frac{p_t(j)}{p_t^c} y_t(j) - w_t n_t(j) - \kappa^v v_t(j) - \Phi_t^\pi(j) \quad (18)$$

where  $\Phi_t^\pi(j) = \frac{\kappa^\pi}{2} \left( \frac{p_t(j)}{p_{t-1}(j)} - 1 \right)^2 y_t(j)$  represents the real Rotemberg price costs, with vacancy and price cost parameters  $0 < \kappa^v < 1$  and  $0 < \kappa^\pi < 1$ . Intermediate firms choose employment, vacancies and prices so as to maximize their profits (18), taking into account the employment law of motion (2), the relative input demand function (14) and the production function (16). Maximization implies that at optimum firms post vacancies according to the following job creation condition:

$$\frac{\kappa^v}{q_t} = a_t m c_t - w_t + (1-s) E_t \beta_{t+1} \frac{\lambda_{t+1}^o}{\lambda_t^o} \frac{\kappa^v}{q_{t+1}} \quad (19)$$

where  $m c_t$  denotes the Lagrange multiplier on equation (14) in the program, in other words the marginal costs of the firms. According to this condition, at equilibrium, firms post vacancies until the current marginal cost of a vacancy (left-hand side) equals the marginal benefit of a match (right-hand side). This marginal benefit is comprised of the marginal product net of wage, plus a continuation value (that same cost one period ahead, discounted, provided the match does not separate). We also obtain the following New-Keynesian Philipps curve which links current inflation to expectations of future inflation and output growth:

$$m c_t = \frac{\epsilon - 1}{\epsilon} + \frac{\kappa^\pi}{\epsilon} \pi_t^c (\pi_t^c - 1) - \frac{\kappa^\pi}{\epsilon} E_t \beta_{t+1} \frac{\lambda_{t+1}^o}{\lambda_t^o} \pi_{t+1}^c (\pi_{t+1}^c - 1) \frac{y_{t+1}}{y_t} \quad (20)$$

where  $\pi_t^c = \frac{p_t^c}{p_{t-1}^c}$  is the gross rate of inflation for core product price. Note that we have dropped the  $j$  subscripts after the maximization as all intermediate firms are identical, and we can also write  $n_t = \int_0^1 n_t(j) dj$  and  $v_t = \int_0^1 v_t(j) dj$ . Terms in equations (19) and (20), obtained from the firm's maximization problem, are discounted with optimizing households' marginal utility as they own the firms.



### 3.4 Wage

The equilibrium wage is determined through a Nash-bargaining process, in which workers and firms share the marginal surplus of a match depending on worker bargaining power  $0 < \zeta < 1$ . The optimal split yields the following wage schedule:

$$\tilde{w}_t = \zeta \underbrace{\left[ a_t m c_t + (1-s) E_t \beta_{t+1} \frac{\lambda_{t+1}^o}{\lambda_t^o} \frac{\kappa^v}{q_{t+1}} \right]}_{\text{surplus from match}} + (1-\zeta) \underbrace{\left[ b - E_t \beta_{t+1} (1-s-f_{t+1}) \left( \mu \frac{\lambda_{t+1}^r}{\lambda_t^r} W_{t+1}^r + (1-\mu) \frac{\lambda_{t+1}^o}{\lambda_t^o} W_{t+1}^o \right) \right]}_{\text{outside option}} \quad (21)$$

where  $\tilde{w}_t$  is the Nash-bargaining wage. According to this rule, for the supply of labour, the worker obtains a share of the firms surplus from a match and a share of an outside option (unemployment benefits net of the average marginal utility of becoming employed). However, following Hall (2005), we introduce some real wage rigidity on top of search and matching frictions to better reproduce cyclical variations in employment and vacancies, addressing a typical issue of search and matching models known as the Shimer puzzle (Shimer, 2005).<sup>2</sup> We implement a wage norm to prevent instantaneous wage adjustments to economic shocks. As in Albertini and Fairise (2013b), the wage norm is set as the steady-state wage, and the real wage in our model follows a weighted average of the Nash-bargaining  $\tilde{w}_t$  and norm  $\bar{w}$  wage levels, with a rigidity parameter  $0 < \nu < 1$ :

$$w_t = (1-\nu)\tilde{w}_t + \nu\bar{w} \quad (22)$$

### 3.5 Governments

In each country, a national government levies lump-sum taxes on households  $\tau_t$  and issues nominal debt  $D_t$  to finance unemployment benefits. The government does not incur other expenditure than these benefits  $b$ . As optimizing households own the firms, they incur price adjustment costs  $\Phi_t^\pi$ . To neutralize the business cycle effect of price adjustment costs, the

<sup>2</sup>The Shimer puzzle refers to the inability of standard search and matching models to account for the fluctuations in the unemployment rate observed in the data.

national government rebates them to optimizing households. Hence the government budget constraint follows in real per capita terms:

$$\tau_t + \frac{D_{t+1}}{P_t} = (1 + i_t) \frac{D_t}{P_t} + bu_t - (1 - \mu) \Phi_t^\pi \quad (23)$$

The national tax rule comprises a counter-cyclical and a debt stabilization component:

$$\tau_t - \bar{\tau} = \phi^y (y_t - \bar{y}) + \phi^d \left( \frac{D_t}{P_t} - \frac{\bar{D}}{\bar{P}} \right) \quad (24)$$

where variables with an upper bar denote steady-state levels and  $\phi^y, \phi^d$  are policy parameters.

In our alternative scenario where the periphery government is cut from financial markets and cannot issue debt, the budget constraint (23) and the tax rule (24) equations are replaced by the following for the periphery:

$$\tau_t^* = b^* u_t^* - (1 - \mu^*) \Phi_t^{\pi^*} \quad (25)$$

$$D_t^* = 0 \quad (26)$$

On top of national governments, a European fund can organize per-capita transfers ( $Tr_t, Tr_t^*$ ) (which can be negative). Real transfers flowing from the European fund are pinned down to changes in unemployment:

$$\frac{Tr_t}{P_t y_t} = \phi^{stab} (u_t - \bar{u}) - \phi^{de} \left( \frac{D_t^e}{P_t} - \frac{\bar{D}^e}{\bar{P}} \right) \quad (27)$$

with  $0 < \phi^{stab} < 1$  representing a policy parameter for the stabilization delivered by the scheme. The higher this parameter, the higher the transfers when unemployment deviates from its steady-state value. The rule above also comprises a debt stabilization component scaled by  $0 < \phi^{de} < 1$  for the debt that the scheme issues  $D_t^e$ , to finance these transfers. This rule ensures that transfers are null at the steady-state: as long as there are no cyclical fluctuations (without shock, at the steady-state), the fund is inactive so that transfers are only temporary. The rule for the periphery reads:

$$\frac{Tr_t^*}{P_t^* y_t^*} = \phi^{stab} (u_t^* - \bar{u}^*) - \phi^{de} \left( \frac{D_t^e}{P_t^*} - \frac{\bar{D}^e}{\bar{P}^*} \right) \quad (28)$$

Written as such, the tax rule at the supra-national level conveys a channel of fiscal risk-sharing. Indeed, the debt stabilization component is common to the rule of each country, the last term of (27) and (28). This means that both countries contribute to the repayment of the supranational debt, whether or not this debt was issued to stabilize a shock at home or in the other country. The budget constraint for the European fund writes in nominal terms:

$$D_{t+1}^e = (1 + i_t)D_t^e + \omega Tr_t + (1 - \omega)Tr_t^* \quad (29)$$

Finally, the central bank sets the union-wide interest rate according a standard Taylor rule, although bounded by the ZLB, to stabilize the average inflation rate of the union  $\Pi_t^u = \omega\Pi_t + (1 - \omega)\Pi_t^*$ . We have:

$$1 + i_t = \begin{cases} \frac{\bar{\Pi}}{\beta} \left( \frac{\Pi_t^u}{\bar{\Pi}} \right)^{\phi^{cb}} & \text{if } i_t > 0 \\ 1 & \text{otherwise} \end{cases} \quad (30)$$

where  $\phi^{cb} > 1$  is the strength with which the central bank reacts to changes in union inflation and  $\bar{\Pi}$  is its target inflation rate.

### 3.6 Market clearing

To close the model, we need to perform aggregation  $c_t = \mu c_t^r + (1 - \mu)c_t^o$ ,  $c_t^c = \mu c_t^{r,c} + (1 - \mu)c_t^{o,c}$ ,  $c_t^p = \mu c_t^{r,p} + (1 - \mu)c_t^{o,p}$ ,  $H_t = (1 - \mu)H_t^o$  and  $\Delta_t = (1 - \mu)\Delta_t^o$ . The financial market equilibrium reads  $\omega(1 - \mu)H_t + (1 - \omega)(1 - \mu^*)H_t^* = \omega D_t + (1 - \omega)D_t^* + D_t^e$ . Finally, according to the equilibrium of the balance of payments, the financial account must be equal to the opposite of the current account. The current account is made of the trade balance, plus interests on net savings of the country, plus transfers. Hence we can write:

$$\omega [H_{t+1} - D_{t+1} - (1 + i_t)(H_t - D_t)] = (1 - \omega)p_t^c c_t^{c*} - \omega p_t^p c_t^p + \omega Tr_t \quad (31)$$

Finally, market clearing for the core and periphery goods read respectively:

$$\omega(y_t - \kappa^v v_t) = \frac{p_t^c}{P_t} [\omega c_t^c + (1 - \omega)c_t^{c*}] \quad (32)$$

$$(1 - \omega)(y_t^* - \kappa^{v^*} v_t^*) = \frac{p_t^p}{P_t^*} [\omega c_t^p + (1 - \omega) c_t^{p^*}] \quad (33)$$

## 4 Calibration

### 4.1 Euro area calibration

The calibration draws on standard parameter values from the DSGE and search and matching literature, as well as key data facts for the euro area.<sup>3</sup> Calibration is documented in Table 2 in Appendix. Time periods are quarters. The core comprises Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands, while the periphery includes Greece, Ireland, Italy, Portugal and Spain. The relative size of the core is set to  $\omega = 0.61$ . The steady-state discount factor is equal to  $\beta = 0.994$  and the central bank target for inflation is  $\bar{\Pi} = 1.005$  so that the annualized steady-state interest rate settles at 4.4%. The risk aversion coefficient is the same for both countries,  $\gamma = \gamma^* = 1.5$ , as is the elasticity of substitution between core and periphery goods  $\sigma = \sigma^* = 0.904$ . The degree of wage rigidity is set to  $v = 0.2$  and  $v^* = 0.15$  to reflect relatively more rigid wages in the periphery than in the core. Following the empirical literature, we set the share of RoT households in the core and the periphery to a half such that  $\mu = \mu^* = 0.5$  (Campbell and Mankiw, 1989).

Turning to labour market frictions, steady-state employment, job finding and vacancy filling probabilities are targeted to compute the matching efficiency, the vacancy cost and steady-state vacancies, with  $\bar{n} = 0.921$ ,  $\bar{f} = 0.3$  and  $\bar{q} = 0.71$  for the core and  $\bar{n}^* = 0.871$ ,  $\bar{f}^* = 0.29$  and  $\bar{q}^* = 0.73$  for the periphery. The steady-state ratio of vacancies over unemployed workers is higher in the core i.e. we have  $\bar{\theta} > \bar{\theta}^*$ . Also, the core labor market is more efficient than the periphery labor market, with higher matching efficiency ( $\kappa^m = 0.4615$  against  $\kappa^{m^*} = 0.4601$ ), lower vacancy cost as a share of GDP ( $\frac{\kappa^v \bar{v}}{\bar{y}} = 0.29\%$  against  $\frac{\kappa^{v^*} \bar{v}^*}{\bar{y}^*} = 0.43\%$ ) and lower separation rate ( $s = 2.57\%$  against  $s^* = 4.3\%$ ). The matching

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<sup>3</sup>We draw on the calibration from Galí (2008); Christoffel et al. (2009b); Albertini and Fairise (2013b); Moyen and Stähler (2014b); Guerrieri and Iacoviello (2015); Mitman and Rabinovich (2015b). Data from 1995 to 2017 is reported in the Appendix.

elasticity and the worker bargaining power are set equal in both countries,  $\eta = \eta^* = 0.5$  and  $\zeta = \zeta^* = 0.9$  respectively, so that the Hosios condition does not hold.<sup>4</sup> Finally, unemployment benefits are a bit higher in the core than in the periphery,  $b = 0.61$  against  $b^* = 0.58$ .

Price adjustment cost parameter, as well as elasticities of substitution between intermediate inputs are equal to standard values  $\kappa^\pi = \kappa^{\pi^*} = 6$  and  $\epsilon = \epsilon^* = 10$ , respectively. We normalize steady-state per capita output in the core to  $\bar{y} = 1$ , while it is lower in the periphery, equal to  $\bar{y}^* = 0.85$ . The home bias is symmetric between the core and the periphery, with  $\Psi = 0.63 = 1 - \Psi^*$ , to mimic the degree of trade openness based on shares of domestic consumption to GDP. The coefficient on the Taylor rule for inflation stabilization is set to  $\phi^{cb} = 1.5$ . The coefficients on output and debt stabilization for the national tax rule are equal to, respectively,  $\phi^y = \phi^{y^*} = 0.3$  and  $\phi^d = \phi^{d^*} = 0.1$  as in Engler and Voigts (2013). An increase in GDP by 1% increases the national tax by 0.3% and an increase in national real debt by 1% increases the tax by 0.1%.

The stabilization component of the transfer rule  $\phi^{stab}$  is set to 1 in the scenario where transfers are activated and to 0 otherwise. Hence, when there are transfers, a 1ppt increase in the unemployment rate compared to the steady-state implies a 1% of GDP in transfers from the scheme. The coefficient on debt stabilization for the transfer rule is  $\phi^{de} = \phi^{de^*} = 0.05$ , such that for each 1% increase in debt issued by the scheme, the country contribution is raised by 0.05%. The debt stabilization component of the supranational fiscal rule (increasing taxes to when debt rises),  $\phi^{de}$  for core or  $\phi^{de^*}$  for periphery, is set high enough to stabilize the supranational debt. But it is set at a lower level than the debt stabilization component of the national tax rule, as we assume that repayment of the supranational debt would happen at a lower rate than the national one. These coefficients are set somewhat arbitrarily, to strike a balance between stabilization delivered by the scheme and debt convergence in the model. But it should be noted that our results are not

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<sup>4</sup>Hence frictions in the labor market arise due to the positive between-group and the negative within-group of searching workers and firms not balancing out.

		Relative std. dev. to output	
		Model (Data)	Model (Data)
		Core	Periphery
Consumption	$\sigma(c)/\sigma(y)$	0.93(0.69)	0.81(0.94)
Unemployment rate	$\sigma(u)/\sigma(y)$	0.47(0.34)	0.72(0.51)
Real wage	$\sigma(w)/\sigma(y)$	0.42(0.29)	0.22(0.41)

*Second order moments obtained from the unconstrained version of the model without transfers from 1000 draws including all shocks. The table compares steady-state and second moments from the model (quarterly statistics) with empirical observations (annual data).*

**Table 1:** Model steady-state and second moments

impacted qualitatively by the parameters of these fiscal rules, and do not change drastically our quantitative results.

Persistence parameters for the discount factor and productivity are set to standard value of 0.9 for both countries. Then variances for these shocks are set so that productivity and discount shocks are slightly more volatile in the periphery ( $\sigma^{a*} = 0.31$  and  $\sigma^{\beta*} = 0.06$ ) than in the core ( $\sigma^a = 0.25$  and  $\sigma^\beta = 0.04$ )

## 4.2 Second moments of the model

To assess the performance of the model, we rely on a comparison, presented in Table 1, between euro area data and the implied business cycle statistics of the calibrated model.

The model manages to reproduce fairly well the standard deviations of consumption, unemployment and real wage relative to output observed in the euro area core and periphery data. However, consumption and real wage is too volatile for the Core, which could be fixed with the inclusion of additional features such as capital but at the cost of model complexity.

## 5 Simulations

We simulate the behaviour of the calibrated economy in response to an asymmetric demand shock, in the form of a discount factor increase in the periphery. Discount factor hikes have been used in the DSGE literature to mimic negative demand shocks which temporarily depress consumption and output. In our simulations, an unexpected increase in  $\beta$  in the periphery brings the periphery discount factor from 0.994 to 1.015, before decreasing with a 0.9 decay. To solve for the non-linear dynamic model, we use the OccBin toolkit described in Guerrieri and Iacoviello (2015). Results for periphery, core and union-wide variables are reported in Figure 1, 2 and 3, respectively.

### 5.1 Assessing the benefits of the EUBS at the zero lower bound

#### Scenario 0 - Asymmetric negative demand shock without the ZLB

We first analyse a hypothetical case in which the central bank is not constrained by the ZLB and can set its nominal interest rate below 0. The corresponding results are depicted with dashed-dotted black lines in the figures.

In the short run, the increase in the discount factor in the periphery depresses periphery consumption by 1.9% compared to steady-state level. Output and employment decrease in response to the falling demand by 1.1% while the price level drops by 7.7%, compared to steady-state. Union inflation drops to -0.5%, and the central bank reacts by cutting its union-wide annualized interest rate from 1.1% to -0.3%. As it reacts to the union inflation rate, averaged over both countries, this reaction is not enough to fully offset the demand shock in the periphery. On the contrary, the interest rate cut triggers a decrease in the real interest rate in the core. Although the demand for core goods drops in the periphery, the expansionary monetary policy translates into an increase in core consumption (by 1%), as well as slight increases in core output and employment (by 0.5%). At the scale of the union, there are small decreases in aggregate consumption and output, about -0.1%.

**Scenario 1 - Asymmetric negative demand shock with a ZLB**

The periphery negative shock brings the economy to the ZLB for 5 quarters. During that time, the central bank cannot decrease the union-wide nominal interest below 0, reducing the amount of stabilization it can deliver. Results for this scenario are reported with solid lines.

As the interest rate hits the ZLB, the fall in periphery consumption is greater (-2.3%). Hence, the periphery experiences a more severe recession with a bigger fall in output and employment (-1.6%). Also, there is now stronger deflation in the periphery.

The decrease in demand for core goods from the periphery is stronger than in the previous scenario, combined to a lower cut in the nominal interest rate due to the ZLB. Thus, the negative demand shock spreads to the core, where the expansion is almost entirely wiped-out. In the previous scenario, the interest rate cut allows an expansion in the core to offset the negative demand shock in the periphery, so that at the scale of the union, the contraction is limited. In scenario 1, at the ZLB the muted response of the central bank to the demand shock produces a larger recession in the periphery, not compensated by an expansion in the core. In the end, union output and employment fall by -0.5% and consumption falls by -0.4%, which is more than in scenario 0.

**Scenario 2 - Asymmetric negative shock with a ZLB and the EUBS**

We now study the same periphery negative shock, with the ZLB, activating the supranational scheme. Results are plotted with crossed lines.

The fall in employment in the periphery triggers transfers in the size of 1.2% of GDP at the height of the crisis. These transfers flow from the European scheme, which issues debt to finance them. Transfers uphold periphery consumption, which falls by -1.9% compared to steady-state against -2.3% in scenario 1 without transfers. The supported consumption translates into higher periphery output (which falls only by -1.2%). Let us note that



transfers do not impact significantly how fiscal policy is conducted at the national level, with little difference in the periphery national tax dynamics between scenario 2 and 3.

Core output increases by 0.2% as demand for both periphery and core goods from the periphery households is supported by the transfers. As a result, when the shock hits, the core contributes to the fund -0.2% of GDP in negative transfers. Since there is a slight expansion and rise in employment, the core disburses transfers towards the EUBS, due to the stabilization component of the transfer rule.<sup>5</sup>

In the end, at the scale of the union, transfers mitigate the crisis, with aggregate output and consumption falling by -0.3, against -0.5% and -0.4% respectively in scenario 1.

The stabilization power of the scheme depends on the presence of non-Ricardian households who are cut from financial markets in the periphery. Indeed, when distributed to Ricardian households, these transfers are regarded as temporary and saved in expectation of higher taxes to consolidate debt. In other words, through Ricardian equivalence effects, transfers do not change the inter-temporal revenue of these households, having no impact on their consumption. In a case (not shown) without any rule of thumb households in the periphery, the transfers would have no stabilization effect.<sup>6</sup> But as a significant share of households is financially constrained, the EUBS mitigates part of the crisis by supporting current disposable income directly in the form of benefits. This builds the case in favour of a fiscal capacity which targets budget constraints directly in the presence of fragmented financial markets.

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<sup>5</sup>Indeed the negative transfers are not linked to the reimbursement of debt issued by the EUBS, since the transfer rule increases contributions to stabilize the debt with a one year lag. Debt issued in  $t$  is  $D_{t+1}^e$ .

<sup>6</sup>Transfers do impact the inter-temporal revenue of core optimizing households, such that transfers break Ricardian equivalence even without RoT households. Indeed, both countries share the same debt repayment component in their respective transfer rule (27) and (28). Hence, for example, core optimizing households would contribute to the repayment of the debt issued by the EUBS to mitigate a shock hitting the periphery. However, in terms of transferred amounts, only the country-specific stabilization component of the transfer rules really matters for the size of transfers, while the debt repayment component is negligible. In the end, with only optimizing households, scenarios 1 and 2 would be virtually identical.

Hence, the scheme partially offsets the presence of the ZLB and the central bank's inability to mitigate the shock. It provides counter-cyclical fiscal policy in the form of European stabilizers, to the extent that there are "Rule-of-thumb" consumers or other financial market imperfections.

## 5.2 Extension: periphery government cut from financial markets

In this alternative scenario, we study the benefits of the EUBS at the ZLB when, following the negative demand shock originating the periphery, the periphery government is cut from financial markets and cannot issue debt anymore. The national government is now prevented from running its counter-cyclical tax policy, and the national tax adjusts to balance the budget. Formally, equations (23) and (24) are replaced by equations (25) and (26). Let us note that market distress only affects the government as optimizing households in the periphery still have access to financial markets. Results are depicted in Figure 4.

### Alternative scenario 3 - Asymmetric negative shock with a ZLB and financial distress

In scenario 1 described in the section above (scenario with the ZLB and without transfers), the periphery government reacts to the recession by decreasing the national tax by -0.5% to deliver some stabilization at the national level. The counter-cyclical cut in national tax translates into a rise in periphery government debt.

In scenario 3, reported with rounded lines in Figure 4, the periphery government is cut from financial markets. The negative shock produces a drop in periphery output and a proportional rise in unemployment. Hence, more benefits have to be financed by the government but since debt cannot be issued, the national tax has to be increased pro-cyclically. The tax increase of 1.3% hurts RoT consumers, and as a result periphery consumption drops by -2.9% compared to -2.3% in scenario 1 (where the government is not financially constrained). The recession is more severe, with periphery output decreasing by -2.1% against -1.6% in scenario 1. The crisis passes on union output, which decreases

by -0.8% compared to -0.5% in scenario 1.

#### **Alternative scenario 4 - Asymmetric negative shock with a ZLB, financial distress and the EUBS**

In scenario 4, presented with starred lines in Figure 4, we activate transfers from the EUBS as in scenario 2 exposed previously, but now the periphery government is cut from financial markets.

The recession triggers positive transfers flowing from the EUBS, distributed to households. As in scenario 2, transfers are effective at upholding consumption since they increase the current disposable income of RoT households. But in scenario 4, where the periphery government cannot issue debt and increases the national tax to finance benefits, the EUBS brings an additional general equilibrium effect. By supporting demand and mitigating the negative shock, transfers from the EUBS contain the recession and the rise in unemployment. As a result, the periphery government faces less fiscal pressure to finance rising benefits, and the national tax rises by only 0.9% compared to 1.3% in scenario 3. The tax increase remains pro-cyclical, but is diminished when the EUBS is active, increasing further the income of RoT households. The scheme (through its own debt issuance) partially compensates the loss of counter-cyclical fiscal policy at the national level caused by market distress. In the end, periphery consumption and output, as well as union output drop to the levels of scenario 1, such that the EUBS alleviates the costs of market distress.

## **6 Conclusion**

In order to assess potential gains from a euro area unemployment insurance scheme, we have calibrated a two-region DSGE model with supply, demand and labour market frictions, as well as a common unemployment insurance, to simulate the effects of a country-specific negative demand shock in the absence and presence of zero nominal interest rates. The introduction of a zero lower bound adds an additional layer of stabilisation losses to the standard one-size-fits-all monetary policy stabilisation in a monetary union. The

results from the simulation of a negative country-specific demand shock to the periphery suggest that the existence of common unemployment insurance expands the set of policy options, in particular the mix of fiscal and monetary policy at the union level, and improves the macroeconomic stabilisation: transfers associated with the unemployment insurance scheme mitigate the drop in periphery and union output. We also show that the EUBS improves stabilization further if the periphery government is cut from financial markets. The EUBS alleviates the fiscal pressure by mitigating the rise in unemployment, which in return contains the pro-cyclical tax increase caused by the loss of debt issuance.

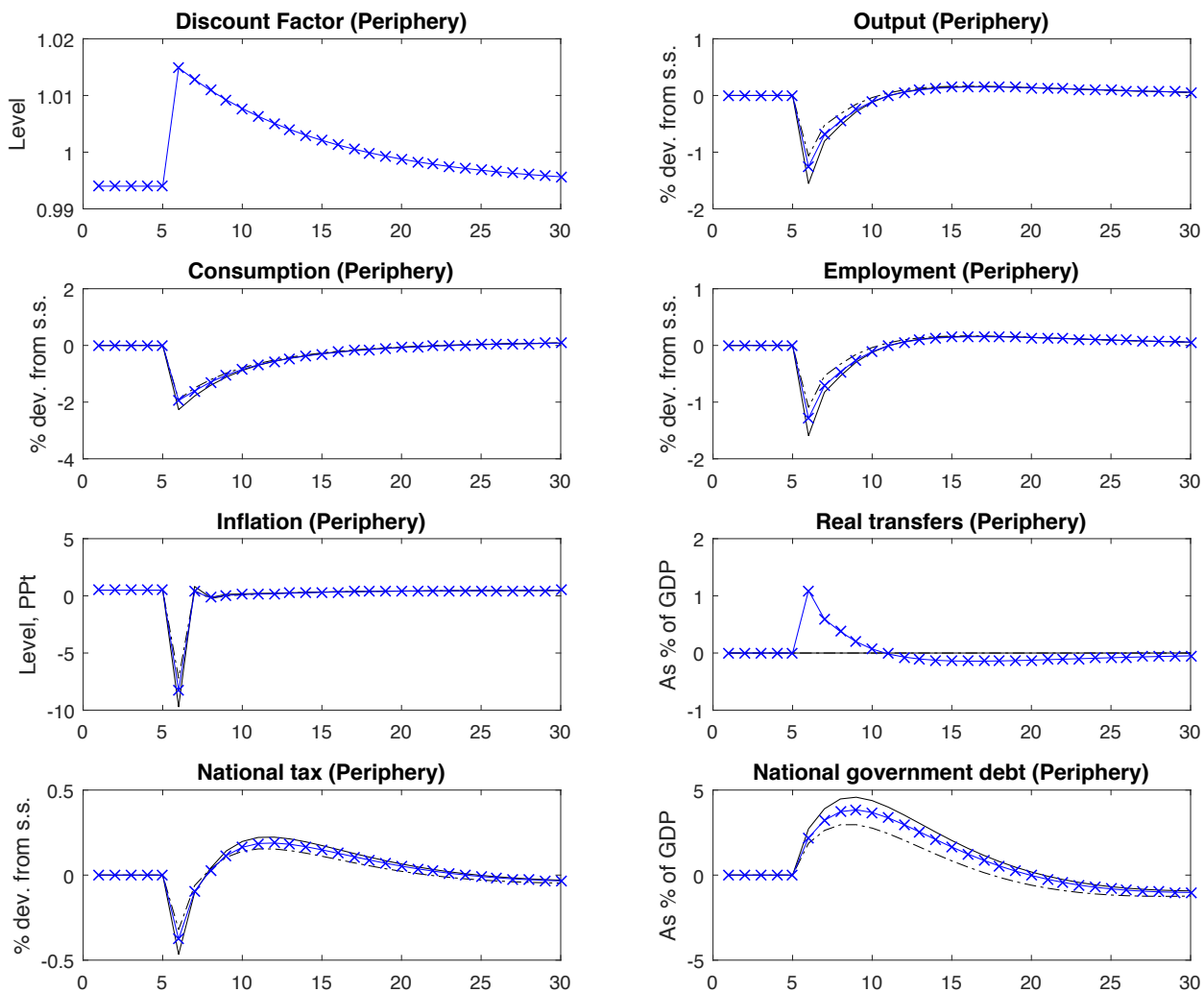
Our analysis could be expanded in two directions. First, the EUBS could be expressed as a reinsurance fund triggered in case of a large shock. Transfers would only flow if unemployment rises above a given threshold, introducing a second occasional binding constraint to the model in addition to the ZLB. Second, strategic interactions between the national and supranational layers of government could be included. Through moral hazard effects, the impact of introducing a European unemployment insurance in terms of how governments insure their workers or carry out reforms to reduce unemployment and improve labor market efficiency could be studied.

## 7 Appendix

Table 2: Calibration

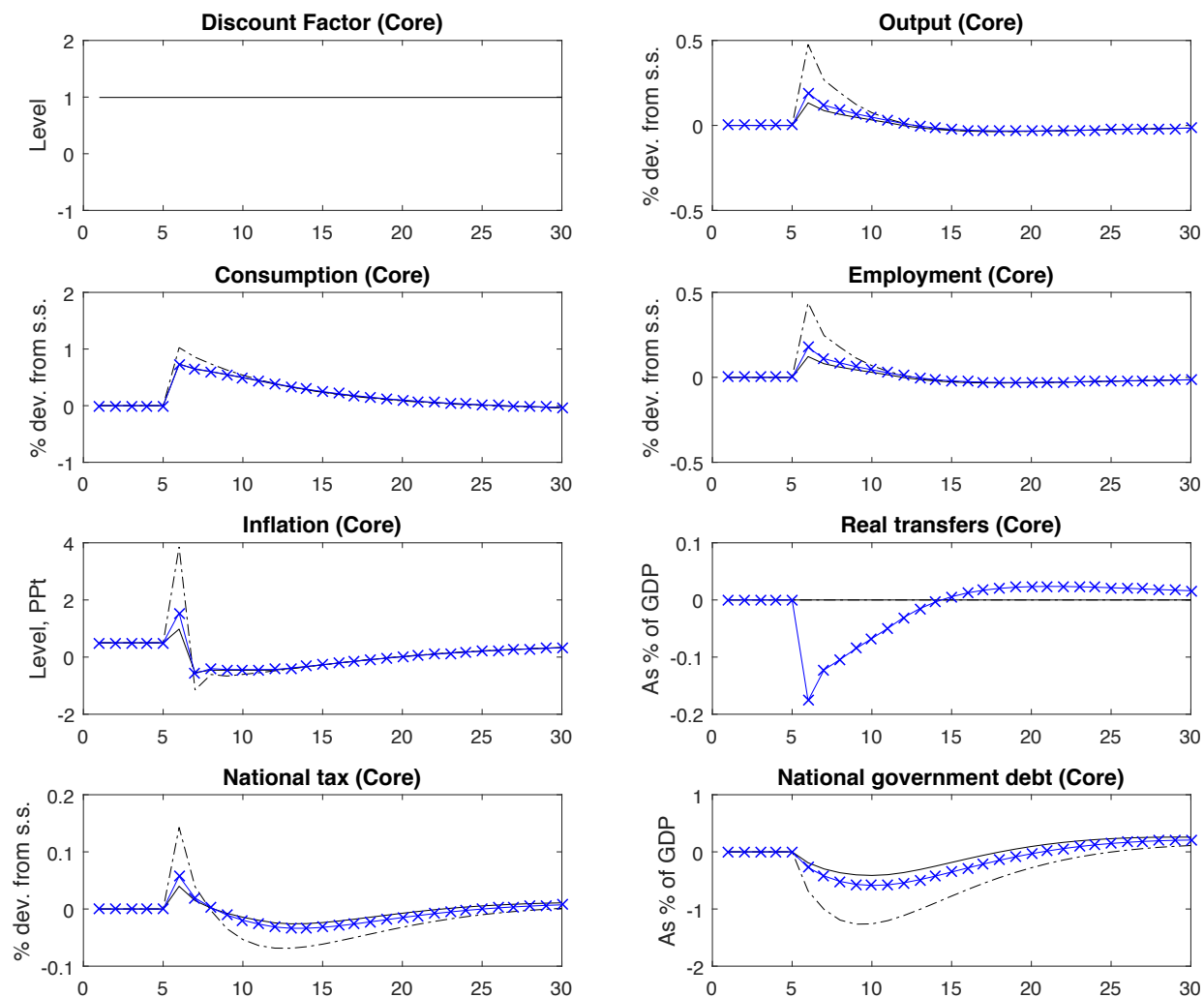
Households and preferences		Core	Periphery
Economic size	$\omega$	0.61	0.39
Discount factor	$\beta$		0.994
Inverse trade elasticity	$\sigma$		0.904
Openness	$\psi$	0.63	0.37
Risk aversion	$\gamma$		1.5
Share of RoT consumers	$\mu$		0.5
Labour markets and wage formation		Core	Periphery
Wage bargaining power	$\zeta$		0.9
Matching elasticity	$\eta$		0.5
Separation rate	$s$	0.0257	0.043
Matching efficiency	$\kappa^m$		0.4583
Wage rigidity	$v$	0.2	0.15
Intermediate firms		Core	Periphery
Productivity	$a$	1.09	0.98
Elasticity of substitution between inputs	$\epsilon$		10
Price adjustment cost	$\kappa^\pi$		6
Vacancy costs	$\kappa^v$	0.0869	0.0707
Governments		Core	Periphery
Unemployment benefits	$b$	0.61	0.58
Coefficient on output (national level)	$\phi^y$		0.3
Coefficient on debt (national level)	$\phi^d$		0.1
Taylor rule	$\phi^{cb}$		1.5
Inflation target	$\bar{\Pi}$		1.005
Stabilization	$\phi^{stab}$		0 or 1
Coefficient on debt (European level)	$\phi^{de}$		0.05
Shocks		Core	Periphery
Productivity shock persistence	$\rho^a$		0.9
Productivity shock variance	$\sigma^a$	0.25	0.31
Demand shock persistence	$\rho^b$		0.9
Demand shock variance	$\sigma^b$	0.04	0.06

Figure 1: Periphery variables



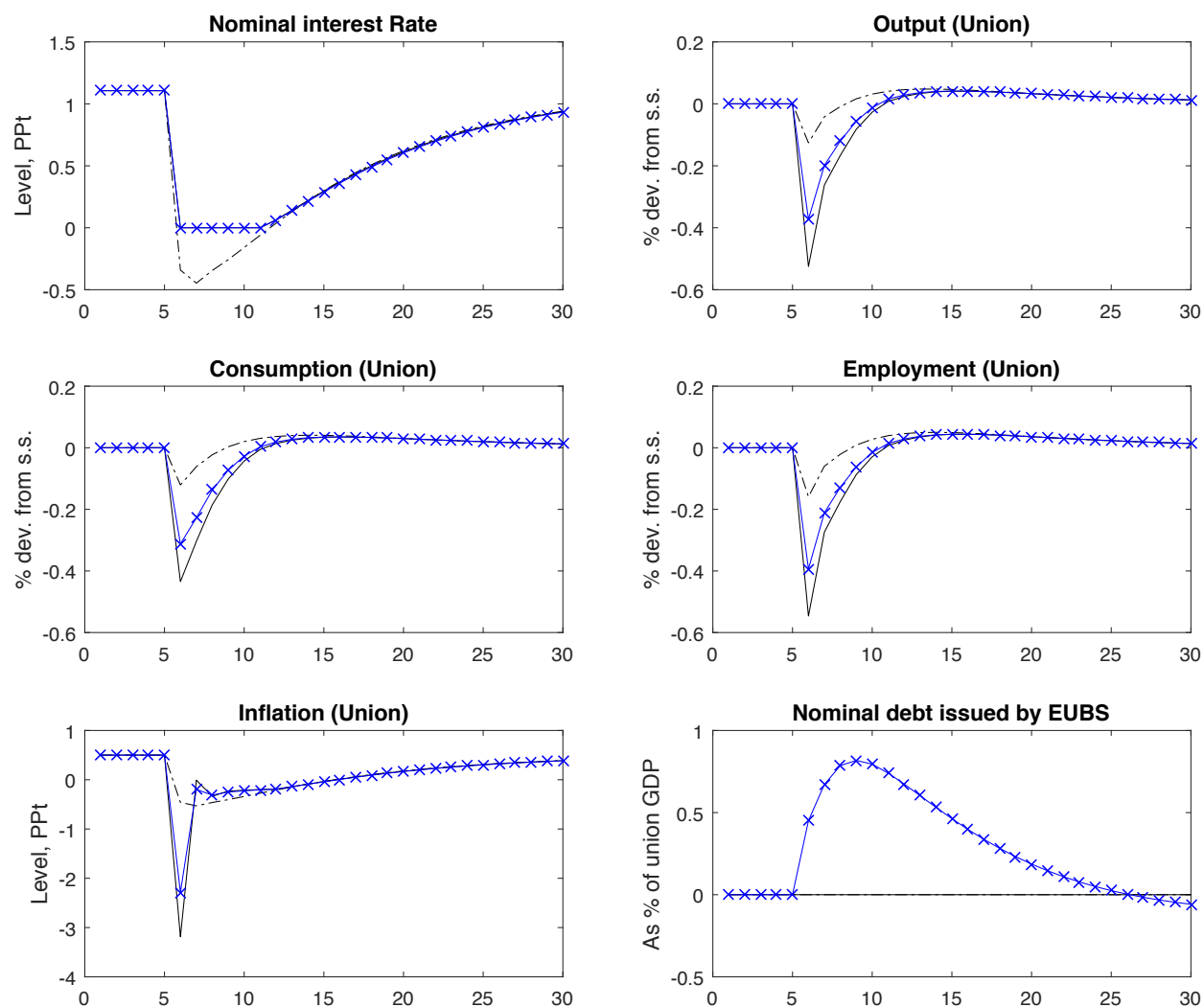
Periods are quarters. A negative demand shock in the Periphery is represented. Dash-dotted lines: shock without ZLB constraint, no transfers (scenario 0); solid lines: shock with ZLB constraint, no transfers (scenario 1); crossed lines: shock with ZLB constraint, with transfers (scenario 2).

Figure 2: Core variables



Periods are quarters. A negative demand shock in the Periphery is represented. Dash-dotted lines: shock without ZLB constraint, no transfers (scenario 0); solid lines: shock with ZLB constraint, no transfers (scenario 1); crossed lines: shock with ZLB constraint, with transfers (scenario 2).

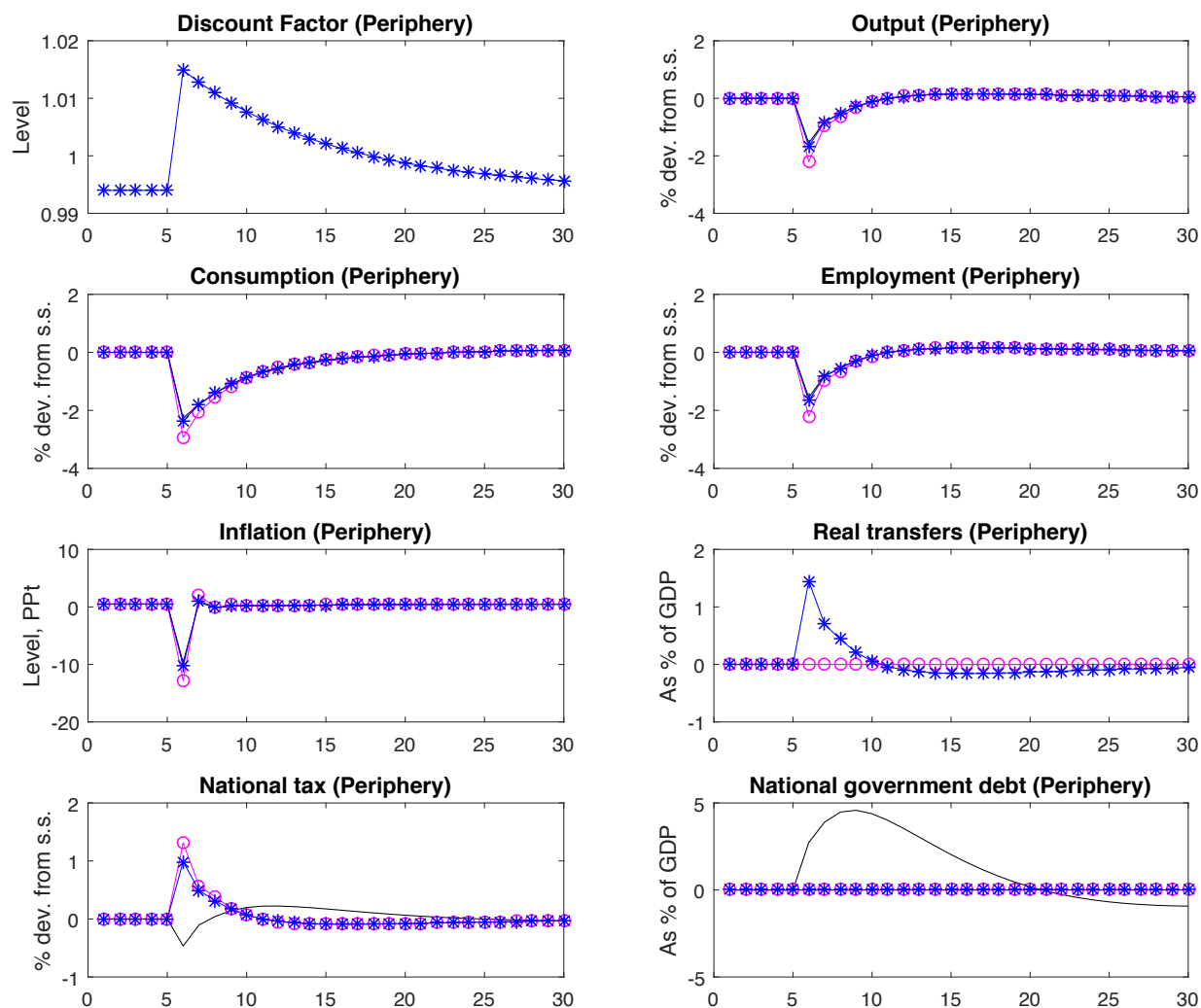
Figure 3: Union variables



Periods are quarters. A negative demand shock in the Periphery is represented. Dash-dotted lines: shock without ZLB constraint, no transfers (scenario 0); solid lines: shock with ZLB constraint, no transfers (scenario 1); crossed lines: shock with ZLB constraint, with transfers (scenario 2).



Figure 4: Alternative scenario



Periods are quarters. A negative demand shock in the Periphery is represented. Solid lines: shock with ZLB constraint, no financial distress, no transfers (scenario 1); crossed lines: shock with ZLB constraint, with financial distress, no transfers (scenario 1b); rounded lines: shock with ZLB constraint, with financial distress, with transfers (scenario 2b).

## Data description

**Country coverage:** Core includes Austria, Belgium, Finland, France, Germany, Luxembourg and the Netherlands. Periphery includes Greece, Ireland, Italy, Portugal and Spain.

**Population** Total population, annual data, 1995-2017, OECD National Accounts, 2018.

**Output:** Gross domestic product (expenditure approach) at 2010 market prices, annual data, 1995-2017, OECD National Accounts, 2018.

**Consumption:** Final consumption expenditure of households at 2010 prices, annual data, 1995-2017, OECD National Accounts, 2018.

**Unemployment rate:** Unemployment rate (age 15 to 64), annual data, 1995-2017, OECD Labor Force Statistics database, 2018. Core and Periphery averages are computed using population weights.

**Real wages:** Average annual wages, deflator GDP, annual data, 1995-2017, OECD Labor Force Survey database, 2018. Core and Periphery averages are computed using population weights.

**Replacement rate:** Initial replacement rate for short-term unemployment replacement rate, long term replacement rate for long-term unemployment replacement rate, level of pre-unemployment income of 67% of the average production worker wage, average of single person household and married couple with one earner household, annual data, 2001-2016, OECD SOCX database, 2018. Core and Periphery averages are computed using population weights. Methodology and calibration is similar to Christoffel et al. (2009a).

# Résumé

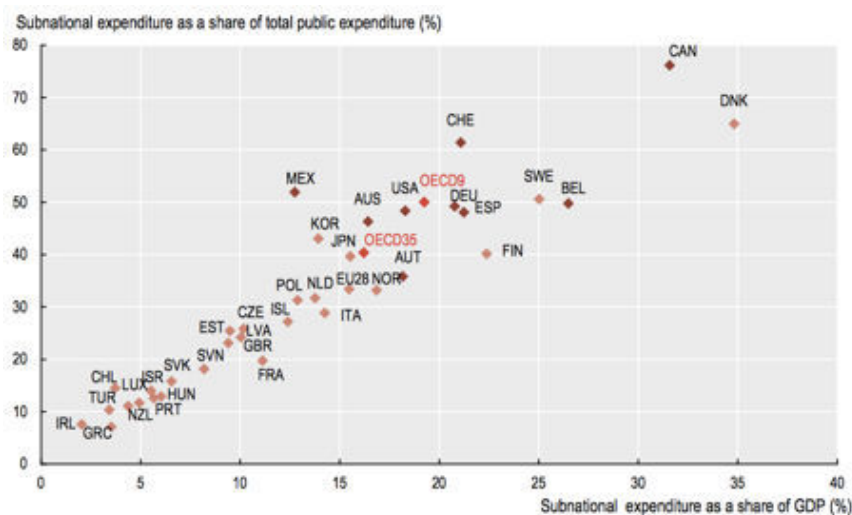
## **Le financement commun des biens publics et des risques macroéconomiques**

Dans un monde où 40% de la population totale vit dans une fédération ou une confédération, les ressources fiscales sont collectées et dépensées simultanément par différents niveaux de gouvernement. L'allocation des politiques économiques entre les gouvernements locaux, qui en 2014 représentaient en moyenne 33% de la dépense publique totale consolidée dans les pays de l'OCDE, et centraux dépend de facteurs institutionnels complexes et interroge sur la distribution des compétences entre entités locales, régionales, étatiques et même fédérales.

Le degré de centralisation, défini comme la dévolution des responsabilités aux gouvernements régionaux, varie grandement entre pays : les dépenses au niveau local comptent pour 7% de la dépense publique totale consolidée en Grèce, contre 75% au Canada (Figure 5). La distribution des compétences entre autorités locales et régionales est hétérogène, et dans certains cas les gouvernements régionaux bénéficient d'une grande autonomie en termes de politiques économiques et de taxes, comme les cantons Suisses.

Le degré de centralisation ou de décentralisation varie aussi en fonction des domaines de l'action publique : en termes de dépense totale, alors que le logement apparaît comme un service public local, l'ordre public et la sécurité sociale sont délivrés par le niveau central (Figure 6). Certains domaines sont partagés par plusieurs niveaux de gouvernement.

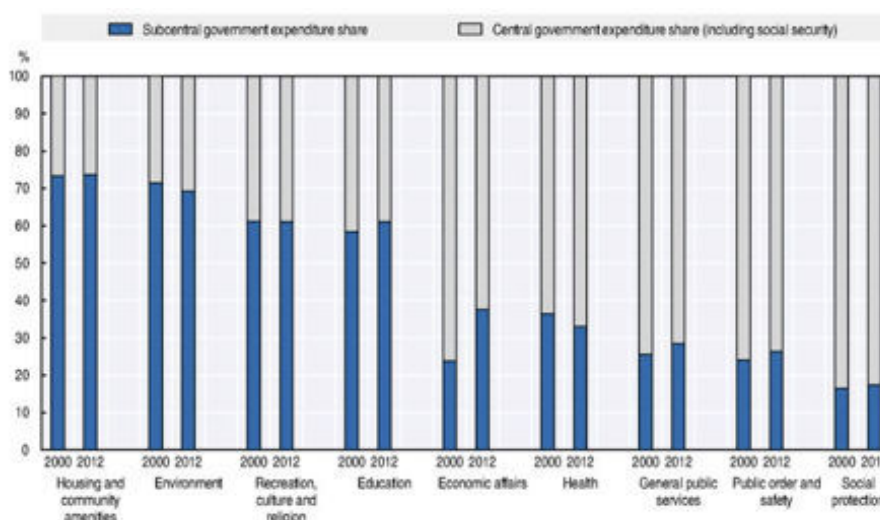
**Figure 5:** Dépense publique régionale en pourcentage du PIB et de la dépense publique totale (2016)



Source: Base de données OECD fiscal decentralization, Allain-Dupré (2018)

Par exemple, concernant l'éducation, les gouvernements locaux peuvent être chargés de l'éducation pré-élémentaire et élémentaire, les régionaux de l'éducation secondaire alors que le centre est responsable de la législation. Cependant, il faut noter que la simple étude des ratios de décentralisation peut être trompeuse, car le véritable pouvoir des gouvernements locaux dépend de leur autonomie fiscale et réglementaire, déterminées par des aspects institutionnels tels que les constitutions fiscales. Il se peut que des indicateurs financiers augmentent pour des localités sans transfert effectif de leur pouvoir à cause d'une régulation et supervision plus strictes imposées par le centre.

En gardant cet aspect à l'esprit, et en étudiant les revenus et dépenses ainsi que les compétences depuis au moins deux décennies, la décentralisation semble avoir progressé avec davantage de compétences transférées au niveau local, notamment en Italie et en Espagne, mais aussi en France (Blöchliger et al., 2016). Certains pays comme la Norvège ont cependant re-centralisé. Mais en général, le fait que les fonctions gouvernementales sont distribuées sur plusieurs niveaux de décision peut créer des débats houleux ou même des conflits concernant le bon niveau de compétence. Les disputes fréquentes entre la Cata-

**Figure 6:** Dépense locale et centrale par domaine

Source: Comptes Nationaux OECD, Blöchliger et al. (2016)

logne et Madrid en sont un bon exemple. En Europe, les membres de l'Union Européenne constituent un cas sans précédent d'union économique où le budget commun ne représente pas plus de 2% de la dépense publique totale, et les états gardent un degré d'autonomie élevé. En même temps, des pans entiers de politique économique sont la compétence de l'Union et d'autres politiques nationales sont contraintes par un ensemble de règles communes. La taille et le cadre des institutions supranationales ont mené à de nombreux et importants points de désaccord entre les pays de l'UE, sans compter entre les citoyens d'un même pays. De telles conceptions divergentes concernant le bon périmètre de l'UE peuvent être interprétées comme, entre autres, des causes pour expliquer le résultat du référendum de 2016 au Royaume-Uni.

Ainsi, l'intervention de gouvernements à plusieurs niveaux implique des prises de décisions conjointes d'une grande complexité et des ressources fiscales partagées pour financer des budgets communs avec de nombreux services publics. Cette observation soulève la question cruciale de la distribution des compétences entre niveaux de gouvernement. On peut se demander ce qui motive les pays à centraliser ou décentraliser certaines politiques, ce qui les

pousse à coopérer en partageant des ressources fiscales, et comment la théorie économique peut guider les choix sur l'allocation des compétences.

Les quatre articles de recherche qui composent cette thèse sont construits indépendamment, cependant ils étudient tous le partage de ressources fiscales utilisées pour produire des biens publics communs ou des transferts pour améliorer la stabilisation macroéconomique. Les deux premiers chapitres sont dédiés à la production de biens publics communs, et les deux autres se concentrent sur une capacité fiscale centrale.

### **Premier thème: produire des biens publics communs en présence de bases fiscales mobiles**

La littérature théorique sur le fédéralisme fiscal identifie plusieurs principes concernant l'affectation des responsabilités entre différents niveaux de gouvernement. Notamment, en présence d'économies d'échelle, il existe un avantage à partager des revenus fiscaux au centre afin de produire des biens publics. En effet, pour la même quantité de ressources, davantage de bien public peut être délivré comparé au niveau local où de telles économies d'échelles ne peuvent pas être exploitées, ou de manière équivalente moins de ressources doivent être collectées par le niveau central pour produire le même montant de bien public. Un exemple typique est la production d'infrastructures ou de réseaux, dont le coût diminue avec la taille. Une fourniture par le centre est aussi plus à même d'internaliser les effets de déversement : les décisions prises au niveau local peuvent échouer à prendre en compte les effets de la production de biens publics sur les autres localités, menant à un niveau trop faible d'investissement en infrastructures. Les externalités et les économies d'échelle peuvent expliquer la centralisation de certaines politiques d'allocation en Europe. Par exemple, la mobilité des biens entre pays de l'UE justifie la centralisation de la régulation du marché unique à un niveau supranational. Ensuite, le marché unique pour les biens engendre un argument économique en faveur de la monnaie unique et d'une politique monétaire centralisée, puisque les bénéfices du mouvement sans entrave des biens et des capitaux sont augmentés en l'absence de risque de change (Bénassy-Quéré et al., 2010).

Cependant, alors que la défense peut être considérée comme un bien public avec de fortes externalités, les pays Européens ont pour l'instant échoué à allouer des responsabilités dans ce domaine ou celui des relations internationales au niveau central. On peut envisager deux raisons possibles : un problème de coordination, où chaque pays préfère se comporter en passager clandestin et profiter des dépenses des autres. Ou alors, l'hétérogénéité des préférences peut fournir une explication à l'absence de défense Européenne, car le niveau des dépenses à engager ou les objectifs communs pourraient entrer en conflit avec les intérêts nationaux.

La divergence des préférences est un élément clé de la théorie du fédéralisme fiscal : comparée au niveau central, on suppose qu'une mise à disposition décentralisée des biens publics est davantage alignée avec les préférences. Soit à cause du manque d'information du gouvernement central, soit parce que celui-ci délivre un niveau uniforme de taxes et de biens publics, on considère que les gouvernements locaux sont plus à même d'opérer en fonction des préférences. Pour la défense, le modèle présenté dans Alesina et al. (2005a) illustre bien cet arbitrage entre hétérogénéité des préférences et économies d'échelle. L'équilibre à faire entre économies d'échelle (ou effets de déversement) et la divergence des préférences est lié au célèbre théorème de la décentralisation de Oates (1972). En l'absence d'économies d'échelle ou d'externalités, la décentralisation est préférable ou au moins équivalente à la centralisation. Selon cette idée, c'est au niveau central de justifier qu'il est le niveau d'intervention pertinent. Dans un contexte Européen, le concept de subsidiarité obéit à ce raisonnement, et peut aussi se comprendre en termes d'économie politique pour expliquer le désir de décentralisation. En effet, un plus grand rôle pour les entités locales peut atténuer les tendances des gouvernements à la taxation ou la dépense excessives, en d'autres termes à se comporter comme des Léviathans (Weingast, 1995). La concurrence entre gouvernements locaux les oblige à respecter les préférences des citoyens puisque ceux-ci peuvent voter avec leurs pieds pour citer Tiebout (1956), ce qui empêche les excès.

Cet effet de discipline de la décentralisation est souligné par les défenseurs de la concu-

rence fiscale : le fait que les bases fiscales sont mobiles incite les gouvernements à réduire les dépenses et à fournir des biens publics efficacement, sinon les facteurs de production se déplacent vers d'autres régions leur offrant des taxes et dépenses plus compétitives. Les effets positifs de la mobilité des bases fiscales sur l'efficacité du secteur public sont visibles empiriquement (Blöchliger and Campos, 2011).

Cependant, une telle mobilité peut mener à des distorsions et des externalités qui justifient la centralisation. D'abord, théoriquement, l'érosion des bases fiscales peut augmenter le coût du secteur public, provoquant une course au moins disant fiscal et une production trop basse de biens publics (Zodrow and Mieszkowski, 1986; Wilson, 1986). Sans coordination ou subventions intergouvernementales, les gouvernements en concurrence ne peuvent pas atteindre un niveau efficient de dépense publique. L'inefficacité liée à l'érosion de la base est magnifiée si différents niveaux de gouvernement partagent la même base, créant des externalités verticales (Keen, 1998). L'autre conséquence de cette mobilité est le report de la taxation sur les bases moins mobiles comme le travail non qualifié (Bucovetsky and Wilson, 1991). Ainsi, la centralisation peut être un remède : un gouvernement central peut internaliser les externalités fiscales et résoudre un problème de coordination entre décideurs locaux. En effet, le niveau central peut imposer une taxation uniforme, dispose par définition d'une plus grande taille que les entités locales (il est donc moins sujet à l'érosion de la base) et peut organiser des systèmes de transferts fiscaux. Alors, décider du degré de centralisation consiste à arbitrer entre les distorsions fiscales comme l'érosion des bases et le respect des préférences : trouver le bon équilibre est au centre du premier chapitre de cette thèse.

L'étude simultanée de l'érosion de la base fiscale au niveau local et de l'hétérogénéité des préférences, présentée dans le premier chapitre, *Optimal centralisation and tax base mobility*, apporte une nouveauté à la littérature. Si on considère que la base fiscale est sensible à la politique fiscale locale<sup>7</sup>, alors l'érosion augmente en coût du secteur public

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<sup>7</sup>Blöchliger and Campos (2011) documente des preuves empiriques de la mobilité des bases fiscales en réaction aux taxes des gouvernements locaux. Le terme local est ici employé de manière générale en opposition à la taxation du niveau central, ainsi la taxation locale peut désigner celle de municipalités, de



local. Cette forme d'inefficacité doit être comparée aux bénéfices d'une production locale en termes d'adaptabilité aux préférences.

Dans ce premier chapitre, on considère un problème de centralisation optimale avec des juridictions qui ont des préférences hétérogènes pour les biens publics et une base mobile pour les financer. On adopte un modèle théorique avec une structure fédérale et un continuum de biens publics. En premier, on décrit les politiques locales et centrales. À cause de l'érosion de la base, les gouvernements locaux produisent leurs biens publics à un niveau trop bas, alors que le gouvernement central produit un niveau uniforme immunisé contre l'érosion mais avec un coût en termes d'adaptabilité aux préférences. Une fois que les politiques centrales et locales ont été décrites, on définit un critère d'optimalité qui isole les deux sources d'inefficacité que nous analysons : érosion de la base au niveau local et faible adaptabilité aux préférences au niveau central. On porte plusieurs conclusions normatives sur le degré optimal de centralisation. On démontre d'abord que la centralisation de biens publics augmente le niveau des biens qui restent au niveau local. Ensuite, on montre qu'en présence d'érosion de la base, des préférences très hétérogènes peuvent correspondre à un degré optimal de centralisation élevé, ce qui apporte un nouvel éclairage par rapport à la littérature. Enfin, on caractérise le niveau optimal de centralisation et on montre qu'une centralisation complète ne peut pas être optimale, au contraire de la décentralisation complète.

Alors que le premier chapitre étudie le degré de centralisation entre des pays qui font tous partie d'une structure fédérale, le second chapitre analyse le nombre de pays participant à une union. La contribution de ce chapitre, *Tax competition and club formation*, est de considérer un modèle de concurrence fiscale où les biens publics sont potentiellement caractérisés par des effets de déversement entre juridictions. Même en présence de ces effets, la coopération pour le partage de biens publics peut ne pas se faire si les gouvernements sont en concurrence fiscale. Il se peut que l'exploitation des effets de déversement ne soit pas suffisante pour l'émergence d'une production de biens publics communs : ces effets

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régions, d'états ou même de pays membres d'une union économique.

doivent être assez importants pour l'emporter sur les bénéfices obtenus en restant hors de la zone de coopération et profiter de l'harmonisation d'autres pays. Dans ce chapitre, nous transformons un modèle traditionnel de concurrence fiscale en ajoutant des effets de déversement dans la production de biens publics. Des pays identiques sont en concurrence pour une base mobile, le capital. Parmi ces pays, un sous-groupe peut coordonner leurs taxes et en retour partager des effets de déversement dans la production de biens publics. Ainsi, ils forment un club de taxes élevées. Des solutions sous forme explicites pour les taxes et l'allocation du capital sont obtenues à l'aide de fonctions spécifiques pour l'utilité et la production (linéaire pour le bien public et quadratique pour le ratio capital/travail, respectivement), cependant des tests de robustesse complètent l'analyse théorique pour montrer que les mécanismes en jeu ne sont pas limités à ces hypothèses. Une fois l'équilibre pour les taxes et l'allocation du capital calculé, on montre que l'utilité des pays du club mais aussi des autres augmente avec le nombre de participants dans l'union. Dans notre modèle, la taille stable de l'union, celle où aucun pays ne préfère la quitter ou la rejoindre, dépend de l'importance des effets de déversement et il se peut que la coopération soit partielle, totale, ou absente. On démontre que la coopération totale peut être atteinte si les effets de déversement dans la production de biens publics sont suffisamment grands pour l'emporter sur les incitations à demeurer un pays non-coopératif avec des taxes faibles. Une implication de politique économique est que pour amener à la coopération, les pays devraient associer les projets d'harmonisation fiscale au financement de biens publics dont la production engendre des effets de déversement élevés, particulièrement si la concurrence fiscale est forte.

### **Second thème: le partage des risques macroéconomiques dans une union monétaire avec une capacité fiscale**

Le partage de ressources fiscales, dans un budget commun permettant de renforcer la faculté de gouvernements décentralisés à stabiliser leur économie, est au centre de vives discussions dans la zone euro, où une telle capacité centrale n'existe pas. Les états fédéraux sont traditionnellement dotés de budgets centraux substantiels dédiés, entre autres fon-

tions, à des objectifs de stabilisation. Par exemple, après la crise financière, un programme appelé "Emergency Unemployment Compensation" a été lancé en 2008 aux États-Unis, entièrement financé par le budget fédéral afin d'étendre les allocations chômage au-delà des 26 semaines habituelles, jusqu'à 99 dans certains états. Empiriquement, des études montrent que les transferts fiscaux délivrent une part non négligeable du partage des risques entre états aux États-Unis (Asdrubali et al., 1996). Plus généralement, les états fédéraux assignent la stabilisation fiscale au niveau central, alors que les gouvernements régionaux et locaux sont contraints par des règles fiscales strictes. Dans la zone euro, le Pacte de Stabilité et de Croissance permet une certaine stabilisation macroéconomique. Cependant, cette flexibilité a été insuffisante pendant la crise de 2012-2013, où les pays membres ont réagi avec des politiques pro-cycliques.

L'idée d'un budget communautaire remonte à bien avant la création de l'union monétaire, avec le rapport MacDougall report (1977). Le fait que la zone euro manque d'instruments de stabilisation importants fait s'interroger sur la mesure nécessaire de la coordination fiscale pour des pays qui ont déjà entièrement centralisé leur politique monétaire.

Il peut être défendu que la sphère privée est à même de se charger du partage des risques. Des marchés financiers fonctionnels devraient permettre suffisamment de possibilités pour les agents afin d'atténuer les chocs asymétriques, en permettant l'accès au crédit dans d'autres pays et à des portefeuilles diversifiés indépendants du revenu national. Mais, toujours avec l'exemple Européen, les canaux privés de partage des risques se sont effondrés pendant la crise, au pire moment, et les marchés financiers restent fragmentés (Furceri and Zdzienicka, 2015). De plus, Farhi and Werning (2017) prouvent théoriquement que les partages des risques privés et publics sont complémentaires. En effet, même en présence de marchés financiers parfaits, un partage des risques purement privé est à un niveau insuffisant car les agents privés n'internalisent pas les externalités macroéconomiques de demande liées à leurs choix d'assurance. L'intervention publique est alors justifiée afin de corriger cette défaillance de marché.

Ainsi, comparée aux états-Unis, la zone euro manque de mécanismes de partage des risques à la fois publics et privés (Nikolov et al., 2016). Dans le débat sur les réformes de la zone euro, les défenseurs d'une capacité de stabilisation fiscale avancent qu'un tel outil commun pourrait compléter les politiques fiscales nationales afin de faire face aux chocs asymétriques et augmenter le partage des risques. Une capacité pourrait aussi résoudre les problèmes de coordination entre gouvernements nationaux et permettre une politique fiscale d'ensemble plus appropriée en fonction du cycle. La combinaison monétaire et fiscale pourrait aussi être améliorée dans le cas où la politique monétaire ne peut pas faire face à des chocs symétriques importants, en particulier si on considère que les multiplicateurs Keynésiens sont plus élevés en récession et lorsque les taux d'intérêt nominaux atteignent le plancher de zéro (Auerbach and Gorodnichenko, 2012; Eggertsson, 2011). Plusieurs propositions ont été annoncées, avec différentes opinions sur la forme qu'une telle capacité commune devrait adopter. Cependant, la réticence des états membres à créer un instrument de stabilisation partagé reflète des inquiétudes profondes et des lignes rouges concernant la façon dont le mécanisme opèrerait en réalité, à la fois à court et long terme.

D'abord, la faisabilité politique dépend du fait que l'instrument doit empêcher tout transfert permanent. En général, les mécanismes de partage des risques et de redistribution sont difficiles à différencier, parce que le partage de ressources pour faire face à des chocs macroéconomiques peut se traduire à long terme par des transferts de richesse. Cependant, la question des transferts permanents n'est pas claire dans le débat actuel. Est-ce que les transferts doivent être délivrés seulement temporairement autour du cycle ? Ou est-ce que les pays devraient rembourser au fonds la totalité du support qu'ils ont reçu ? Cette ambiguïté doit être abordée par des choix prudents en termes de design.

Une autre source de désaccord consiste à décider si la capacité doit pouvoir emprunter sur les marchés financiers. Une telle capacité d'emprunt pourrait mener à une émission de dette centralisée et à des transferts implicites entre pays. De plus, comme pour tout mécanisme de partage des risques, des problèmes d'aléa moral se posent, possiblement de deux façons. D'abord entre gouvernements : l'aide financière pourrait, si elle est atten-

due en cas de crise, réduire l'incitation à mener des réformes structurelles qui diminuent les risques de perte de revenu ou améliorent l'aptitude de l'économie nationale à résister aux chocs. Une autre source potentielle d'aléa moral est présente si la capacité centrale fournit des transferts interpersonnels, sous la forme d'allocations chômage par exemple. Une telle politique pourrait altérer les incitations à la recherche d'emploi, et aussi entrer en conflit avec les préférences nationales si le montant total de l'assurance est modifié par l'intervention centrale. L'hétérogénéité des préférences représente alors un problème pour définir le bon niveau commun de support.

Les questions de transferts permanents et d'hétérogénéité des politiques sociales nationales sont au centre du débat sur une capacité fiscale pour la zone euro. Nous les abordons dans le troisième chapitre, Unemployment insurance union, co-écrit avec Marius Clemens<sup>8</sup>. La capacité discutée consiste en une assurance chômage commune. On construit un modèle DSGE de la zone euro (avec un cœur et une périphérie) avec des rigidités nominales, financières et sur le marché de l'emploi. Un modèle de référence où les politiques sont uniquement nationales, comme c'est le cas aujourd'hui, est établi pour le calibrage et celui-ci reproduit des observations empiriques pour la zone euro. Ensuite, on introduit une assurance chômage commune qui transfère une partie des stabilisateurs nationaux au centre. Les chômeurs sont alors assurés par les deux niveaux et quand un choc négatif survient, ils reçoivent des transferts positifs nets du fonds. Il est souvent souligné que, à cause de l'hétérogénéité des systèmes nationaux en termes d'allocations et périodes d'éligibilité, un régime commun nécessiterait une harmonisation des systèmes d'assurance. Une harmonisation serait difficile, puisque la politique sociale reste une prérogative nationale profondément liée aux préférences, et les gouvernements gardent leur autonomie lorsqu'il s'agit de décider du montant et de la durée de l'indemnisation. La nouveauté de ce chapitre est de présenter un design qui s'inclut dans les politiques nationales, afin de montrer qu'il est possible de construire une assurance chômage commune sans convergence

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ou même changement dans le montant totale de l'assurance. Nous montrons aussi que l'émission de dette est importante si la capacité doit faire face à des chocs asymétriques. De plus, les transferts permanents sont discutés. La question de permettre des transferts à l'état stationnaire est exclue de l'analyse. Ceci ferait du mécanisme un système de redistribution, où les pays avec un marché du travail plus efficace financent ceux avec un marché du travail moins efficace, ce qui est politiquement impossible. Ainsi, dans tous nos scénarios, des règles permettent que les transferts n'opèrent qu'autour du cycle. Ensuite, on présente un scénario où les transferts permanents sont complètement évités, car les pays remboursent le fonds du même montant qu'ils ont obtenu. Il n'y a alors pas de partage de risque, mais la stabilisation est fournie par une règle fiscale Européenne moins stricte qu'au niveau national, de sorte qu'une stabilisation fiscale est délivrée par l'assurance commune.

Enfin, le quatrième chapitre, Euro area unemployment insurance and the ZLB co-crit avec Jan Stráský<sup>9</sup>, analyse comment une capacité fiscale ciblant directement les ménages peut améliorer la stabilisation lorsque les taux d'intérêt sont au plancher égal à zéro. Nous reprenons la base du modèle du chapitre 3 pour y inclure une contrainte pour la politique monétaire. À notre connaissance, les bénéfices d'une capacité fiscale en présence d'une telle contrainte n'ont jamais été étudiés dans la littérature. Dans ce chapitre, on commence par un choc négatif de demande dans la périphérie. La politique monétaire commune est par construction inapte à faire face à ce choc asymétrique. Mais la contraire sur la politique monétaire réduit encore son pouvoir de stabilisation. Lorsque l'on introduit une assurance chômage commune qui peut emprunter sur les marchés financiers, des transferts fiscaux contra-cycliques atténuent le choc de demande, car ils soutiennent la demande dans la périphérie et, à travers des liens commerciaux, celle du coeur. Les imperfections sur les marchés financiers jouent un rôle clé : c'est parce que certains ménages ne peuvent pas lisser leur consommation que les transferts fiscaux sont efficaces à stabiliser l'économie. Dans une extension, on montre aussi que la capacité fiscale permet un bénéfice supplémentaire si le gouvernement de la périphérie est coupé des marchés financiers. En effet, l'aide fiscale

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<sup>9</sup>Jan Stráský, Economiste, Département d'économie, OECD.

du centre atténue la hausse pro-cyclique des taxes nécessaire pour équilibrer le budget, ce qui améliore encore plus la stabilisation en comparaison avec un scénario sans transfert.

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# List of Figures

1	Subnational government expenditure as a percentage of GDP and total public expenditure (2016) . . . . .	2
2	Sub-central and central government expenditure by policy area . . . . .	3
1	Change in share of sub-central revenue and expenditure as % of total government, change 1995-2014 . . . . .	14
2	Eurobarometer survey : More decisions should be taken at the EU level . .	16
3	Total deadweight loss as a function of $c$ . . . . .	37
4	Total deadweight loss as a function of $c$ with lower base erosion . . . . .	39
5	Deadweight loss . . . . .	43
1	Utilities as functions of $m$ . . . . .	69
2	Robustness check with iso-elastic utility function . . . . .	70
3	Robustness check with iso-elastic utility and Cobb-Douglas production functions . . . . .	71
1	Baseline case . . . . .	91
2	EUI . . . . .	104
3	Home variables . . . . .	120
4	Foreign variables . . . . .	121
5	Union variables . . . . .	122
1	Periphery variables . . . . .	150
2	Core variables . . . . .	151

<i>LIST OF FIGURES</i>	180
3 Union variables . . . . .	152
4 Alternative scenario . . . . .	153
5 Dépense publique régionale en pourcentage du PIB et de la dépense publique totale (2016) . . . . .	156
6 Dépense locale et centrale par domaine . . . . .	157

# Sharing the financing of common public goods and macroeconomic risks

The four research articles composing this PhD dissertation study the sharing of fiscal resources used to provide common public goods or transfers to contribute to macroeconomic stabilization. In the first chapter, we consider an optimal centralization problem with jurisdictions that have heterogeneous preferences for public goods and tax a mobile base to finance them. We adopt a theoretical model with a federal structure and a continuum of public goods to draw several normative conclusions from the study of the optimal degree of centralization. The contribution of this second chapter is to consider a tax competition model where public goods potentially exhibit cross-border spillovers. We show that full cooperation can be attained if spillovers in public good provision are high enough to remove the incentives to remain a low-tax non-cooperative player. In the third chapter, we build a DSGE model of the euro area (with a core and a periphery) with nominal, labor and financial rigidities. A baseline model where policies are only national, as it is the case now, is set as the reference for calibration which reproduces key empirical observations for the euro area. Then, we implement a common unemployment insurance and study its stabilization properties. The fourth chapter focuses on how a fiscal capacity targeting directly households can improve stabilization at the zero lower bound.

**Keywords:** Public finance, fiscal federalism, Macroeconomics, European integration

# Le financement commun des biens publics et des risques macroéconomiques

Les quatre articles de recherche qui composent cette thèse étudient le partage de ressources fiscales utilisées pour produire des biens publics communs ou des transferts pour améliorer la stabilisation macroéconomique. Dans le premier chapitre, on considère un problème de centralisation optimale avec des juridictions qui ont des préférences hétérogènes pour les biens publics et une base mobile pour les financer. On adopte un modèle théorique avec une structure fédérale et un continuum de biens publics afin de porter plusieurs conclusions normatives sur le degré optimal de centralisation. La contribution du deuxième chapitre est de considérer un modèle de concurrence fiscale où les biens publics sont potentiellement caractérisés par des effets de déversement entre juridictions. On démontre que la coopération totale peut être atteinte si les effets de déversement dans la production de biens publics sont suffisamment grands pour l'emporter sur les incitations à demeurer un pays non-coopératif avec des taxes faibles. Dans le troisième chapitre, on construit un modèle DSGE de la zone euro (avec un cœur et une périphérie) avec des rigidités nominales, financières et sur le marché de l'emploi. Un modèle de référence où les politiques sont uniquement nationales, comme c'est le cas aujourd'hui, est établi pour le calibrage et celui-ci reproduit des observations empiriques pour la zone euro. Ensuite, on introduit une assurance chômage commune afin d'étudier ses propriétés stabilisatrices. Le quatrième chapitre analyse comment une capacité fiscale ciblant directement les ménages peut améliorer la stabilisation lorsque les taux d'intérêt sont au plancher égal à zéro.

**Mots-clés:** Finances publiques, Fédéralisme fiscal, Macroéconomie, Intégration Européenne