Centralized Fiscal Spending by Supranational Unions

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Abstract

We study fiscal spending by supranational unions, where participation is voluntary and countries bargain over contributions to and the allocation of a central budget. Since nations can threaten to exit (veto), bargaining power over the allocation becomes a function of contributions, which generically causes inefficiency in the presence of income asymmetry between member nations. This link between the budget allocation and contributions explains patterns of inefficient spending in the EU, for example why resources are diverted to low-productivity projects in high-income countries: due to the option of veto, there exist an inherent tradeoff between efficiency on the contributions margin (high-income countries contribute disproportionately to the budget) and efficiency on the allocation margin (spending is allocated where it has the highest marginal product).

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1 Motivation

Recent calls for more centralized spending at the EU level have been put forth by both EU politicians and groups of prominent European economists (van Rompuy (2012), Picketty et al. (2014), "Eiffel" and "Glienicker" Groups (2013)). Those in favor of a greater budget cite a need to counterbalance monetary policy and enforced austerity through centrally promoting cohesion and growth in low-income areas. This desire to centralize spending is unsurprising given the fiscal federalism literature's classic predictions of efficiency gains from coordinated public goods provision.[2] However, there exists an overwhelming perception that the available funds are inefficiently allocated, suggesting more spending is unwarranted (see Boldrin and Canova (2001) for a prominent critique, and Dellmuth and Stoffel (2012) for an overview).

A prime concern, raised by both academics and pundits, is that EU funds are diverted to spending on projects in high income countries, such as funding for art galleries in the UK, that do little to advance the stated goals of cohesion and growth. As stated by The Economist (2007), "the scandal is not that the EU shifts money from rich countries to poorer newcomers, but that it recycles large sums straight back to wealthy countries." Similar concerns are raised by Boldrin and Canova (2001), who ask "Why does the process of European political decision making imply that, to reduce the size of the transfer, 'donor countries' must create new reasons for receiving transfers from Brussels instead of just reducing the existing ones (Objectives 2, 3,4 and 6 exist only because of this)?" (p.245). Despite the heated debate, there is little theory regarding the basic fiscal task of raising and allocating a budget within the framework of a supranational union where, unlike a federation, sovereign countries bargain over outcomes.

In this paper, we argue that EU fiscal outcomes are not simply the result of an inefficient political process, but rather represent the constraint of the underlying supranational setting, where participation is voluntary. Therefore, in stark contrast to a federation, while union members might agree over which outcome is efficient ex-ante, they cannot typically commit not to bargain again over budget contributions and spending rules ex-post. We show that it is precisely this lack of commitment that prevents a union from realizing their ex-ante constitutional goal: When nations can credibly threaten to veto the budget, their contributions to the union budget influence the de facto distribution of bargaining power over the allocation of the budget - a link that generally leads to inefficient outcomes and, in particular, explains

[2] That is, there are net efficiency gains from centralization in at least some policy areas; see for example Oates (1972), pp. 4-11 and the more recent contributions of Lockwood (2002) and Besley and Coate (2003) for a discussion.

excessive spending on projects in high-income countries.[3]

We provide a theoretical framework to analyze how bargaining affects centralized fiscal spending when self-interested nations voluntarily participate in a union and cannot commit at the constitution stage to binding contracts over contributions to the central budget and the allocation of the joint funds.[4] In our model, the motivation to form a union stems from a set of projects that benefit from centralized provision, modeled as a technology unavailable to each nation individually. Nations have heterogeneous preferences over these projects, but enjoy positive spillovers from all of them. As an example, one may think about joint resources being spent on infrastructure improvement: Every member country likely gains from an integrated transportation network; at the same time each country might prefer, all else equal, that spending is allocated to infrastructure projects within its borders. Our paper shows that in a supranational setting, the distribution of relative bargaining positions arises endogenously from the countries' contributions, their national incomes, and the public good spillovers of their preferred projects: this is our main departure from the existing literature. We highlight the resulting link between contributions and allocations through the implied bargaining position as a major source of inefficiency in a union's spending decision.

The intuition for this link is best explained in a "partial equilibrium" thought experiment: Suppose contributions to the union budget were fixed before nations bargain over the allocation of the joint funds. Each nation's bargaining position depends on its outside option, which is to withdraw from the union and consume its contribution. Therefore, a higher contribution, all else equal, implies a larger outside option, and a stronger position to bargain for the individually preferred (but possibly inefficient) allocation of funds. Thus, the allocation of the union budget to union projects is linked to the scheme of individual contributions. That is not the case in the efficient allocation, where funds should simply be allocated to the highest marginal return projects, without regard to who finances the joint budget. This link is a direct consequence of the voluntary nature of supranational spending - it would not be present if nations could not threaten to withdraw their contribution and revert to autarky during the bargaining process. We show that this source of inefficiency is

[3]In the EU any country can veto the allocation of any money to the EU structural fund (the main vehicle for fiscal spending), independent of their participation in other EU institutions. According to Open Europe (2012), in recent budget negotiations at least seven nations threatened to use their veto and, empirically, Bodenstein and Kemmerling (2011) show that even controlling for need there is still large variability in spending between regions, suggesting that the bargaining power of individual nations is important to the final allocation.

[4]This modeling feature pertains to the EU, as recently highlighted by the UK's threat to veto the entire EU budget. As Carrubba (1997) argues, contributions to the centralized budget are flexible and subject to bargaining given that "the member states maintain ex-post control over every country's net transfer position" (p. 473).

retained in the "general equilibrium" setup, where nations bargain simultaneously over contributions and the allocation. This interdependency of contributions and allocation of funds generically results in distortions both in terms of efficient funding as well as efficient spending.

Our setup allows us to explicitly track under which circumstances unstructured bargaining leads to inefficient outcomes. In the presence of income asymmetry, unstructured bargaining generically leads to the budget being both raised and allocated inefficiently. In a number of numerical simulations, we show that inefficiencies are more severe the more unequal nations are ex-ante. In particular when the high spillover projects are located in the poorer member states, increasing income asymmetry translates into a growing tension between the two efficiency margins: efficiency on the contribution margin entails that the high-income country shoulders a greater share of the budget. This in turn implies, however, that too much spending will be diverted to the high-income country's low productive project - a pattern of "recycling of resources" also observed in the EU. Moreover, we show that as the union budget increases, the bargaining process implies that spending on all projects is increased, that is also inefficient projects will receive larger amounts. This seems discouraging from a static perspective, since it suggests that inefficient spending is a necessary feature of supranational fiscal spending in the presence of income asymmetries, and that increasing the EU budget will increase the observed inefficiencies. However, we emphasize that dynamically, even an inefficiently spent budget might contribute to *income* convergence and thus alleviate the fundamental source of inefficiency we identify.

Related literature

So far, the understanding of union-level fiscal spending mainly derives from the literature on fiscal federalism. Lockwood (2002) analyzes the decision of a federation to supply a district-level public good with global spillovers. Due to legislative bargaining, centralization can result in inefficiencies since the majority coalition will not consider the welfare of districts outside of the coalition when determining outcomes. Similarly, Besley and Coate (2003) find that centralization can result in excessive public spending. Harstad (2007) considers the situation in which districts (or nations) have private information about their valuation of a public good and finds that a uniform federal (or union) policy mitigates the inefficiencies created by the private information. Kessler et al. (2009) examine optimal government structures in a setting where districts bargain over outcomes ex-post and face a holdup problem, which implies a tradeoff between optimal investment and optimal implementation.

In contrast to fiscal policy administered within a federation, however, fiscal outcomes at the supranational level are influenced by the implicit threat of veto.

That is, the voluntary nature of supranational unions implies that bargaining over fiscal spending occurs under the shadow of exit. Our paper emphasizes the exit option as a source of inefficiency of fiscal spending at the supranational level that is largely absent at the federal level. This inefficiency arises since, due to the autarchic nature of international relations, nations are not able to commit to not bargain over outcomes ex-post. Therefore, nations are unable to commit to the ex-ante agreed-upon (efficient) schedule of contributions and allocations. This mechanism relates to the familiar holdup problem, where ex-post bargaining distorts ex-ante investment (e.g. Grossman and Hart (1986); see Harstad (2005) for an analysis the holdup problem within a context of legislative bargaining). In our paper, however, distortion arises due to the inability for the union to determine contributions and allocations independently.

Our paper joins a set of recent articles examining efficient institutions for international governance. Maggi and Morelli (2006) examine the optimal majority rule in a dynamic setting, where a single union project is repeated over time. If nations are patient enough, and are sufficiently uncertain about their future preferences, then the optimal majority rule can be supported even with voluntary participation. Barbera and Jackson (2006) analyze which voting weights maximize aggregate utility in unions of nations, where voting is limited to one vote per country. In a similar setting, Koriyama et al. (2013) show that with concave utility, digressive proportionality maximizes a utilitarian social objective.

Lastly, our paper is also related to the literature on the breakup of nations, which considers the effect of participation constraints on taxation and spending at the national level (e.g. Bolton and Roland (1997)). Relatedly, Alesina et al. (2005) model international unions as institutions that regulate domestic policy, and compare the effect of uniform and non-uniform union policy on aggregate welfare and the equilibrium size of unions. Our paper takes a complementary approach to examine fiscal spending, where the union directly controls a centralized budget. To further clarify, Alesina et al.'s regulation approach constrains the allocation of each nation's project to equal that nation's contribution (they also explore a uniform subsidy and decentralized public good decisions). Therefore, their framework does not capture the bargaining and redistribution that occurs under a centralized fiscal program, which is precisely what we explore here.

The remainder of the paper is organized as follows: Section 2 introduces the basic setup, and is followed by the characterization of the relevant efficiency benchmarks in section 3. Then, section 4 analyzes the bargaining solution, gives conditions under which efficiency is achievable, and discusses characteristics of the inefficiencies that generally result from the bargaining process. Numerical simulations and com-

parative static results are provided here as well. Section 5 discusses the applicability of the results to fiscal spending in the EU and derives policy implications. Section 6 concludes. All proofs are relegated to the appendix.

2 Setup

There are n nations that may form a union. At stage zero, the constitution stage, before incomes and preferences are revealed, these nations are identical. Nations decide whether to form a union and define a common goal (maximizing ex-ante utility), which will serve as the efficiency benchmark. The member nations would like to select an ex-post binding contract specifying individual contributions to a centralized budget as well as its allocation to achieve the common goal. However, countries do not have access to a technology that allows such commitment. We choose full uncertainty in stage zero for tractability. Our results are mostly qualitative and do not change as long as some uncertainty over income and preferences remains at the initial stage.

At stage one, each nation receives an income, y, and an individual preference parameter, α, each drawn, without replacement, from a finite set. We assume that the drawing process is randomized such that each country faces a uniform probability distribution over all possible pairs. After uncertainty is revealed, we denote countries with subscripts $i = 1, ..., n$.

At stage two, contributions to the union budget, as well as the allocation of that budget, are determined through a bargaining process, which we describe in more detail in section 4. Importantly, at the bargaining stage, each nation still retains the option to veto the union and withdraw its contribution.

Technologies

Each country can either consume its income domestically (c_i) or contribute to a union-wide budget (x_i). Contributions to the union budget must satisfy the nation's individual budget constraint

$$c_i + x_i \leq y_i \quad \forall i. \tag{1}$$

Moreover, we assume that $x_i \geq 0$ for all i. Together the contributions form the union's budget

$$X = \sum_i x_i. \tag{2}$$

Forming a union allows the countries to implement a set of projects $\{g_i\}_{i=1}^n$. These joint projects produce according to a linear production function, so that the union

wide budget constraint becomes

$$\sum_{i=1}^{n} g_i \leq X, \tag{3}$$

with $g_i \geq 0$ for all i. The union projects essentially produce public goods that can be enjoyed by all members of the union.

We do not introduce a technology to directly transfer utility between nations. Realistically, there is no clear mechanism by which utility can be *directly* transferred at the supranational level. It is conceivable that "transfers" are made by increasing centralized spending in a given nation or by decreasing their contribution to the centralized budget, which is precisely what our model allows.

Preferences

Each nation receives utility from domestic consumption as well as the union projects. Among the joint projects, each nation values one particular project the most, but may benefit from (positive) spillover effects from other projects:

$$U_i(c_i, g_1, ..., g_n) = u(c_i) + v(g_i + \sum_{j \neq i} \alpha_j g_j). \tag{4}$$

We assume $u(\cdot)$ and $v(\cdot)$ are continuously differentiable, strictly increasing and concave, and satisfy standard Inada conditions.[5] α_j denotes the spillover effect a country gains from the implementation of project g_j. It is restricted to $\alpha_j \in [0, 1)$. Thus, each project is valued most by the respective "home country," but produces weakly positive and symmetric spillovers for all other countries.[6] We restrict utility over consumption and public-goods projects to be separable for tractability.

To economize on notation, we denote

$$u_i' = \frac{\partial u(c_i)}{\partial c_i} \quad \text{and} \quad v_i' = \frac{\partial v(g_i + \sum_{j \neq i} \alpha_j g_j)}{\partial (g_i + \sum_{j \neq i} \alpha_j g_j)},$$

and define the ex-post individual surplus from setting up the union as

$$S_i \equiv u(y_i - x_i) + v_i - u(y_i). \tag{5}$$

[5]Specifically, we assume that $\lim_{x \to 0} u'(x) = \infty$, $\lim_{x \to 0} v'(x) = \infty$, $\lim_{x \to \infty} u'(x) = 0$, and $\lim_{x \to \infty} v'(x) = 0$.

[6]More generally, we could write the utility country j gains from being in the union as $v(\sum_i \alpha_{ij} g_i)$. In the analysis we restrict the spillover effects of each project g_i to be symmetric across all but one countries, i.e. $\alpha_{ij} = \alpha_i$ for all $j \neq i$, and for country i to strictly prefer project g_i over all others, i.e. $\alpha_{ii} = 1$. This restriction allows us to derive clean and intuitive expressions for the inefficiencies arising from bargaining. We point out when relaxing these constraints leads to additional interesting results.

3 Efficiency Benchmarks

Since there is no overarching authority governing the union, we do not pick any specific social welfare function to measure efficiency. Instead, we focus on the common ex-ante goal set jointly by all member nations at stage zero as a benchmark. The following characterization of inefficiencies thus refers to a departure from the allocation that all union members would like to commit to at the constitution stage.

Since countries are ex-ante identical, they have identical objectives at stage zero. Pure self-interest naturally leads to the common goal being the allocation that maximizes each nation's expected individual utility.[7] Formally, a nation's expected individual utility surplus from forming the union is defined as

$$\mathbb{E}[S_i] = \mathbb{E}[u(y_i - x_i) + v_i - u(y_i)]. \tag{6}$$

To simplify the analysis and to allow for explicit correlation structures between y_i and α_i in our later analysis, we assume that each nation draws a pair (y_i, α_i), without replacement, from a set $S = \{(y_i, \alpha_i)\}$ with cardinality n. While this assumption excludes uncertainty over the aggregate profile of the union, it is without loss of generality with respect to our main results.[8] The expected utility gain for each nation then is

$$\mathbb{E}[S_i] = \frac{1}{n} \sum_{(y_i,\alpha_i)\in S} S_i(y_i, \alpha_i).$$

The set of efficient contributions x_i and project allocations g_i is thus the one that

[7] This benchmark is analogous to the ex-ante expected utility benchmarks used in Harstad (2005) and Barbera and Jackson (2006). Moreover, the mechanism behind our main results persists even if there is ex-ante heterogeneity, as long as some uncertainty remains and countries are identical with respect to the remaining uncertainty.

[8] If y_i and α_i are drawn independently, multiple aggregate union profiles are possible. Associated with each profile, and with each (y_i, α_i) pair within a profile, is a corresponding surplus S_i. Denote with $\{S_i\}_n$ the ordered set of surpluses associated with each feasible union profile $(y_i, \alpha_i)^n$ and take $\mathbf{S}$ to be the set of all $\{S_i\}_n$. Let m be the cardinality of $\mathbf{S}$. Since each profile is equally likely, and each country has an equal probability of being assigned to each pair, the expected utility surplus of the union is equal to $\sum_{\{S_i\}_n \in \mathbf{S}} \frac{1}{m} \sum_{S_i \in \{S_i\}_n} \frac{1}{n} S_i$. Full ex-ante efficiency then specifies that the inner sum, which is equal to aggregate ex-post utility, is maximized for each feasible union profile, which corresponds exactly to the problem (7) through (12).

solves:

$$\max_{\{c_i,x_i,g_i\}_{i=1,\dots,n}} \sum_{i=1}^{n}[u(c_i) + v(g_i + \sum_{j\neq i} \alpha_j g_j)] \tag{7}$$

$$s.t. \quad c_i + x_i \leq y_i \quad \forall i \tag{8}$$

$$\sum_i x_i = X \tag{9}$$

$$\sum_i g_i \leq X \tag{10}$$

$$x_i \geq 0 \quad \forall i \tag{11}$$

$$g_i \geq 0 \quad \forall i. \tag{12}$$

Note that this formulation does not imply that we look at utilitarian social welfare. Maximizing the expected individual payoff for each nation *coincides* with maximizing the aggregate utility surplus of the union only because we assume ex-ante identical nations.[9] The optimality conditions to this problem imply the following definitions of potential efficiency benchmarks:

Definition 1 (Efficiency Benchmarks)

(I) *Given a total budget X, a set of individual contributions $\{x_i\}$ is called* BUDGETARY EFFICIENT *if*

$$\begin{aligned} u'(y_i - x_i) &= u'(y_j - x_j) \quad \forall i,j \text{ whenever } x_i, x_j > 0 \\ u'(y_i) &\geq u'(y_j - x_j) \quad \forall i \text{ whenever } x_i = 0. \end{aligned} \tag{13}$$

(II) *Given a total budget X, a set of project allocations $\{g_i\}$ is called* ALLOCATIVE EFFICIENT *if*

$$\begin{aligned} v_i' + \alpha_i \sum_{j\neq i} v_j' &= v_j' + \alpha_j \sum_{i\neq j} v_i' \quad \forall i,j \text{ whenever } g_i, g_j > 0 \\ v_i' + \alpha_i \sum_{j\neq i} v_j' &\geq v_j' + \alpha_j \sum_{i\neq j} v_i' \quad \forall i \text{ whenever } g_j = 0 \\ \sum_i g_i &= X. \end{aligned} \tag{14}$$

(III) *A set of contributions and allocations is called* SOCIALLY EFFICIENT *if it is budgetary and allocative efficient and the size of the total budget X is such*

[9] All our results remain true even if countries were ex-ante heterogenous, as long as some uncertainty remains and countries face the same probability distribution over that remaining uncertainty. In that case, the efficiency benchmark would not coincide with maximizing a Utilitarian welfare function.

that

$$u'(y_i - x_i) = v_i' + \alpha_i \sum_{j \neq i} v_j' \quad \forall i. \tag{15}$$

Budgetary efficiency (I) prescribes that contributions should be diverted where it is least costly in terms of forgone consumption, whereas *allocative efficiency* (II) requires funds to be spent such that the union makes best use of all available technologies. Both benchmarks describe technological aspects of efficiency. *Social efficiency* (III) on the other hand also dictates the size of the centralized budget. Since union-level spending is the only channel for inter-country redistribution available, concerns regarding the redistribution of *income*, rather than gains from coordination, pin down the optimal budget size. However, the size of the budget might be limited by ex-post political constraints on the degree of redistribution within the union. Therefore, we focus on the first two dimensions of efficiency defined for *any* given budget. If an allocation satisfies both (I) and (II), we refer to it as efficient. The reader may interpret the size of the union budget X compared to aggregate GDP among the countries as a measure of importance of the intended union.[10] Because the total budget X is set exogenously, and since utility is separable between the consumption good and public goods projects, the definitions of budgetary (I) and allocative (II) efficiency are not connected. Either benchmark could be reached without the other being satisfied.

It is important to note that at the efficient allocation, i.e. the one all union members would like to commit to ex-ante, there is no connection between what each specific country contributes to the budget and how much is allocated to its preferred project. However, when nations bargain, we will see that there is a link between their contributions and the allocation. Naturally, contributions influence the bargaining position of each nation. This is the source of inefficiency at the heart of this paper. In what follows we will discuss how exactly the bargaining process between nations distorts the two efficiency margins and derive conditions under which the bargaining outcome achieves the constitutional goal of the union.

[10] Note, however, that setting the total union budget exogenously does not mean that participation constraints are assumed to hold exogenously as well. In the bargaining process analyzed below, the outside option for every nation remains to withdraw from the union and consume all income domestically, regardless of whether the budget is determined exogenously or through a bargaining process. Therefore, the results we present in the following section all extend to the case where countries also bargain over the size of budget.

4 Analysis

In this section, we study the union's budget negotiations as an unstructured bargaining process. Unstructured bargaining is both the least complex institution for raising and allocating funds (from a political perspective), and is the institution most commonly used by the EU for fiscal spending programs. Formally, countries bargain à la Nash (1950) over the utility surplus created by the union.[11] The Nash bargaining solution is tailored to situations where no specific institutions govern the bargaining process and each participant is a veto player, and is therefore the appropriate solution concept for our model.[12]

We assume that countries have *equal ex-ante bargaining weights*, so that the resulting allocation solves the following problem:[13]

$$\max_{\{x_i,g_i\}_{i=1,\dots,n}} \prod_{i=1}^{n} [u(y_i - x_i) + v(g_i + \sum_{j\neq i} \alpha_j g_j) - u(y_i)] \tag{16}$$

$$s.t. \quad \sum_i g_i \leq X \tag{17}$$

$$\sum_i x_i = X, \tag{18}$$

as well as $x_i, g_i \geq 0$ for all i. The disagreement point is for all countries to revert to autarky and consume their individual income y_i.

With the power to veto, participation constraints gain an important role in determining the bargaining outcome. No country can be worse off in the union than it would be under autarky. Moreover, the Nash bargaining solution reflects a compromise that weighs each player's payoff in the union against his outside option. The value of the union to each player, however, is endogenous to the specific set of contributions and allocations in question. The Nash bargaining solution takes this into account - the de-facto distribution of bargaining power underlying the

[11] While Nash bargaining represents a cooperative (and axiomatic) approach to unstructured bargaining, Binmore et al. (1986) famously show that the solution of a non-cooperative, alternating-offers, bargaining game approaches the Nash bargaining solution as the time between offers approaches zero. Therefore, without an institutional structure that limits the time between offers, Nash bargaining is arguably also an appropriate solution concept for supranational bargaining under the assumption that nations use an alternating offer structure. Moreover, Chiu and Yang (1999) argue that Nash bargaining solution's sensitivity to the threat point is appropriate when the rejection of cooperation is non-binding (re-negotiable), as is arguably the case in the supranational setting.

[12] Under alternative coalition-based approaches the fundamental link between contributions and allocations that we seek to analyze would be retained. Moreover, regarding EU budget negotiations, veto power is a realistic assumption.

[13] The Nash bargaining solution assumes that agents bargain over a convex set of utility outcomes. As noted in Conley and Wilkie (1996), however, the set of utility outcomes is not generally convex when spillovers are present. In Appendix A, we prove that the Nash bargaining solution extends to the relevant non-convex sets.

bargaining process that leads to the Nash bargaining solution is endogenous.

For example, suppose that a proposed contribution schedule specifies a larger contribution for one country than another, even though they have the same income. For the former not to veto such a schedule, a disproportionate amount of funds must be allocated to its preferred - albeit not necessarily more efficient - project. The higher contribution increases that nations outside option and so its de facto bargaining position when negotiating the allocation of funds. This link of contributions to allocations via the implied bargaining power is an important source of inefficiency that has not been previously explored.

We analyze the problem as if nations were choosing both contributions and allocations simultaneously. Even if nations in reality sometimes bargain first over contributions and then separately over allocations, we are interested in situations where their outside option in the second step remains to withdraw from the union and consume their contribution. Then, a two-step procedure would not break the link between contributions and the nations' bargaining positions in the second step. It is easy to verify - assuming nations choose subgame-perfect strategies in the first step - that the resulting allocation is indifferent to whether the analysis is done in one or two steps. In this respect our setup differs crucially from the bargaining games analyzed by Harstad (2005), where contributions from the first stage are fixed in the second stage and create a hold-up effect that influences the incentive structure of the whole game.

We do not model the bargaining process explicitly. However, the Nash bargaining solution and hence the distribution of surpluses reflects the underlying bargaining position of each nation. Hence, we can interpret the set $\{S_i\}$ as a statistic about the implied bargaining positions. Naturally, this setup does not allow us to explicitly measure bargaining power. Instead we analyze how changes in the underlying parameters affect the distribution of surpluses and thus imply relative changes in bargaining positions. With that caveat in mind, we refer to the bargaining positions implied by the primitives of the model as bargaining power.

4.1 Bargaining over Allocations

We start by solving only a subpart of the full problem to illustrate the main source of inefficiency. Taking the set of contributions as exogenously given, but maintaining the outside options for nations to withdraw them, will illustrate the respective connection between budgetary contributions (x_i) and technological contributions (α_i) to the implied bargaining position.

Suppose that two countries, $i = a, b$, bargain only over allocating funds to the set of projects $\{g_a, g_b\}$, while their contributions $\{x_a, x_b\}$ to the union budget are

fixed ex-ante. In this case, the bargaining problem simplifies to:

$$\max_{\{g_a, g_b\}} (S_a)(S_b) \tag{19}$$

$$s.t. \quad g_a + g_b \leq X. \tag{20}$$

Since Nash bargaining selects among the set of ex-post Pareto optimal points, constraint (20) is binding. The resulting maximization problem is concave, which allows us to use the first-order-conditions to implicitly solve for the equilibrium level of g_a and g_b:

$$\frac{(1-\alpha_b)v_a'}{(1-\alpha_a)v_b'} = \frac{S_a}{S_b}. \tag{21}$$

Equation (21) illustrates some basic properties of the bargaining solution. It states that the allocation the two nations will compromise on will not equalize the marginal returns of the two union projects unless $S_a = S_b$ (a special case we discuss below). Instead, the Nash bargaining outcome represents a balance between efficiency (equalizing the marginal returns of the projects) and bargaining power, which depends on the players' outside options and thus their contributions. This illustrates the main insight: Since outside options influence bargaining power, the bargaining process generally distorts efficiency.

Equation (21) clearly illustrates the correspondence between the primitives of the model and the implied distribution of bargaining power. First, equation (21) implies a positive relationship between x_a and g_a, since S_a is decreasing x_a and v_i' is decreasing in g_i. It is not always obvious, however, which player has the larger bargaining power and will tilt the allocation toward his preferred project. Bargaining power is also an increasing function of the project spillovers α_i since, by equation (21), an increase in α_a results in a higher ratio of S_a and S_b.

To explore the relationship between contributions, spillovers and efficiency, suppose countries are symmetric, i.e. $y_a = y_b = y$ and $\alpha_a = \alpha_b = \alpha$. However, their contributions to the joint budget are exogenously set to differ such that $x_a > x_b$. The efficient allocation of the joint funds would be $g_a = g_b = g$, regardless of the difference in contributions, implying

$$\frac{(1-\alpha_b)v_a'}{(1-\alpha_a)v_b'} = \frac{(1-\alpha)v'}{(1-\alpha)v'} = 1. \tag{22}$$

At this allocation, surpluses S_a and S_b would be

$$S_a = u(y - x_a) + v((1+\alpha)g) - u(y) < u(y - x_b) + v((1+\alpha)g) - u(y) = S_b, \tag{23}$$

so that $S_a/S_b < 1$. Thus, condition (21) is not satisfied at the efficient allocation.

The Nash bargaining outcome in this case would be such that $g_a > g_b$ and thus inefficiently allocate too much to project g_a. Nation a's larger opportunity cost of participating in the union increases its relative bargaining position, and it is able to skew the allocation in its favor.

Similarly, suppose countries are symmetric in incomes and contributions, but not project spillovers; i.e. $y_a = y_b = y$, $x_a = x_b = x$, and $\alpha_a > \alpha_b$. The efficient allocation of the joint funds in this case specifies $g_a^* > g_b^*$ so that the marginal returns of both projects are equalized: $(1-\alpha_b)v_a' = (1-\alpha_a)v_b'$. At this allocation, $S_a > S_b$.

As equation (21) demonstrates, if countries are otherwise symmetric, the Nash bargaining outcome does allocate more to the higher spillover project ($g_a > g_b$). At the efficient allocation, however, since $(1-\alpha_b)v_a' = (1-\alpha_a)v_b'$ the following expression would hold:

$$\frac{(1-\alpha_b)v_a'}{(1-\alpha_a)v_b'} < \frac{S_a}{S_b}, \tag{24}$$

which when compared to equation (21) demonstrates that despite skewing the allocation towards g_a, the Nash bargaining outcome still under-funds g_a: i.e. $g_b < g_a < g_a^*$.

The discussion in this section highlights the two channels through which the primitives of the model influence the bargaining outcome. The implied distribution of bargaining power is determined both by the utility values of the nations' contributions and the spillovers of their projects. In what follows, we show that this sensitivity of the outcome to the distribution of bargaining power among the players generically distorts efficiency.

4.2 Joint Bargaining over Funds and Allocation

We proceed by formally analyzing the full bargaining setup over both contributions to the joint budget and its allocation to the union projects. For expositional simplicity, we present the main results for the special case of $n = 2$ countries. All formal proofs are done for a general number of countries in the appendix.

The allocation that solves the general Nash bargaining problem (16) through (18) for two countries is characterized by the following conditions for optimality:

$$\frac{u_a'}{u_b'} = \frac{S_a}{S_b} \tag{25}$$

$$\frac{v_a'}{v_b'} = \frac{(1-\alpha_a)}{(1-\alpha_b)}\frac{S_a}{S_b} \tag{26}$$

$$g_a + g_b = X \tag{27}$$

$$x_a + x_b = X. \tag{28}$$

We first discuss two special cases when the Nash bargaining solution does achieve

general efficiency. Their existence is remarkable, because they depict conditions under which a union of countries achieves an efficient allocation simply through unstructured bargaining. That is, under some conditions, simply sitting in a room and negotiating a compromise works at least as well as any other more structured institutional setup could.

Proposition 1 (Efficiency under special conditions)
For any budget X, the Nash bargaining solution satisfies both budgetary and allocative efficiency, if

a) countries are ex-post perfectly symmetric, i.e. $y_a = y_b$ *and* $\alpha_a = \alpha_b$*, or*

b) preferences are quasi-linear in domestic consumption, i.e. $U_i = c_i + v(g_i + \alpha_j g_j)$.

Perfect symmetry implies equal opportunity costs for all players and so leads to a perfectly uniform distribution of bargaining power in equilibrium. Thus, at this particular point, the Nash bargaining solution coincides with the efficient allocation. Quasi-linear preferences, on the other hand, reduce the effect of opportunity costs of funds on the bargaining position of each player to a simple linear relationship, so that *budgetary* efficiency ($u'_a = u'_b$) is met regardless of the domestic consumption allocation. The Nash bargaining solution then simply sets the allocation that maximizes the total surplus and uses contributions to split the utility surplus.

A third scenario of efficiency may arise in corner solutions, which we discuss in detail in Appendix B.2, but exclude from the following analysis. Suppose from now on that $u(\cdot)$ is strictly concave.

Proposition 2 (Inefficiency from bargaining)
Generically,

a) the efficient allocation cannot be supported as a Nash bargaining solution;

b) the Nash bargaining outcome distorts both budgetary and allocative efficiency;

c) the Nash bargaining solution redistributes resources, i.e. $x_i \neq g_i$.

Efficiency requires the allocation of available resources to the highest return technologies. Ideally, marginal returns of all union projects are equalized and funds raised where it is least costly, without regard of each country's individual gain. When bargaining, however, each individual country considers its own surplus only. How well it is able to push for its preferred allocation depends on its relative bargaining position toward the other players. The efficient allocation of funds, on the other hand, almost never implies a ratio of surpluses consistent with the implied distribution of bargaining power, because it doesn't take into account how differences in income or the spillover effects of projects benefit one country more than another.

Given the efficiency results derived above, the outcome of an unstructured bargaining process may sometimes not be very far from efficient. However, in the commonly relevant case where the asymmetry in terms of income and spillovers of the proposed projects is not extreme, both margins of efficiency are distorted. This complicates the direct measurement of inefficiency and thus the comparison of different scenarios. In fact, the Nash bargaining solution is not monotone with respect to changes in asymmetry in either income or spillovers.

To nonetheless gain some intuition about the order of magnitude of inefficiencies, we numerically explore different scenarios of parameter combinations for a simple example with the following form of log-preferences:

$$U_i = log(c_i) + log(g_i + \alpha_j g_j) \quad \text{for } i = a, b.$$

The following simulations confirm that inefficiencies grow more than proportionally with the degree of asymmetry between nations. Moreover, we show that the distortion is more severe on the allocation margin when asymmetry is in terms of incomes (experiment 1), but more severe on the contribution margin if spillovers are asymmetric (experiment 2).

Experiment 1 - income asymmetry

Suppose spillovers are symmetric, i.e. $\alpha_a = \alpha_b$. Keeping aggregate income constant, we vary asymmetry in domestic incomes. Figure 1 shows the Nash bargaining outcome compared to the generally efficient solution. As country a's income increases, so does its outside option and thus its bargaining position relative to country b in equilibrium, leading to an inefficient outcome. The allocation of funds to the union projects (left panel) depicts this channel very clearly: While the efficient allocation is independent from the distribution of national incomes, the Nash bargaining solution reflects the changing distribution of power. Nation a is able to tilt the allocation more toward its own preferred project the higher its income. Moreover, it is able to negotiate a "discount" for its contribution. While x_a increases with y_a, country a pays less than would be budgetary efficient given its higher income (right panel).

Experiment 2 - spillover asymmetry

Suppose domestic incomes are symmetric, i.e. $y_a = y_b$, but the spillover effects of the projects vary. The change in technology has a direct impact on aggregate utility at the efficient solution. For a meaningful comparison between the efficient and the Nash bargaining solution, we vary spillovers such that aggregate utility remains constant.[14] Figure 2 shows similar results as before: Here, as α_b increases, funds should efficiently be re-allocated toward project g_b, while contributions should

[14] Appendix B.5 explains the setup of this exercise in more detail.

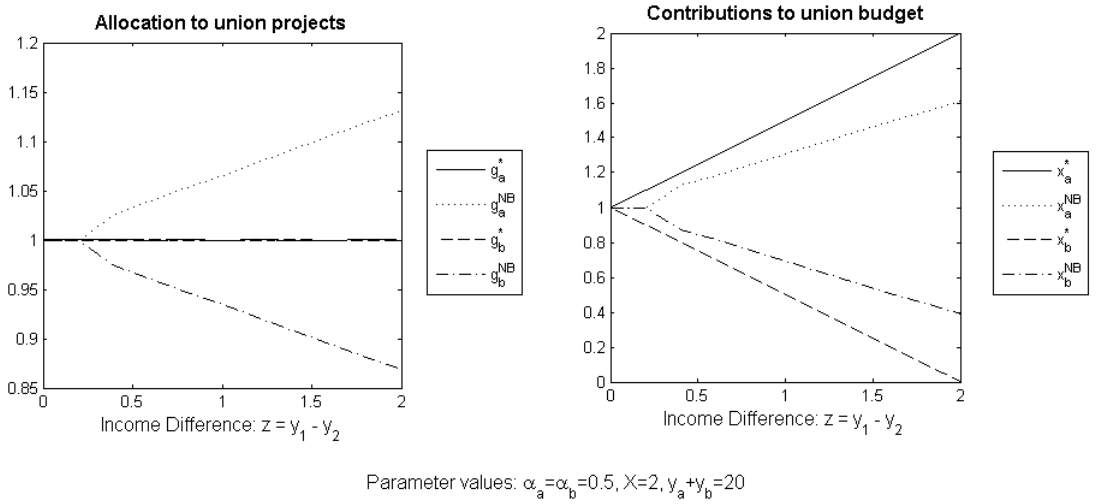

Figure 1: Asymmetry in income

remain unchanged. At this efficient allocation, however, nation a's surplus would be smaller than nation b's,[15] leading to a increase in bargaining power of nation a relative to nation b. Consequently, the outcome of the bargaining process is again skewed in a's favor. The contributions of country a decrease away from the efficient level (right panel) and at the same time the allocation of union funds tilts toward a's preferred project $g_a > g_a^*$ (left panel).

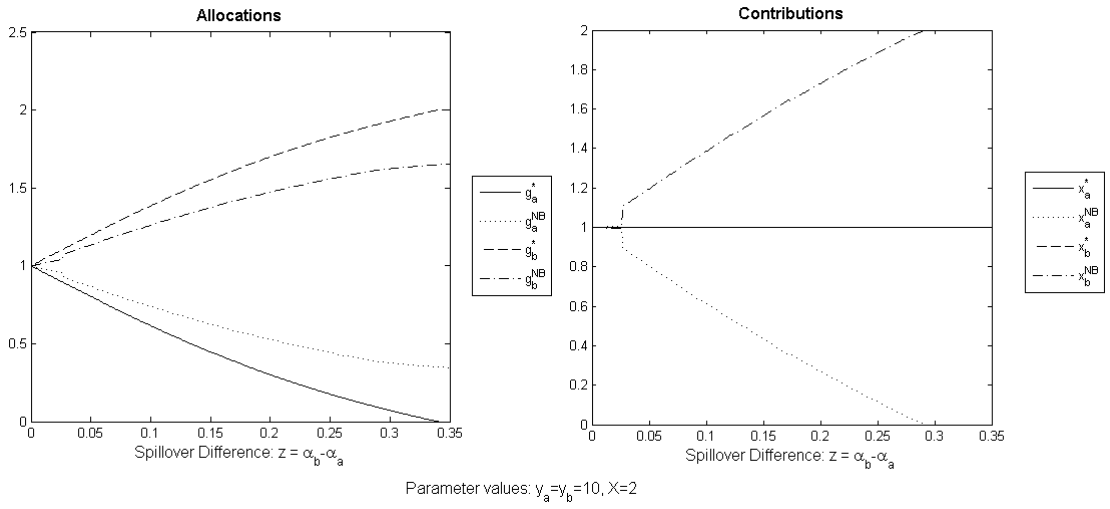

Figure 2: Asymmetry in spillovers

Experiments 1 and 2 illustrate the intuition that greater asymmetry results in less efficient fiscal outcomes. This pattern is particularly pronounced when income and spillovers are negatively correlated. When the high spillover project is located in

[15] This follows since at the efficient allocation $v_a'(1-\alpha_b) = v_b'(1-\alpha_a)$, so that with $\alpha_a < \alpha_b$ we get $v_a < v_b$.

the low-income country, there is a strict tension between the two efficiency margins: efficiency on the contribution margin entails that the high-income country shoulders a greater share of the budget, which implies that too much spending will be diverted to the high-income country's low productive project.

The data on EU structural funds show precisely this pattern: while contributions to the budget are increasing in income, rich nations still receive large amounts of the funds meant to promote convergence within the union. As illustrated by the quotes in the introduction, this is a much criticized characteristic of EU fiscal spending. However, our model explains that such a pattern of "recycling of resources" in rich member countries is not simply a consequence of an "inefficient" political process; instead we show that the lack of commitment inherent in the supranational setting leads to a tradeoff between efficiency on the contribution and allocation margin. Simply put, inefficient spending in rich countries is necessary to compensate them for paying a larger share of the budget. Moreover, this is true for any budget size, implying that these inefficiencies cannot be eliminated by simply decreasing the size of the budget (as suggested by Boldrin and Canova (2001)).

4.3 Comparative Statics

First, we explore the effect of union size on the efficiency of allocations. Formally, we define the size of the union in terms of a general vector of potential member countries:

Definition 2 (Union Size)
Take Z to be an infinite ordered sequence of countries: $Z = \{(\alpha_1, y_1), (\alpha_2, y_2), ...\}$. A union of size n consists of a union of the first n countries in Z.

This definition allows us to characterize the effect of union size for any constellation of union members.

The following proposition illustrates the positive effect of size on allocative efficiency:

Proposition 3 (Efficient allocation in large unions)
For any sequence of countries, Z, there exists an N such that for any union of size $n \geq N$, unstructured bargaining yields ALLOCATIVE *efficiency.*

Proposition 3 suggests that large unions are better able to allocate funds, a result that obtains because adding additional countries increases the relative benefit of allocation to high-spillover projects. Another way to characterize the result is that adding additional countries to the union increases the relative bargaining power of countries with high spillover projects. This interpretation implies that, as the union grows, it will stop funding the most inefficient projects.

Next, we analyze the effect of increasing the union budget on allocations and contributions. Figure 3 provides an illustration when the more efficient project is located in (left-to-right) the low and high-income country.

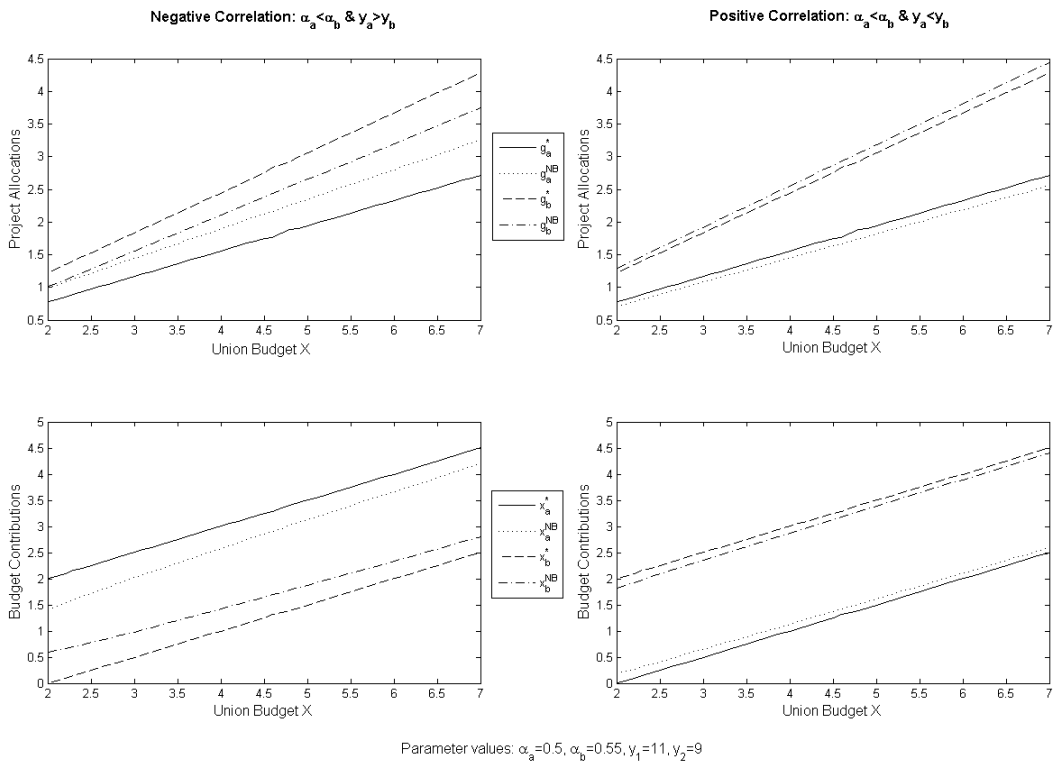

Figure 3: Increasing the union budget

Generally, as long as the Nash bargaining solution is not a corner (i.e. all countries contribute something to the budget and receive some funding for their project, as is the case in the EU) a marginally increased budget will be spent on all projects. This implies that spending on inefficient projects will increase as overall spending grows. However, how the spending *ratios* change is highly dependent on the parameter constellation. In Figure 3, note that spending on the high-income country's project is increasing at a faster rate than spending on the low-income country's project, as the high-income country shoulders a greater share of the (larger) budget; proportionally, this implies that spending on the inefficient project increases with the budget when the high-spillover project is located in the low-income country.

In case of a negative correlation between income and spillovers (left column), increasing the budget will also result in utility convergence. While letting the richer nation (here nation a) contribute more to the joint budget may seem desirable in terms of the EU's convergence objective, it will necessarily bargain for a higher allocation of funds to its own preferred, but relatively less valuable, project. In case of a positive correlation (right column), the outlook might be more positive: Here, at least contributions to the union budget will converge towards the efficient levels.

5 Discussion: Implications for the EU

The theoretical framework we analyze above enables us to characterize the inefficiencies in fiscal spending observed in the EU as a result of the inherent autarchic nature of supranational governance. Linking inefficiencies to the underlying bargaining structure also allows us to provide insight into how institutions might be designed to alleviate them. If member nations have access to partial commitment, in terms of committing to alternative structures for bargaining over the allocation of the budget, then the bargaining outcome can be improved.

For example, as the EU has expanded from the original six nations to the current 28, there has been a concurrent evolution of decision making rules. Specifically, the EU has transitioned from unanimity to qualified majority rule in many areas of competency, although the allocation of the structural and cohesion funds still requires unanimity among all member nations. Majority rule in fiscal matters can be welfare improving since it breaks the link between contributions and allocations, at least for the nations in the minority. In a working paper version (Simon and Valasek (2013)), we show that majority rule over fiscal spending can improve efficiency as long as nations with high spillover projects are endogenously selected into the majority coalition. Our analysis shows that a randomly-selected formateur will select a majority coalition containing the high spillover nations as long the contributions to the budget by these members is also relatively low. Therefore, majority rule might be an appropriate institution when income and spillovers are negatively correlated.

The EU might also benefit from enforcing rules specifying contributions as a function of national income (such rules exist, but as we discuss in the introduction, are easily and often circumvented). In Simon and Valasek (2013), we show that an exogenous tax rule may indeed improve overall efficiency when compared to a fully unstructured bargaining process. Specifically, such a rule improves efficiency on the contribution margin, forcing wealthier members to pay more. At the same time, however, for countries with high incomes and projects with low social returns, this will necessarily lead to a less efficient allocation of funds. We show that the efficiency-equality trade-off inherent in the bargaining outcome over allocations will always distort the equity (budget) margin relatively more than the efficiency (allocation) margin. Therefore, an exogenous tax rule that shifts contributions away from the bargaining outcome and towards the efficient contributions will improve overall efficiency.

In the context of adopting more efficient institutions, it is important to note that Nash bargaining is an "absorbing state" after the constitution stage, in the sense that it is ex-post Pareto efficient and member nations will therefore never unanimously approve a *switch* to an alternative institution. Therefore, the discussion

of alternative institutions is particularly relevant when considering new institutions that increase fiscal spending at the union level, such as the proposed EU growth pact. That is, if unstructured bargaining is used initially, even though a majority rule is preferable and implementable relative to the status quo, the opportunity for the EU to adopt a more efficient institution is lost.

Another factor that affects the efficiency of the allocation of the budget is the size of the union. As detailed in Proposition 3, when more nations are added to the union, the return on high-spillover projects increases, shifting the resource allocation towards the efficient outcome. Rodríguez-Pose and Novak (2013) point to evidence that structural fund spending has been more successful in promoting growth after the expansion from 15 to 25 member, casually in line with the prediction that the efficiency of allocation will improve in a larger union. However, this channel has limited scope for decreasing inefficiency as the number of potential entrants are limited, and new countries might contribute to more heterogeneity within the EU, counteracting the benefits of scale.

Lastly, and perhaps most importantly, we would like to emphasize that the inefficiencies we highlight here only describe a static setting, where income inequalities are fixed. When assessing the overall desirability of fiscal spending at the EU level, however, it is important to also take into account dynamic considerations. Crucially, we have shown that inefficiencies in EU spending stem from hetrogeneity in income levels: As evidenced in Proposition 1, fiscal spending is fully efficient in a union of nations with homogenous incomes, even when they differ with regard to their relative efficiency in public goods spending. Therefore, convergence, one of the prime goals of EU fiscal spending, will mitigate the inefficiencies of fiscal spending at the supranational level.

The evidence on the effect of EU fiscal spending on convergence is mixed: EU reports highlight overall economic convergence as support for its programs (Barca (2009)), but more in-depth studies of the effect of the structural and cohesion funds on growth have produced results ranging from highly positive to negative (for a prominent critique, see Boldrin and Canova (2001)), often depending on the "a priori positions held by different researchers" (Rodríguez-Pose and Novak (2013)). Additionally, researchers have highlighted that separating the effect of structural fund spending on growth from other factors is a difficult empirical challenge, and pointed out that structural policy takes time to produce measurable results (Begg (2010)).

Under the assumption that fiscal spending at the EU level does indeed directly promote income convergence, even an inefficient centralized budget can promote convergence to the efficient outcome. While a full dynamic model is beyond the

scope of this paper, intuitively, if y_i^t is an increasing and concave function of g_i^t, then the endogenous pressure for higher fiscal spending to low income countries directly contributes to convergence. Therefore, when viewed in a dynamic context, greater spending may increase inefficient spending in the short-run, but may at the same time speed up the process of income convergence, allowing the nations in the EU to realize the full gains of centralized fiscal spending in the long run.

6 Conclusion

A prime justification for centralizing policies at the supranational level under the framework of the European Union is that centralization allows member countries to access benefits of scale and coordination not available to each nation individually. But while such benefits from centralization may exist, our analysis shows that there is an inherent efficiency loss due to the autarkic nature of supranational governance and the budget negotiations that follow. The key element in our analysis is that nations retain the outside option of exiting the union and consuming their contributions, as in the EU bargaining process. This leads to a distribution of bargaining power over allocations that is endogenous to individual contributions to the budget, which produces a link between contributions to and allocation of a joint budget that was previously unexplored. Moreover, this link arguably explains inefficiencies observed in EU fiscal spending as a function of the underlying supranational setting, rather than as simply an outcome of an "inefficient" political process.

The results of our model are also remarkably suggestive of the reality of fiscal spending of the European Union today. In particular, we find that the unstructured bargaining will result in high income countries shouldering a disproportionate share of contributions to the budget, which in turn implies inefficient spending on low-priority projects in those countries (e.g. art galleries in the UK). Additionally, as long as member nations are not too asymmetric, a larger budget will result in increased spending on inefficient projects. We emphasize that these results do not imply that the EU budget should not be increased: Perhaps the most interesting takeaway of our analysis from a policy perspective is that inefficiencies in supranational fiscal spending will disappear as national per-capita incomes converge. Therefore, to the extent that spending speeds up convergence, increasing the budget might be *dynamically* efficient.

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Appendix

A Nash Bargaining over Non-Convex Sets

The Nash bargaining Problem asks how individuals "who have the opportunity to collaborate for mutual benefit" (Nash (1950)) divide the utility gained through collaboration. Nash (1950) proved that there exists a unique solution to this problem that is: independent of the cardinality of the utility functions, gives a Pareto optimal outcome, symmetric, and independent of irrelevant alternatives. Moreover, he shows that the bargaining solution maximizes the product of the individual utility surpluses from cooperation: this division of utilities is know as the Nash bargaining Solution.

Nash's original proof of the Nash bargaining Solution was limited to bargaining over a convex set of utility outcomes, S. A set of papers extend the Nash bargaining (NB) Problem to non-convex sets by imposing alternative axioms (Herrero (1989), Conley and Wilkie (1996), Zhou (1997)). This appendix takes an alternative approach: we show that the NB solution holds on a relevant set of non-convex sets utility outcomes. Specifically, we weaken the convexity constraint in Nash's seminal paper to the following:

Convexity Constraint: The convex hull of the set of Pareto outcomes is in S.

The following Theorem shows that Nash's standard bargaining solution holds on this more general set of utility outcomes.

Theorem 1

There exists a unique set of utilities, $\{u_1^*, u_2^*\}$, that satisfy the Nash bargaining axioms. Moreover, $\{u_1^*, u_2^*\}$ is the unique maximum of $u_1 u_2$.

Proof: Since S is compact there exists a $\{\hat{u_1}, \hat{u_2}\}$ in S that maximizes $u_1 u_2$. Without loss of generality, we renormalize $\{\hat{u_1}, \hat{u_2}\}$ to $\{1, 1\}$. In Nash's original setup, where S is convex, two results would trivially follow:

Claim 1: $\{\hat{u_1}, \hat{u_2}\}$ is the unique maximum of $u_1 u_2$ in S.

Claim 2: There does not exist $\{u_1', u_2'\}$ in S such that $u_1' + u_2' > 2$.

Here we prove that claim 1 and claim 2 still hold given our weakened convexity constraint. We start with claim 2.

Proof of claim 2: First, we show that $\{1, 1\}$ is in the set of Pareto outcomes, which we label P. By contradiction, if $\{1, 1\}$ is not in P, then there is a point in S, $\{\check{u_1}, \check{u_2}\}$ with $\check{u_1}, \check{u_2} \geq 1$, and either $\check{u_1} > 1$ or $\check{u_2} > 1$. Since $\check{u_1}\check{u_2} > 1$, $\{1, 1\}$ does not maximize $u_1 u_2$.

Next, note that if there exists a $\{u_1', u_2'\}$ in S such that $u_1' + u_2' > 2$, then there also exists $\{u_1'', u_2''\}$ such that $u_1'' + u_2'' > 2$ and $\{u_1'', u_2''\} \in P$: if $\{u_1', u_2'\} \notin P$, then there exists some exists $\{u_1'', u_2''\} \in P$ such that $u_1'' + u_2'' > u_1' + u_2' > 2$. Lastly, since $u_1'' + u_2'' > 2$ there is a convex combination of $\{u_1'', u_2''\}$ and $\{1, 1\}$ such that $u_1 u_2 > 1$. And since $\{u_1'', u_2''\}$ and $\{1, 1\}$ are both in P, and the convex hull of P is in S, this convex combination is also in S, which contradicts the fact that $\{1, 1\}$ maximizes $u_1 u_2$.

Proof of claim 1: Assume $\{u_1', u_2'\}$ maximizes $u_1 u_2$ on S, i.e. $u_1' u_2' = 1$. Claim 2 shows that $u_1' + u_2' \leq 2$. Substituting in for u_2' gives $u_1' + \frac{1}{u_1'} \leq 2$, which, after some algebra, gives $(u_1' - 1)^2 \leq 0$. This equation is only satisfied when $u_1' = 1$, which in turn implies that $u_2' = 1$.

This completes the proof; given Claim 1 and Claim 2 the result follows from Nash's original proof. □

Theorem 1 gives the following result, which proves that the Nash bargaining model hold in our model.

Corollary 1

The Nash bargaining Solution maximizes:

$$\max_{\{x_i, g_i\}_{i=1,\ldots,n}} \prod_{i=1}^{n} [u(y_i - x_i) + v(g_i + \sum_{j \neq i} \alpha_j g_j) - u(y_i)] \tag{29}$$

$$s.t. \sum_i g_i = \sum_i x_i \tag{30}$$

Proof: The Pareto set is the set of g_i's such that $\sum_i g_i = \sum_i x_i$. Since $v(\cdot)$ is concave and $\partial v(g_i + \sum_{j \neq i} \alpha_j g_j)/\partial g_i > \partial v(g_i + \sum_{j \neq i} \alpha_j g_j)/\partial g_j$ for any combination

of g_i's and for all $j \neq i$, the convex set of the Pareto set is contained within the set of utility outcomes that are achievable with budget $\sum_i x_i$. □

B Proofs

We present all propositions and their proofs for the general case of n countries. The Nash bargaining solution for general n is characterized by:

$$\frac{u_i'}{u_j'} = \frac{S_i}{S_j} \qquad \forall i, j \tag{31}$$

$$v_i'(1-\alpha_j) = v_j'(1-\alpha_i)\frac{S_i}{S_j} - (\alpha_i - \alpha_j)\sum_{k \neq i,j} v_k' \frac{S_i}{S_k} \qquad \forall i, j \tag{32}$$

$$\sum_{i=1} g_i = X \tag{33}$$

$$\sum_{i=1} x_i = X \tag{34}$$

where again $S_i = u(y_i - x_i) + v_i - u(y_i)$ denotes the surplus generated for country $i = 1, ..., n$ respectively.

Note that equation (31) remains the same as in the two-country case (compare to equation (25)), implying that the relative split of utility surplus between country i and country j is still determined by the ratio of their marginal utilities from domestic consumption. Equation (32), which defines the relative allocation of funds between countries i and j, however, has the additional term $[(\alpha_i - \alpha_j)\sum_{k \neq i,j} v_k' \frac{S_i}{S_k}]$. This shows that the relative allocation of funds reflects the impact of country i's spillovers on all other countries, not just country j.

B.1 Efficiency under special conditions (Proposition 1)

Part 1: *If countries are perfectly symmetric, i.e. $y_i = y_j$ and $\alpha_i = \alpha_j$ for all i, j, then, for any intended budget X, the Nash bargaining solution coincides with the efficient allocation.*

In case all n nations are perfectly symmetric, the definitions (I) and (II) imply efficient contributions and allocations $x_i = x_j = x$ and $g_i = g_j = g$ for all i, j, which exactly achieves $S_i = S_j$ for all i, j.

Then the equations in definition (I) and definition (II) are the same as 31 through 34 characterizing the Nash bargaining solution, so that the allocations are identical. □

Part 2: *If preferences are quasi-linear in domestic consumption, i.e. $U_i = c_i +$*

$v(g_i + \alpha_j g_j)$, then, for any intended budget X, the bargaining solution coincides with one efficient allocation.

With quasi-linear preferences, condition 31 reduces to $S_i = S_j$ for all i, j, so that in turn conditions 32 through 34 exactly coincide with the efficiency conditions in definitions (I) and (II). □

B.2 Corners (Lemma 1)

In this subsection we address corner solutions. If, for example, spillovers are very asymmetric, it may happen that it is efficient to fund only one of the projects. Equivalently, very asymmetric domestic incomes may call for the union activities being funded by the richest country exclusively. It turns out that the Nash bargaining solution can, in some cases, achieve these efficient corners[16] as well, even though neither conditions of Proposition 1 *a*) or *b*) are satisfied.

Lemma 1 (Corners)
There exist Nash bargaining corner solutions that are budgetary and/or allocative efficient.

We simply proof this lemma by example. Suppose preferences are

$$U_i = log(c_i) + log(g_i + \alpha_j g_j) \quad i = a, b$$

and parameters $y_a = 10$, $y_b = 5$, $X = 2$, $\alpha_a = 0.9$, and $\alpha_b = 0.1$. Then, both the efficient allocation and the Nash bargaining solution specify $x_a = 2$, $x_b = 0$, $g_a = 2$, and $g_b = 0$. Examples with just a corner in contributions or allocations can be constructed similarly.

The lemma states that there can also be efficient "double corners" where the complete budget is provided by only one country *and* allocated to only one project. We do not consider this case to be particularly relevant or interesting,[17] and therefore exclude it from the subsequent analysis.

[16] It should be noted again, though, that efficient corners only arise because contributions and projects are restricted to be non-negative. At an efficient corner solution, marginal utilities are not equalized, as described in the efficiency definitions (I) and (II).

[17] There are two scenarios that constitute a "double corner": The first is when the same country contributes *and* receives the complete budget. This case maps to a classic public good problem and union dynamics do not play a role. The second scenario has one country contribute the complete budget and another country receive all the funds, which intuitively resembles foreign aid or foreign direct investment. Both are not relevant in the context of a supranational union of sovereign countries that is the focus of our paper. There are, however, institutional examples where some countries contribute, but do not receive funding (e.g. the EU cohesion funds), and where some countries receive funding, but do not contribute (e.g. the World Bank). Such "single corners" are not excluded from our analysis, unless otherwise noted.

B.3 Generic inefficiency (Proposition 2)

Suppose that $u(\cdot)$ is strictly concave and that parameters are such that the solution is not a "double corner".

Suppose the bargaining solution was efficient. Comparing equilibrium conditions (31) through (34) to the optimality conditions of the definitions (I) and (II) shows that the Nash bargaining solution is efficient if and only if the surpluses are exactly equal, i.e. $S_i = S_j$ for all countries. However, the efficient allocation implies $S_i \neq S_j$ almost always, which in turn implies that the bargaining solution is not efficient. We arrive at a contradiction. Exceptions may arise under specific combination of parameters where the efficient solution by coincidence exactly yields $S_i = S_j$. In any of these cases, changing any one of the parameters by $\epsilon \neq 0$ will again lead to $S_a \neq S_b$ and so to the Nash bargaining solution to not be efficient.

Moreover, if $S_i \neq S_j$ for all i, j, then both budgetary efficiency and allocative efficiency are not satisfied.

Lastly, consider the Nash bargaining problem 16 through 18 with the additional constraints that there be no redistribution, i.e.

$$x_i - g_i = x_j - g_j \quad \forall i, j \tag{35}$$

Setting up the Lagrangian and associating Lagrange multipliers μ_{ij} to these extra constraints yields

$$\mu_{ij} = \frac{1}{2}(u_b' S_i - u_a' S_j) \tag{36}$$

$$\mu_{ij} = \frac{1}{2}(v_j'(1-\alpha_i)S_i - v_i'(1-\alpha_j)S_j) \tag{37}$$

For the multiplier to be zero, the functional forms and parameters would have to exactly line up so that both terms on the right hand sides are zero simultaneously exactly at the allocation where $x_i = g_i$ for all countries i. This can only be true at points with zero mass. Whenever $\mu_{ij} \neq 0$, the Nash bargaining solution without these constraints would actually violate it, i.e. have $x_i \neq g_i$. $\square$

B.4 Union size (Proposition 3)

The proof follows from the fact that, for a union large enough, both the efficiency condition and the Nash bargaining result specify that the whole budget be allocated to the project with the highest spillovers.

First, note that in the allocative efficiency condition (definition (II)),

$$v_i'(1-\alpha_j) = v_j'(1-\alpha_i) - (\alpha_i - \alpha_j)\sum_{k\neq i,j} v_k' \quad \forall i,j,$$

the term $\sum_{k\neq i,j} v_k'$ is strictly increasing in n, and g_i is increasing in $\sum_{k\neq i,j} v_k'$ if $\alpha_i > \alpha_j$. Therefore, for an n large enough, allocative efficiency will require that $g_m = X$ for country m s.t. $\alpha_m = max\{\alpha_i\}_n$.

The same logic holds for the Nash bargaining solution:

$$v_i'(1-\alpha_j)\frac{S_j}{S_i} = v_j'(1-\alpha_i) - (\alpha_i - \alpha_j)\sum_{k\neq i,j} v_k'\frac{S_i}{S_k} \quad \forall i,j$$

□

B.5 Asymmetric spillovers: Description of the numerical experiment in section 4.2

We perform an exercise on increasing asymmetry. However, simply changing the spillovers α_i changes also the efficient solutions, and so hinders the comparison between welfare achieved by bargaining to the efficient outcome. Therefore we use the following routine to pick parameter combinations with increasing asymmetry, but constant efficient aggregate welfare.

Take $\alpha_a = \alpha$ and $\alpha_b = \alpha + z$. Fixing contributions at the efficient level (not influenced by α, only a function of incomes), take $W(\alpha) = \max_{g_a,g_b}(U_a + U_b)$; i.e. the efficient level of aggregate utility. Trivially, $W(\alpha)$ is strictly increasing in α, since aggregate utility increases as α increases even without re-optimizing g_a and g_b. Therefore, for a given budget and a given z, the α s.t. $W(\alpha) = Q$ (some constant), is unique.

This implies that, for any increasing sequence $\{z\}$, for a fixed Q and efficient contributions (x_a, x_b), there exists a unique corresponding sequence of $\{\alpha\}$, which we compute. Then, we compute the Nash bargaining solution for the parameters $\{X, \alpha, z\}$ and compare aggregate utility from Nash bargaining to Q.