

June 2026

“Bargaining over EU Budgetary Items:
Trade-offs and Marginal Valuations”

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Abstract: This paper analyzes the determinants of the EU budget bargaining process across different expenditure sections for each EU member state. The central hypothesis is that the countries may accept lower allocations in one budget section in exchange for higher shares in others. To explore this, we first develop a theoretical bargaining model that captures member states' preferences across budgetary items. We then empirically test the model using an unbalanced panel dataset covering EU member states from 1976 to 2020, estimating the marginal rate of substitution between different types of expenditure. The results reveal significant trade-offs among certain budgetary items. On average, structural funds emerged as the most valued expenditure category, followed by agricultural and natural resources policies.

Keywords: EU budget, bargaining, agricultural policy, structural funds.

JEL codes: D72; H61; O52; Q18.

1. INTRODUCTION

The European Union (EU) expenditure budget is not an inconsiderable extent of resources. In 2019, total expenditures amounted to €159,095.5 million. Each EU member must contribute to the EU budget by means of GNI-based resources, VAT-based own resources, and traditional own resources. In 2019, total EU revenues collected came to €63.917,6 million. Although the relative weight of EU budget is not so important (around 1% of EU-28 Gross National Income in 2019), it has revealed several positive and non-negligible impacts (Núñez-Ferrer and Katarivas, 2014).

Some crucial policies have been developed using EU funding. Among others, agricultural and cohesion policies have traditionally been two of the most significant policies developed through the EU budget. Structural funds in the EU budget emerge as a key instrument to foster EU cohesion objectives across EU regions and countries. Common Agricultural Policy has evolved from a policy instrument to protect farmer income levels to a more modern model compiling broader societal concerns regarding the environment or animal welfare issues (Boulanger and Philippidis, 2015).

The process of drafting and approving the EU budget involves multiple stages.¹ Throughout this process, negotiation over budgetary allocations between member states is a critical feature. Building on the foundational work of Buchanan and Tullock (1962), these negotiations are sometimes modeled as instances of logrolling—a process in which member states trade concessions across policy dimensions². That is, countries may accept losses in certain areas (typically those of lower priority) in exchange for gains in areas they value more, thereby achieving mutual benefit (Tajima and Fraser, 2001).

The aim of this paper is to study how member states express relative valuation over various expenditure categories within the EU budget and whether they engage in trade-offs between them. Specifically, we hypothesize that a country may accept a reduced share in one budget category in exchange for a larger share in another that it prioritizes. To test this hypothesis, we first present a theoretical bargaining model and then examine it empirically by estimating the marginal rates of substitution across budget items. Despite previous works have analyzed how different countries or users compete for an overall budget and allocating their shares³, no existing work has studied the outcome of the bargaining process across the shares on different budgetary items at the EU level.

¹ First, based on the multi-annual financial framework in force and yearly budgetary guidelines, the European Commission develops a preliminary draft budget. During this stage, spending priorities are set, caps on the maximum growth rate of different budgetary items and the total budget are decided. Next, the European Commission sends the draft to the Council and the Parliament. Both institutions set the final EU total budget.

² There is a growing body of theoretical and empirical literature supporting the presence of logrolling in the EU's legislative and budgetary processes. For example, Crombez (2000) develops a theoretical spatial model of logrolling within the EU, focusing on issues of efficiency and stability. Aksoy (2012) provides empirical evidence of logrolling, showing how voting rules and the dimensionality of legislation influence the likelihood of strategic vote trading. Kardasheva (2013) explores inter-chamber logrolling between the Council of Ministers and the European Parliament, demonstrating that package deals are more likely when proposals are redistributive and urgent, when institutional preferences diverge, and when negotiations involve key parliamentary leaders on multi-issue proposals.

³ For instance, Thomas and Zaporozhets (2017) assessed a bargaining model in the context of water policies.

We begin by illustrating the core idea with a simplified bargaining model, demonstrating how countries may trade off allocations across different budget categories. While the bargaining model developed in this paper does not involve explicit vote trading, its underlying logic is closely related to logrolling, as it captures how countries may accept concessions in one budgetary item in exchange for gains in another, reflecting strategic trade-offs across issues. To test this theoretical framework, we employ a data set of EU budget allocations across various budgetary items spanning the period 1976-2020. The econometric model, based on a multi-equation model, allows us to consider the connections among different shares and budget sections. The simultaneous estimation of the three budget shares is in line with the budgetary bargaining process, where any decision is made considering the budget as a whole. We observe that both regional development and agricultural funds are the most valued budget items.

This research is structured as follows. In Section 2 the theoretical model is briefly described, as well as its econometric specification. Section 3 presents the results, with a discussion of the main findings. Finally, Section 4 concludes with some policy implications related to the EU budget.

2. LITERATURE REVIEW

The allocation of the European Union (EU) budget is one of the most relevant aspects of European integration, and while its absolute size is limited, its distributive implications are profound (D'Apice, 2015). The literature on this topic is extensive, broadly dividing into needs-based explanations, political power approaches, with notable gaps in modeling trade-offs across budget items.

A core strand of research posited that EU spending aligned with stated policy objectives, prioritizing agriculturally intensive economies and regions needing economic convergence (Kauppi and Widgrén, 2004). Early studies documented strong correlations between member states' budget receipts and need indicators, such as relative purchasing power per capita (Courchene et al., 1993) or agricultural sector employment shares (Tyers, 1994; Ardy, 1996; Tangermann, 1998). Kandogan (2000) refined this vision by relating relativized budget shares for agricultural and structural funds to countries' needs in terms of upper deviations in agricultural employment (weighted by productivity) and lower GDP per capita from the EU average, capturing the size and relevance of potential voters benefiting from the corresponding policy.

Further evidence from Kauppi and Widgrén (2004), Rodden (2002), Mattila (2006), Aksoy and Rodden (2009), Aksoy (2010), Schneider (2013), Zaporozhets et al. (2016) and Mikulaschek (2018) showed net per capita transfers and gross shares decreased with GDP per capita and unemployment rates (due to reduced structural funds) but rising with agricultural labor enrollment or agricultural GVA shares (via higher CAP receipts). Schneider (2013) interpreted these variables as measures of "fair share" relative to peers, and other authors highlighted the interchangeability of gross agricultural and structural funds as a key redistribution mechanism, framing the EU budget as side payments from

trade-integration winners (developed core states) to peripheral members (Aksoy and Rodden, 2009).

Critiquing overly simplistic needs views (Kirman and Widgrén, 1995; Baldwin et al., 1997), political economy models treated the Council of the EU as utility-maximizing agents who exchanged political decisions to attain winning coalitions. Kirman and Widgrén (1995) constructed Shapley-Shubik power indices (SSI) under varied voting scenarios, arguing that "packaged" policies balancing appeals across diverse members was the optimal strategy to pass radical changes in budget allocations amid growing EU heterogeneity post-enlargements. Baldwin et al. (1997) empirically linked per capita votes and SSI to higher gross receipts, explaining that becoming pivotal country for successful decisions in the Council increased its gains from the EU budget.

Subsequent work built on these indices (Kandogan, 2000; Kauppi and Widgrén, 2004; 2007; Schneider, 2011; 2013; Zaporozhets et al., 2016) showed that SSI, normalized Banzhaf, and nucleolus indices were positively associated with agricultural, structural, and total receipts. Kandogan (2000) attributed this to voting rules that let poorer entrants tilt negotiations toward development funding, as the voting system was targeted to policy weights over the total budget, but not over its explicit distribution across countries. Schneider (2011; 2013) viewed the SSI as a proxy capturing the capacity of "loophole exploitation" during budget negotiations—via economic resources for vote-buying or administrative staff swaying via reports and build-up of relationships—while enlargements and pre-election timing amplified veto threats. Strikingly, Kauppi and Widgrén (2004, 2007) reported SSI (post-bloc controls) explaining 87-90% of receipts variation, prioritizing power over needs. Zaporozhets et al. (2016) tempered this finding by accounting for nonlinearities, heteroskedasticity, and unbalanced panels, showing that the nucleolus index equated the importance between political power and economic needs.

Another branch of studies proved that over-representation of small states in the EU Parliament and Council of Minister further skewed outcomes. Rodden (2002), Mattila (2006), Aksoy and Rodden (2009), and Aksoy (2010) demonstrated that higher weighted votes per capita, SSI per capita, and Banzhaf indices relative to population boosted absolute and relative net transfers through agricultural/structural funds, without depressing contributions, which was argued as evidence for vote-trading on the expenditure, but not on the revenue side, due to simple and transparent financing rules that made unequal treatment harder to conceal (Mattila, 2006). In fact, large states (e.g., Germany, France) traded *de facto* power for cheap support from over-represented small states (e.g., Denmark, Ireland, Luxembourg) on EU enlargements, often via fiscal transfers (i.e., agricultural and structural funds) alongside regulatory and trade favors (Rodden, 2002; Aksoy and Rodden, 2009).

To sum up, it is rather clear that both needs and political power, conditional on other factors, such as domestic politics or the rules of the voting system, explained a large extent of the variation in total transfers and the distribution of policies on the total budget. However, the literature on cross-item bargaining remains scarce. Kemmerling and Bodenstein (2006) is the only work that empirically analyzed the interchangeability between budget items. Using a cross section of 116 regions, and their allocation of funds according to the 2000-2006 Financial Perspective, they found positive, but non-

significant correlation between the perceived structural and agricultural funds per capita. They argued that despite the trade-off between structural and agricultural spending should be present, this was obscured by the heterogeneity present at that level of disaggregation.

In this sense, this study aims to fill this gap by developing theoretical and empirical frameworks to analyze the bargaining and trade-off across EU budget items (structural, agricultural and other funds). In the theoretical model, we adopt the bargaining framework of Baron and Ferejohn (1989), which provides a rigorous link between institutional design, voter incentives, proposal power, and legislative outcomes such as coalition formation and benefit allocation.⁴ While the benchmark model considers a single budget, we extend it to allow for the simultaneous negotiation of multiple budget items. To maintain tractability, we focus on a one-shot setting rather than a dynamic framework. With payoffs defined over a vector of budget shares, countries may trade off lower allocations in one dimension for higher shares in another, generating cross-budget substitutions in equilibrium even without explicit vote trading. These trade-offs have a natural interpretation in terms of marginal rates of substitution, capturing revealed preferences in the bargaining process. The model thus implies that cross-budget trade-offs arise naturally in multilateral bargaining and that preferences over expenditure categories can be inferred from observed substitution patterns.

Empirically, we use bounded budget shares, instead of per capita net transfers, satisfying aggregation constraints for clearer identification. Moreover, we leverage the largest dataset to date (1976-2020) for statistical power and updated insights, considering a more complex model of simultaneous fractional probit equations, which allows us to deal with potential estimation biases and robustness issues. This will be key to identifying each country's marginal valuation of each policy, potentially improving negotiation efficiency and revealing divergences from the population's true valuation.

3. MATERIALS AND METHODS

In this section, we describe both the theoretical and empirical modelling approaches. As previously mentioned, our theoretical contribution is based on the standard model of Baron and Ferejohn (1989). We extend it by considering the simultaneous negotiation of different agents over multiple budgetary items. Empirically, we develop a fractional model to capture the trade-offs over EU budget items.

3.1 Budget Bargaining Process: A Simplified Framework

Consider a committee $N = \{1, \dots, n\}$ responsible for allocating $m \geq 2$ budgets of fixed sizes. Denote by s_j^i the country j 's share in budget $i = 1, \dots, m$. Vector \mathbf{s}_j represents to vector of shares in every budget $i = 1, \dots, m$ for given country $j \in N$, while \mathbf{s}^i denotes the

⁴ Its predictions have been widely validated in both empirical and experimental settings (see Eraslan and Evdokimov, 2019).

vector of shares allocated to all countries $j \in N$ for given budget $i = 1, \dots, m$. In what follows, we denote vectors in bold and scalars in plain text.

Let

$$\Delta = \{x \in R^n \mid x_j \geq 0, \forall j \in N \text{ and } \sum_{j=1}^n x_j \leq 1\},$$

$$\bar{\Delta} = \{x \in R^n \mid x_j \geq 0, \forall j \in N \text{ and } \sum_{j=1}^n x_j = 1\}.$$

We assume that $s^i \in \Delta$ for all $i = 1, \dots, m$.

To ensure tractability, budget shares are determined simultaneously through a one-period ultimatum bargaining à la Baron and Ferejohn (1989). For simplicity, assume a fixed proposer,⁵ who offers allocations s_j to the countries $j \in N$. Each country can cast “yes” or “no” votes.

Decisions follow a *weighted majority* rule (w, q) , with vector of weights $w \in \bar{\Delta}$ and quota $q \geq 0$. A proposal passes if, and only if, the total weight of the countries supporting the decision meets or exceeds q . Any such coalition of countries is called *winning*, and we denote by \mathcal{W} the set of all winning coalitions.

Each country cares solely about their own shares, according to utility function:

$$u_j(s_j) = \alpha_j \cdot s_j \equiv \sum_{i=1}^m \alpha_j^i s_j^i, \quad (1)$$

where $\alpha_j = (\alpha_j^1, \dots, \alpha_j^m)$ with $\alpha_j^i \geq 0$ for all $i = 1, \dots, m$ and $j \in N$. The parameters α_j^i represent the relative importance that country j assigns to different budget categories. The marginal rate of substitution between budgets i and i' for country j is given by:

$$MRS_{ii'}^j = -\frac{\alpha_j^i}{\alpha_j^{i'}}.$$

If a proposal fails, countries receive their default shares δ_j^i , which may correspond, for instance, to the previous year's shares. We assume that $\delta^i \in \Delta$ for all $i = 1, \dots, m$.

Denote

$$\bar{u}_j = \alpha_j \cdot \delta_j$$

the reservation utility for each country $j \in N$.

Country $j \in N$ supports the proposal if and only if:

$$\alpha_j \cdot s_j \geq \bar{u}_j.$$

A (pure) strategy for country j consists of:

1. A proposed allocation s_j^i for each country $j \in N$ in each budget $i = 1, \dots, m$.
2. A response function assigning a “yes” or “no” to all possible proposals.

Ties are resolved in favor of the proposer. We focus on subgame perfect Nash equilibria of this bargaining game.

3.1.1 Key Theoretical Implications

⁵ Alternatively, we could assume that Nature selects a proposer according to probability vector $p \in \bar{\Delta}$. However, this modification would not affect our results.

Suppose country l is selected as a proposer. To ensure acceptance, the proposer must secure a winning coalition T while maximizing its own payoff:

$$\begin{aligned} & \mathbf{max}_{T,s} \sum_{j \in T \setminus l} \alpha_j \cdot s_j \\ & \text{subject to:} \\ & \alpha_j \cdot s_j \geq d_j \text{ for } j \in T \setminus \{l\} \quad (2) \\ & \sum_{j \in T} s_j^i \leq 1 \text{ for } i = 1, \dots, m \\ & s_j^i \geq 0, j \in N, i = 1, \dots, m \end{aligned}$$

Define:

$$i^*(j, l) = \mathbf{argmax}_i \frac{\alpha_j^i}{\alpha_i^i} \text{ for } \forall j \in T \setminus \{l\}. \quad (3)$$

Assumption A1.

$$\text{For } \forall i, l \sum_{j: i^*(j, l) = i} \frac{\bar{u}_j}{\alpha_j^i} < 1.$$

Proposition. Suppose country l is selected as proposer and chooses coalition T . Under assumption **A1**, there exists an equilibrium, in which:

1. Coalitional partners $j \in T \setminus \{l\}$ receive exactly their disagreement utility. The allocation to country j is concentrated entirely in the budget $i^*(j, l)$ that minimizes the proposer's cost:

$$\begin{cases} s_j^i = 0, \text{ if } i \neq i^*(j, l) \\ s_j^i = \frac{\bar{u}_j}{\alpha_j^i}, \text{ if } i = i^*(j, l), \end{cases}$$

2. Countries outside the coalition $j \notin T \setminus \{l\}$ receive zero allocations in all budgets: $s_j^i = 0$ for $i = 1 \dots m$.⁶

Proof. See Appendix A0

Remark. The equilibrium trade-off between budgets i and i' for country $j \in T \setminus \{l\}$ can be measured by:

$$\frac{s_j^i - \delta_j^i}{s_j^{i'} - \delta_j^{i'}}$$

Corollary:

In the special case $m = 2$, the equilibrium trade-off between budgets for each country $j \in T \setminus \{l\}$ equals to the marginal rate of substitution between the budgets:

$$\frac{s_j^1 - \delta_j^1}{s_j^2 - \delta_j^2} = -\frac{\alpha_j^2}{\alpha_j^1} = MRS_{21}^j.$$

Remark. When $m \geq 3$, equilibrium trade-offs take a more complex form. In particular, when $m = 3$ and $i^*(j, l) = 1$ in (3), it follows that for each country $j \in T \setminus \{l\}$:

⁶To avoid this (as we do not observe zeros) and to reflect preferences for budgetary stability, we could assume that a fraction $\rho \in [0,1]$ of each budget i is allocated based on predetermined default shares, δ_j^i , while the remaining fraction $1 - \rho$ is determined via bargaining. However, the key implications continue to hold in this setting.

$$\frac{s_j^1 - \delta_j^1}{s_j^2 - \delta_j^2} = -\frac{\alpha_j^2}{\alpha_j^1} - \frac{\delta_j^3 \alpha_j^3}{\delta_j^2 \alpha_j^1} = MRS_{21}^j + \frac{\delta_j^3}{\delta_j^2} MRS_{31}^j$$

i.e., a linear combination of marginal rates of substitution.

This result shows that cross-budget trade-offs arise endogenously in equilibrium and are governed by the marginal rates of substitution implied by the country's utility function. In particular, equilibrium allocations reveal the ratios of preference parameters across budget categories.

In empirical application, we exploit this relationship to recover countries' relative preferences over expenditure categories from observed allocations.

3.1. The empirical model to test the EU budgetary bargaining process.

Common Agricultural Policy and Structural Funds have been the main sections of EU budget⁷. The first one is currently part of a more extensive section on the preservation and management of natural resources, while structural funds include several cohesion and competitiveness policies oriented to economic development in target regions. Therefore, we focus the empirical model on three different budget sections: 1) structural policies (s_{it}^{sf}), 2) agricultural policies (s_{it}^{agr}) and 3) the remaining policies (s_{it}^r) for country i in year t .

Based on the theoretical framework described in the previous section, the empirical model is based on the following equation:

$$s_{it}^{sf} = \Phi(\beta_1 s_{it}^{agr} + \beta_2 s_{it}^r + f(\mathbf{Z}_{it}) + u_i) + e_{it} \quad (4)$$

where i and t are the country and time indicators; s_{it}^{sf} , s_{it}^{agr} and s_{it}^r are the fractions of the structural funds, agricultural funds and remaining funds allocated to each country respectively. Additionally, \mathbf{Z}_{it} is a vector of strictly exogenous covariates - variables representative of power, needs, and the budgetary item size: s^{tdg} , $lnInc$ and sg^{sf} - and $f(\cdot)$ is a linear combination of these covariates including the intercept, as well as time and country fixed effects controlling for unobserved heterogeneity. Finally, u_i are the random effects, and e_{it} is the idiosyncratic error term.

Since s_{it}^{sf} is a fractional dependent variable -i.e., $0 \leq s_{it}^{sf} \leq 1$ -, the conditional expected value $E(s_{it}^{sf} | \cdot)$ should not be estimated through linear assumptions in parameters and must use quasilielihood estimation techniques, otherwise estimators would be inefficient (Papke and Wooldridge, 1996; 2008). In this sense, we assume $\Phi(\cdot)$ follows the inverse of the cumulative distribution function of the standard normal distribution -i.e., probit function. However, this distributional assumption creates a problem when dealing with unobservable heterogeneity due to the well-known incidental parameters problem. Since

⁷ Although the relative weight of these items has decreased over the last years, both sections covered around 66% of the total EU budget in 2020.

dummy or fractional variables cannot be demeaned, introducing country parameters in (4) might lead to inconsistent estimates if the time dimension is not sufficiently large (Greene, 2018).

A solution to this problem is the Mundlak's (1978) approach, which consists in including the group means of the covariates used in (4). This approach also allows us to test the appropriateness of fixed or random effects by testing the joint significance of the Mundlak variables. Besides, the inclusion of dummies controlling for common time effects when the number of individual entities is close to the number of observed time periods (i.e, $N \approx T$) also causes an incidental parameter problem (Fernández-Val and Weidner, 2016). Following Greene (2018), we also include Mundlak time variables including the time means of the covariates of (4).

Besides the unobservable heterogeneity problem, the theoretical model poses that s_{it}^{agr} and s_{it}^r are endogenous regressors due to simultaneous causation -i.e., if the bargaining model is true, increasing the share in a budget implies a simultaneous reduction in other shares-. Besides, these variables can be strongly correlated to any omitted variable, increasing the likelihood of biased estimates. To tackle this issue, we follow the Seemingly Unrelated Regressions (SUR) approach to estimate (4) making an efficient use of available data while minimizing the potential endogeneity bias (Greene, 2018). To avoid a problem of identification, we model the fractions of the agricultural and remaining funds as follows:

$$\begin{aligned} s_{it}^{agr} &= \Phi(\rho_1 agr_{it} + \rho_2 sg_t^{agr} + u_i) + v_{it} \\ s_{it}^r &= \Phi(\gamma_1 dep_ratio_{it} + \gamma_2 sg_t^r + u_i) + w_{it} \end{aligned} \quad (5)$$

Where v_{it} and w_{it} are idiosyncratic error terms. Additionally, agr_{it} and dep_ratio_{it} are used as exogenous instruments to explain part of the bargaining process on agricultural funds and the remaining budget respectively. Both variables capture the "objective needs" of each country. Moreover, we also control for the size of each budgetary item (sg_t^{agr}, sg_t^r).

After estimating equation (4) with the aforementioned methods, the marginal effects associated with s_{it}^{agr} and s_{it}^r can be used as estimates of the marginal rate of substitution (MRS) between items of the budget -i.e., how many percentage points (p.p.) of a given budget the average country is willing to sacrifice in order to gain 1 p.p. of a different budget. Using the theorem of the implicit function, the MRS can be read as

$$MRS_{agr,sf} = \frac{ds_{it}^{sf}}{ds_{it}^{agr}} = \beta_1 \quad (6)$$

$$MRS_{r,sf} = \frac{ds_{it}^{sf}}{ds_{it}^r} = \beta_2 \quad (7)$$

$$MRS_{agr,r} = \frac{MRS_{r,sf}}{MRS_{agr,sf}} = -\frac{\beta_1}{\beta_2} \quad (8)$$

3.2. Data and variables

To test our hypothesis on the EU budget bargaining process, an unbalanced panel data set was made up of information on the EU member states for the period 1976-2020 (799 observations). In 2016 United Kingdom started the Brexit process, finishing in 2021. Therefore, Brexit is a significant shock that could distort the normal functioning of EU institutions (Haas and Rubio, 2017). Moreover, a new budgetary period (multiannual financial framework 2021 - 2027) is starting in 2021, injecting additional funds through the implementation of the Next Generation EU recovery instrument. For those reasons, we decided to consider a temporal series concluding in 2020. Table 1 describe the enlargement process at the EU, displaying the number of observations in each stage.

Table 1 Summary statistics by period: EU enlargement process

Period	Countries	Observations
EU-9 (1976-1980)	Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands, United Kingdom	45
EU-10 (1981-1985)	Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, United Kingdom	50
EU-12 (1986-1994)	Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, United Kingdom	108
EU-15 (1995-2003)	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom	135
EU-25 (2004-2006)	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom	75
EU-27 (2007-2020)	Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom	190
EU-28	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom	196

Source: own elaboration

Budget shares have been calculated using the information taken from the European Commission financial reports⁸. Most control variables were built using information from the Eurostat statistics website. Table 2 displays the variables definition and other features. Table 3 shows the summary statistics of the variables included in the analysis.

⁸ For further information, check http://ec.europa.eu/budget/biblio/documents/index_en.cfm.

Table 2 Variables description

Variable	Definition	Source	Time variability exclusively
s^{sf}	Share of the structural policies budget corresponding to each country	European Commission Financial Reports	No
s^{agr}	Share of the agricultural policies budget corresponding to each country	European Commission Financial Reports	No
s^r	Share of the remaining funds budget corresponding to each country	European Commission Financial Reports	No
$lnInc$	Natural logarithm of ratio between each country's per capita GDP and EU's average per capita GDP	Eurostat	No
s^{tdg}	Share of the total EU budget corresponding to each country	European Commission Financial Reports	No
$agri$	Weight of the agricultural sector over gross value added in each country	Eurostat	No
dep_ratio	Population aged 0 to 14 years and 65 years or over divided by population aged 15 to 64 years	Eurostat	No
sg^{sf}	Share of structural policies budgetary item in the global EU expenditure budget	European Commission Financial Reports	Yes
sg^{agr}	Share of agricultural policies budgetary item in the global EU expenditure budget	European Commission Financial Reports	Yes
sg^r	Share of remaining policies budgetary item in the global EU expenditure budget	European Commission Financial Reports	Yes

Source: own elaboration

As commented in the previous section, equation (4) contains some crucial covariates that we expect to shape the EU bargaining process. First, we include $lnInc$ as each country's relative development level. We expect those countries who are above average development to be less interested in structural funds, which are mainly devoted to expanding economic growth.

The period considered in this research covers different phases of EU integration: from 1976 to 1980 (EU-9), from 1981 to 1985 (EU-10), from 1986 to 1994 (EU-12), from 1995 to 2003 (EU-15), from 2004 to 2006 (EU-25), from 2007 to 2012 (EU-27) and from 2013 to 2020 (EU-28). On top of that, there have been some changes in the budget structure throughout the period⁹. As mentioned previously and in order to control for those changes, since the budget items have different weight in the total budget, some variables representative of each budget relative size are included in the equation system (sg_t^{sf} , sg_t^{ag} , sg_t^r). All these specific time-variant variables would also capture budgetary methodological issues but also the changes observed in the allocation rules among different budgetary sections¹⁰.

Table 3 Summary statistics

Variable	Mean	SD	Min	Max
s^{sf}	0.056	0.067	0.001	0.379
s^{agr}	0.056	0.061	0	0.275
s^r	0.056	0.060	0.001	0.479
$lnInc$	-0.048	0.314	-0.894	1.022
s^{tdg}	0.050	0.049	0.001	0.226
$agri$	0.056	0.067	0	0.338
dep_ratio	0.503	0.049	0.386	0.716
sg^{sf}	0.280	0.078	0.073	0.384
sg^{sgr}	0.482	0.106	0.336	0.769
sg^r	0.239	0.061	0.157	0.391

Source: own elaboration

Secondly, we include the share of the total EU budget captured by each country, s^{tdg} , with the aim of controlling simultaneously for several unobserved or imperfectly measured variables determining the overall bargaining process. As shown in the Appendix¹¹, most common political power indices are strongly and positively correlated with the total share obtained after each negotiation, then those countries endowed with a higher negotiating power gain a larger share of the EU budget, as expected. Additionally, the number of countries of the EU is also negatively and significantly associated with that

⁹ In particular, we distinguish four different budgetary frameworks: from 1976 to 1991, where the main budget sections were *EAGGF, Guarantee, EAGGF, Guidance, Fisheries, Regional, Fund, Social, Fund*; from 1992, with *Agriculture, Structural, actions, Internal, policies, External, actions and Administration* as the main expenditure budget sections; from 2007 to 2013, where the key sections were denominated *Competitiveness, Cohesion, Natural resources, Freedom, security and justice, Citizenship, The EU as a global player and Administration*; and finally, from 2014 to 2020, where budget sections were slightly changed with respect to the latter sub-period. The UK rebate (from 1985) and other compensations among countries have also been part of the EU budget for most periods.

¹⁰ Check Zaporozhets et al. (2016) for a description of reforms concerning the structure of the EU budget.

¹¹ A brief discussion on political power indices is included in the Appendix.

share, as expected since a larger EU requires the average country to yield a larger share of the budget.

It is also interesting to observe statistics over time. Table 4 considers different periods corresponding to the sequential enlargement process. The shares decrease when the number of EU country members competing for resources is higher. Regarding the weight of the budget items, the share of agricultural policies has decreased over time since the remaining budget items have increased their weight in the EU budget.

Table 4 Summary statistics by period: EU enlargement process

Period	Statistic	s^{sf}	s^{ag}	s^r	$lnInc$	s^{tdg}	$agri$	dep_ratio	sg^{sf}	sg^{agr}	sg^r
EU-9	Mean	0.111	0.111	0.111	-0.016	0.099	0.111	0.564	0.105	0.726	0.170
	Std.Dev.	0.097	0.074	0.075	0.190	0.065	0.102	0.063	0.019	0.024	0.015
EU-10	Mean	0.100	0.100	0.100	-0.019	0.088	0.100	0.523	0.127	0.648	0.225
	Std.Dev.	0.089	0.076	0.106	0.202	0.065	0.096	0.067	0.006	0.035	0.039
EU-12	Mean	0.083	0.083	0.083	-0.032	0.075	0.083	0.498	0.219	0.595	0.186
	Std.Dev.	0.068	0.067	0.063	0.255	0.049	0.074	0.051	0.049	0.040	0.017
EU-15	Mean	0.067	0.067	0.067	-0.028	0.062	0.067	0.498	0.311	0.501	0.187
	Std.Dev.	0.077	0.064	0.054	0.230	0.051	0.064	0.030	0.026	0.013	0.017
EU-25	Mean	0.040	0.040	0.040	-0.072	0.037	0.040	0.480	0.319	0.455	0.226
	Std.Dev.	0.059	0.054	0.044	0.380	0.043	0.053	0.034	0.016	0.014	0.002
EU-27	Mean	0.037	0.037	0.037	-0.068	0.033	0.037	0.489	0.320	0.419	0.260
	Std.Dev.	0.046	0.046	0.043	0.373	0.034	0.047	0.046	0.019	0.038	0.042
EU-28	Mean	0.036	0.036	0.036	-0.058	0.031	0.037	0.518	0.316	0.378	0.306
	Std.Dev.	0.046	0.041	0.041	0.349	0.030	0.047	0.047	0.058	0.015	0.057

Source: own elaboration

4. RESULTS AND DISCUSSION

Table 5 shows the main estimation results of the fractional probit system posed in equations (4) and (5). Standard errors are robust to individual heterogeneity. To check if the system of equations estimated jointly is a more efficient econometric alternative, we report the correlation coefficients between each pair of the error terms of all three equations.

Except for the pair structural funds and remaining funds, the cross-correlation coefficients of the other pairs of equations are significantly different from zero at the 1% level of significance. This confirms our hypothesis that some common and unobservable characteristics drive budget items in the whole EU budget bargaining process, then strict exogeneity in budget shares is rejected. Furthermore, since M1 shows the estimates assuming strict exogeneity in budget shares, the comparison with the estimated coefficients with M2 and M4 -models that do not fall into the incidental parameters problem-, proves that ignoring endogeneity leads to an underestimation bias of the marginal rates of substitution between budgets. Further discussion on endogeneity issues, attrition bias, and temporal autocorrelation is included in the Appendix.

Regarding the relevance of unobserved country and time heterogeneity, estimations M3 and M4 also show important deviations from the base estimates of specification M2. While specification M3 shows that including standard two-way (country and time) fixed

effects -i.e., dummy variables- might prove the base model overestimates coefficients due to unobserved heterogeneity, specification M4 proves the contrary. This is likely a consequence of the incidental parameters problem (see the previous Section), given the similar and finite number of countries and time periods of our database creates a problem of inconsistency in estimated parameters. In this sense, and following Greene (2018), we pose the best-fitting specification in the present study is that using the Mundlak's approach for two-way fixed effects in each equation (M4).

Observing estimates in Table 4, results are quite robust across specifications. As expected by the theoretical model, an increase in the captured share of structural funds (the reference budget) entails a reduction in the captured share of the CAP and remaining funds. Therefore, we cannot reject our initial hypothesis of countries "buying" shares from the most desired budgets by "selling" the shares from the least desired ones.

Table 5 Estimates of the EU bargaining process

	M1	M2	M3	M4
s^{sf}				
s^{agr}	-8.130*** (-13.63)	-8.138*** (-13.65)	-6.434*** (-11.13)	-8.703*** (-14.17)
s^r	-3.225*** (-10.00)	-3.232*** (-10.01)	-3.198*** (-9.84)	-3.239*** (-10.43)
$lnInc$	-0.321*** (-6.23)	-0.320*** (-6.24)	-0.264*** (-3.65)	-0.006 (-0.06)
s^{tdg}	20.585*** (21.14)	20.586*** (21.14)	18.670*** (22.23)	19.702*** (19.23)
sg^{sf}	-0.475*** (-3.48)	-0.480*** (-3.52)	0.161 (0.39)	-1.026*** (-5.28)
<i>Intercept</i>	-2.060*** (-44.37)	-2.058*** (-44.32)	-2.278*** (-15.81)	-1.816*** (-13.27)
s^{agr}				
<i>agri</i>		4.919*** (27.12)	1.576*** (3.41)	1.064*** (2.71)
sg^{agr}		0.467*** (3.75)	0.549 (1.43)	-0.233 (-0.66)
<i>Intercept</i>		-2.202*** (-33.39)	-1.468*** (-5.33)	-2.194*** (-20.04)
s^r				
<i>dep_ratio</i>		2.063*** (5.38)	2.110*** (4.62)	1.183** (2.10)
sg^r		-2.507*** (-8.07)	-1.431 (-1.54)	-2.682*** (-8.65)
<i>Intercept</i>		-2.061*** (-10.22)	-1.977*** (-4.89)	-3.592*** (-5.36)
ρ^{12}		0.016*** (5.55)	0.005*** (5.42)	0.016*** (8.54)
ρ^{13}		0.004 (1.50)	0.000 (0.34)	0.001 (0.54)
ρ^{23}		0.033*** (6.22)	0.017*** (4.45)	0.026*** (5.25)

Two-way FE	NO	NO	YES	NO
Two-way Mundlak FE	NO	NO	NO	YES
Observations				799

Notes: *t* statistics in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

Additionally, we find that those countries capturing a larger share of the total budget (s^{tdg}), which is closely related to political power and the existing number of negotiating countries, obtain a larger share of the reference budget (structural funds). Finally, those countries with a higher relative weight in the agricultural sector show an increased likelihood of negotiating higher shares in that specific budget, while those countries with elevated age dependency ratios are more biased towards the non-structural and non-agricultural budgets. Regarding the relative economic position of countries ($lnInc$), while there is a negative relationship with demanded structural funds for the M1, M2 and M3 specifications, it is not statistically significant for the preferred specification (M4).

Table 6 shows the estimated marginal rates of substitution of the CAP and remaining funds for structural funds for the entire sample, and each stage of the enlargement process of the EU. We observe that, for the entire sample, the average country would be willing to sacrifice between 0.823 and 0.306 p.p. of the potentially captured share of structural funds in exchange for a 1 p.p. share increase in agricultural and remaining funds. Additionally, the marginal rate of substitution of the CAP funds for the remaining funds equaled 0.372 p.p.¹² -i.e., the average country would be willing to sacrifice 0.372 p.p. of the share of CAP funds in exchange for a 1 p.p. share increase in the remaining funds without including the structural funds. In other words, we find that, on average, the representative country valued more the structural funds over the CAP funds, and the CAP over remaining funds.

Table 6 Average marginal rates of substitution

	ds^{sf}/ds^{agr}		ds^{sf}/ds^r	
Total	-0.823***	(-13.65)	-0.306***	(-10.34)
EU9	-1.335***	(-13.09)	-0.497***	(-9.97)
EU10	-1.216***	(-13.21)	-0.453***	(-10.28)
EU12	-1.091***	(-13.23)	-0.406***	(-10.28)
EU15	-0.943***	(-12.79)	-0.351***	(-9.76)
EU25	-0.696***	(-13.31)	-0.259***	(-10.02)
EU27	-0.634***	(-13.81)	-0.236***	(-10.43)
EU28	-0.612***	(-12.90)	-0.228***	(-10.14)

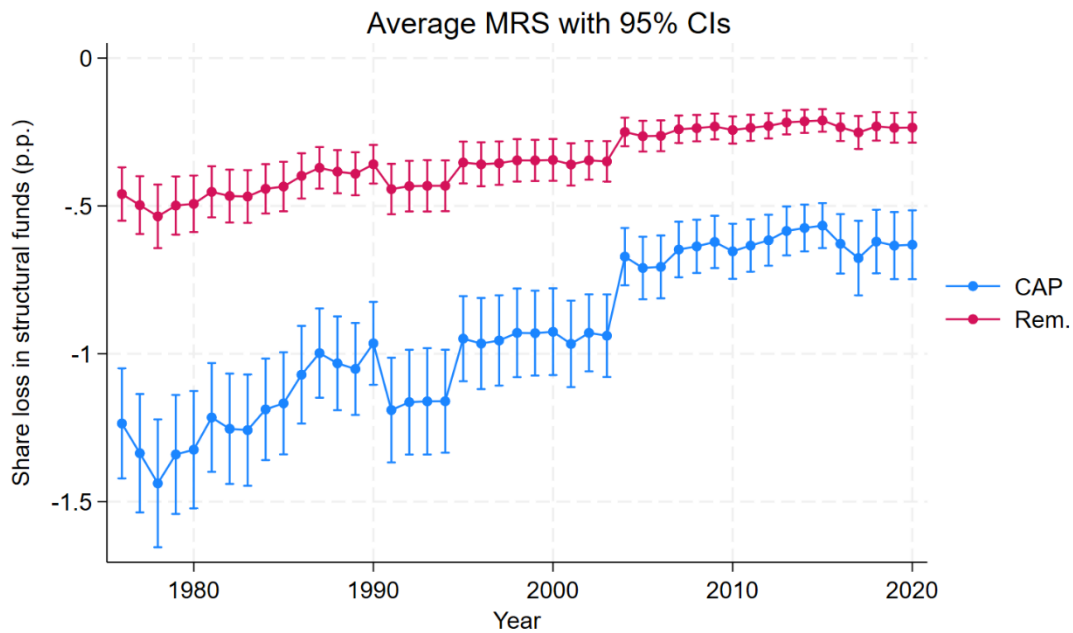
Notes: *t* statistics in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

However, further examination of Table 6, apart from Figure 1, shows that these estimated valuations were not constant throughout time. Moreover, the agricultural item was the most valued from 1976 to 1994 (EU9 to EU12), when EU members were still reliant on the agricultural sector (the agricultural value added of the average EU member weighted more than 8% of total value added). The estimated marginal rates of substitution ranged from 1.335 p.p. during the EU9, to 1.091 p.p. during the EU12 (the average country was

¹² See equation (8).

willing to sacrifice more than 1 p.p. of negotiated structural funds in exchange for increasing its share on agricultural funds in 1 p.p.). The addition of Austria, Finland and Sweden in 1995 (EU15), and other countries in subsequent years accelerated the loss of importance of the agricultural sector for the EU bargaining process. This decreasing valuation was also replicated by the remaining funds, albeit it was never more valued than the structural or CAP funds.

Figure 1 Time evolution of marginal rates of substitution (maximum p.p. a country is willing to lose in the share of structural funds for a 1 p.p. increase in the share of CAP or remaining budgets)



Source: own elaboration

Even more, Table 7 shows the ordering of relative valuations can change for each country and the whole period. For instance, the bulk of southern European countries (Greece, Italy, Portugal and Spain), and other large countries with historical protection and importance of agricultural production such as France, Germany or Poland, presented average marginal rates of substitution between CAP and structural funds above 1 p.p. Therefore, this group of countries considered the CAP shares the most valuable item during the EU budget negotiations, followed by the structural funds and the remaining budget. Spain was the country with highest willingness to sacrifice potential structural funds for CAP funds, with a willingness to pay of more than 2 p.p. of structural funds per 1 p.p. in CAP funds. Conversely, the group of Nordic countries (Sweden, Finland and Denmark), and several small countries such as Austria, Cyprus or Malta, valued more the structural funds over the CAP funds, with marginal rates of substitution below 0.5 p.p. In this sense, Luxembourg presented the lowest willingness to sacrifice structural funds for CAP or remaining funds (less than 0.2 p.p. in the first case, and 0.07 p.p. in the second one).

Table 7 Average marginal rates of substitution by country

	ds^{sf}/ds^{agr}		ds^{sf}/ds^r	
Luxembourg	-0.190***	(-7.15)	-0.071***	(-6.23)
Austria	-0.257***	(-10.73)	-0.096***	(-8.17)
Sweden	-0.275***	(-10.74)	-0.102***	(-8.28)
Finland	-0.288***	(-11.82)	-0.107***	(-8.76)
Cyprus	-0.313***	(-11.88)	-0.116***	(-9.12)
Slovenia	-0.339***	(-13.33)	-0.126***	(-9.49)
Denmark	-0.353***	(-12.98)	-0.131***	(-9.09)
Malta	-0.377***	(-13.06)	-0.140***	(-9.14)
Estonia	-0.426***	(-15.63)	-0.159***	(-10.92)
Belgium	-0.510***	(-12.86)	-0.190***	(-13.76)
Netherlands	-0.511***	(-14.53)	-0.190***	(-9.83)
Ireland	-0.562***	(-13.10)	-0.209***	(-9.39)
Lithuania	-0.567***	(-14.49)	-0.211***	(-10.42)
Slovakia	-0.618***	(-13.52)	-0.230***	(-9.86)
Bulgaria	-0.623***	(-14.54)	-0.232***	(-11.07)
Romania	-0.653***	(-15.81)	-0.243***	(-11.31)
Hungary	-0.657***	(-14.43)	-0.244***	(-10.34)
Average	-0.823***	(-13.65)	-0.306***	(-10.34)
Portugal	-1.030***	(-11.45)	-0.383***	(-9.34)
Latvia	-1.039***	(-12.88)	-0.387***	(-9.67)
Greece	-1.156***	(-13.75)	-0.430***	(-10.27)
France	-1.159***	(-15.69)	-0.431***	(-11.17)
UK	-1.216***	(-12.72)	-0.452***	(-10.92)
Germany	-1.405***	(-12.89)	-0.523***	(-9.91)
Poland	-1.568***	(-11.67)	-0.583***	(-9.29)
Italy	-1.747***	(-12.26)	-0.650***	(-9.66)
Spain	-2.184***	(-12.18)	-0.813***	(-9.94)

Notes: *t* statistics in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

Additionally, the information provided in Table 7 can be useful for further successful and more efficient negotiations of the EU budget. For instance, the pairs Spain-Italy and Luxembourg-Austria could largely benefit each other since per each p.p. of CAP funds sacrificed by Luxembourg or Austria, they could be rewarded by Spain or Italy with more than 7 times their willingness to accept expressed in p.p. of structural funds (e.g., Luxembourg is willing to accept selling 1 p.p. of CAP funds for, at least, 0.19 additional p.p. in structural funds, while Spain is willing to pay up to 2.184 p.p. of structural funds for that additional p.p. of CAP funds; in this case, Spain is willing to pay more than 11 times the minimum asked by Luxembourg to reach an agreement).

5. CONCLUSION

In this paper, we attempt to characterize the allocation process of the EU budget. Although the literature assessing the EU budget from a global perspective is broad, papers analyzing the bargaining process of expenditure items among country members are still scarce (Kemmerling and Bodenstern, 2006). As an original contribution, the current study goes further exploring the shares obtained by each country member on different

expenditure items over a long temporal period, to characterize EU country members expenditure marginal valuation and bargaining processes.

An innovative approach is proposed in both theoretical and empirical modelling. We extend a basic theoretical bargaining model (Baron and Ferejohn, 1989), considering a simultaneous negotiation on multiple budgetary items, showing the valuation of players across them. Depending on those values it may be possible that a player accepts a smaller amount in one budget section in exchange for a higher share in another section. Moreover, we developed an original empirical specification (using a fractional probit model) which allow us to address this research question in an efficient and robust way.

Similar to previous literature, we have considered the role of both needs and political factors when explaining the shares of different budgetary sections. As new insights, we detected significant trade-offs among different EU budget shares on different items, estimating the marginal rates of substitution across them. On average, the structural funds policy was the most valued item, since countries were willing to sacrifice significant percentual points of the remaining budget items.

Our findings showed that the agricultural budget was the second most valued item. However, valuations evolved throughout time, with agricultural budget losing relevance in the late EU multiannual financial frameworks. In this respect, country preferences go in line with the future evolution of Common European Agricultural Policy. In 2013, a hard-fought CAP budget agreement was reached for the multiannual financial framework 2014 - 2020. This compromise proposed nominal expenditure cuts of 13% in pillar 1 (market measures and direct payments) and 18% pillar 2 (rural development measures) for the period 2014 - 2020.

The multiannual financial framework 2021 - 2027 amounts to €1,074.3 billion for the EU-27 in 2018 prices. Moreover, Next Generation EU recovery instrument has injected €750 extra billion to support recovery from Covid-19 pandemic and resilience. The latter instrument has led Cohesion Funds to an increase around 60% of the total EU budget. However, the Natural Resources and Environment item represents 20% of total EU budget. Had it not been for the NGF, both items would have experienced a significant reduction. The bargaining process would have become extremely complex under those notable budgetary cuts affecting one of the most valuable EU policies.

Moreover, our findings could provide useful information to guide future bargaining procedures related to EU budget. Thus, we have detected strong differences among EU country members in the valuation of budget items. Given the estimated strong differences in marginal valuations of countries, it seems the current allocations of shares across countries are still far from being efficient. The discrepancy in relative valuation creates incentives for different groups of countries to change their current decisions and be better off.

Likewise, the EU budgetary framework must continue deepening in public support, as it has been expressed in multiple polls at the European level (e.g., Eurobarometer, European Values Survey). This is exemplified by the increased citizen support in the last years for environmental or security policies within the EU. Recent events in geopolitical terms may even reinforce this trend. However, in some cases (such as that of environmental policies),

it is not clear whether citizens' valuations are adequately reflected in budgetary allocations or not.

Finally, the elaboration of the dataset has revealed that this level of disaggregated information (shares by country and budget item) does not have a great visibility on the EU webpage. Thus, greater transparency is needed concerning the EU budget, by urging the publication and spread of information on expenditure shares allocated to each policy by the member states, along with the statistics related to citizens' valuations in each country. This would enable a comprehensive understanding of the EU budget negotiation process and allow for a more informed and transparent assessment of territorially heterogeneous EU policies.

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APPENDIX

A0. Proof of the Proposition (sketch)

Let $l \in N$ denote the proposer and $T \in \mathcal{W}$ the chosen coalition. The proposer optimally minimizes the transfers to coalitional partners - subject to their participation constraints - to maximize their own payoff. The problem (2) can thus be rewritten as:

$$\begin{aligned}
 & \min_{s_j} \sum_{j \in T \setminus l} \alpha_l \cdot s_j \\
 & \text{subject to:} \\
 & \alpha_j \cdot s_j = d_j \text{ for } j \in T \setminus l \quad (A0) \\
 & s_l^i = 1 - \sum_{j \in T \setminus l} s_j^i \text{ for } i = 1, \dots, m \\
 & s_j^i \geq 0, j \in T \setminus l, i = 1, \dots, m \\
 & s_j^i = 0, j \notin T \setminus l, i = 1, \dots, m
 \end{aligned}$$

A linear objective function combined with linear constraints yields a corner (bang-bang) solution, which determine the structure of the equilibrium shares.

A1. Main power indices

Subsection 3.1 shows that countries must trade-off different sections of the budget, based on their preferences. The magnitude of this trade-off is further shaped by their bargaining positions, which, in our model, are determined by the probability of becoming the proposer. Consequently, voting power is a significant variable explaining the final distribution of budget shares.

We focus on power indices that are particularly suitable for a distributional context. While research on power measures has expanded significantly in recent decades, no consensus has emerged on the most appropriate approach. For example, studies on the distribution of the EU budget, such as Kauppi and Widgrén (2004), often rely on the widely used Shapley-Shubik index. Felsenthal and Machover (1998) argue that the Shapley-Shubik index is a measure of “P-power,” where P stands for “purse,” and reflects the voter’s expected share on a fixed budget. In contrast, Zaporozhets et al. (2016) advocate for the nucleolus —introduced by Schmeidler (1969)—as an alternative index, which is especially relevant in distributional settings. The Shapley-Shubik index can also be interpreted as a measure of “I-power” (Felsenthal and Machover, 1998), which assesses the probability of a player casting a decisive vote. Other I-power measures include the Banzhaf index, the Johnston index, and the Deegan-Packel index.

To ensure robustness, we consider the Shapley-Shubik Index and the Nucleolus, but also several additional power measures, such as the Banzhaf Power Index, the Johnston Power Index, the Deegan-Packel Power Index, and Public Good Index. For more detailed

information on these measures, readers are encouraged to consult Felsenthal and Machover (1998).

Power indices were computed using an updated version of the program developed for Zaporozhets et al. (2016). Table A1 displays the strong correlation between each country's share on the total EU budget (s^{tdg}) and the political power indices. This variable is also correlated with the number of EU country members.

Table A1. Correlation coefficients with total share (s^{tdg})

Variables	s^{tdg}
<i>power_ss</i>	0.901*** (0.000)
<i>power_bz</i>	0.897*** (0.000)
<i>power_pg</i>	0.722*** (0.000)
<i>power_j</i>	0.893*** (0.000)
<i>power_dp</i>	0.738*** (0.000)
<i>power_nucl</i>	0.835*** (0.000)
<i>Number of EU countries</i>	-0.428*** (0.000)

Legend: *power_ss*: Shapley-Shubik index; *power_bz*: Banzhaf index; *power_pg*: Public Good index ; *power_j*: Johnston index; *power_dp*: Deegan-Packel index; *power_nucl*: Nucleolus index.

Source: own elaboration *p-value* in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

A2. Endogeneity and weak instruments

As far as we know, testing endogeneity and the appropriateness of the chosen instruments is incompatible with the SUR approach. We decided then to follow the control function method (Wooldridge, 2015), which is a standard procedure to tackle endogeneity in non-linear models, similarly to Guerrero et al. (2025): i) we estimated separately the reduced-form fractional equations and generalized residuals of each suspected endogenous regressor -i.e., the remaining budget shares s_{it}^{agr} and s_{it}^r against exogenous regressors and instruments; ii) performed the Wald-tests to measure the strength of the instruments; iii) performed the modified refutability test (Guevara, 2018) to analyze instrument exogeneity in the presence of a non-linear model. The chosen regressors and instrumental variables are the same as those of the preferred SUR model (M4)¹³.

¹³ The share “ s_{it}^r ” is dropped at estimating the modified refutability test due to multicollinearity.

Table A2 Estimates of fractional probit reduced-form equations for agricultural and remaining shares

	s^{agr}	s^r
<i>agri</i>	-1.939*** (-5.20)	
sg^{agr}	-0.073 (-0.17)	
<i>dep_ratio</i>		2.949*** (6.79)
sg^r		0.141 (0.17)
<i>lnInc</i>	0.355*** (4.18)	0.332*** (2.81)
s^{tdg}	7.607*** (15.64)	6.384*** (8.67)
sg^{sf}	0.215 (0.53)	-0.033 (-0.06)
<i>Intercept</i>	-2.300*** (-8.82)	-0.481 (-0.55)
Wald joint-significance test of instruments ($\sim \chi^2(4)$)	32.12*** (p=0.000)	57.37*** (p=0.000)
Mundlak FE		YES
Mundlak time FE		YES
Observations		799

t statistics in parentheses * $p < .10$, ** $p < .05$, *** $p < .01$

According to the estimates in Table A2, we must reject the null hypothesis of joint insignificance of instruments in the reduced-form equations. That is, the Wald statistic of the chosen instruments shows that these are strong enough to explain sufficient variation in the allegedly endogenous variables. Besides, Table A3 shows that we cannot reject the null hypothesis that assumes their exogeneity. The modified refutability statistic shows a value of 1.87, which proves that there is no additional information obtained from using the nesting model instead of the nested one. Then, the variation of the share of structural funds explained by confounding factors associated with the other shares, seems to be properly accounted for after including the residuals from the reduced-form equations. That is, the chosen instruments seem to present the relevance and exogeneity properties (Greene, 2018) for unbiased estimates. Furthermore, the statistical significance of \hat{u}_1 proves the existence of endogeneity in the naïve model mostly associated with the agricultural share.

Table A3 Estimates of fractional probit equation for structural fund share with control function estimates

	Nested model	Nesting model
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s^{agr}	-14.655*** (-14.90)	-20.505*** (-19.63)
s^r	-2.194** (-2.31)	2.628** (2.25)
$lnInc$	0.120 (1.23)	0.319*** (3.70)
s^{tdg}	26.040*** (24.29)	29.284*** (31.02)
sg^{sf}	-1.305*** (-7.15)	0.581 (1.37)
\hat{u}_1	3.660*** (7.74)	6.321*** (11.89)
\hat{u}_2	-0.506 (-1.02)	-3.385*** (-5.78)
$agri$		-5.159*** (-9.80)
sg^{agr}		0.401 (0.80)
dep_ratio		-1.517*** (-2.76)
<i>Intercept</i>	-1.754*** (-13.74)	-4.893*** (-7.54)
Modified refutability test ($S_{mREF} \sim \chi^2(7)$)		1.87 (p=0.966)
Mundlak FE		YES
Mundlak time FE		YES
Observations		799

t statistics in parentheses * $p < .10$, ** $p < .05$, *** $p < .01$. \hat{u}_1 and \hat{u}_2 are the residuals from the reduced-form equations. For robustness, standard errors are bootstrapped with 500 repetitions.

A3. Unbalanced panel, attrition bias and group heterogeneity

Since we use an unbalanced panel due to nonrandom attrition from the sample of countries, that is, different countries become EU members over different periods due to partially deterministic reasons, we face a potential problem of attrition or sample bias (Wooldridge, 2010; Greene, 2018). Estimating the bargaining model without taking into account this problem can lead to biased estimators in the fashion of an omitted variable or misspecification error (Heckman, 1979; Wooldridge, 2010).

To partially deal with the attrition bias problem, we constructed several dummy variables identifying the 6 waves of countries entering the European Union. Therefore, D_EU9 takes the value of 1 for all those countries observed throughout the entire period, while D_EU10 only takes the value of 1 for Greece, D_EU12 for Spain and Portugal, and so forth (see Tables 1 and A5 for a comprehensive depiction of the country members). Therefore, these dummy variables only identify those countries that took part in the same wave, assuming they share some time-invariant factors that made them suitable for the inclusion into the EU, and can be somehow associated with their bargaining decisions.

Table A4 shows the results of the estimation of the preferred SUR model (M4) including these variables.

Table A4 Estimates of the EU bargaining process accounting for attrition bias

	s^{sf}
s^{agr}	-8.126*** (-13.82)
s^r	-3.249*** (-10.48)
$lnInc$	-0.199** (-2.38)
s^{tdg}	20.154*** (20.86)
sg^{sf}	-1.191*** (-6.72)
D_EU9	0.677*** (7.21)
D_EU10	0.532*** (7.16)
D_EU12	0.507*** (6.40)
D_EU15	0.418*** (3.99)
D_EU25	0.225*** (3.02)
D_EU27	-0.189* (-1.85)
<i>Intercept</i>	-2.081*** (-13.07)
ρ^{12}	0.009*** (6.05)
ρ^{13}	0.002 (0.83)
ρ^{23}	0.026*** (5.25)
Base estimation controls and instruments	YES
Two-way Mundlak FE	YES
Observations	799

t statistics in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

The statistical significance of the EU entry wave dummies shows that attrition bias is present, and missing observations are not due to purely random phenomena. It seems that being part of the older waves increases the share of perceived structural funds. However, comparison with the original model shows minimal differences in the parameters of interest. For instance, the estimated parameter for s^{agr} increases from -8.703 to -8.126 (+7%), while for s^{tdg} changes from -3.239 to -3.249 (less than -1%). We conclude then

that despite attrition bias is present in the unbalanced panel, it is small, and the estimates seem to be robust regardless of the specification.

Table A5 Entrants by period

Period	Countries
EU-10 (1981-1985)	Greece
EU-12 (1986-1994)	Portugal, Spain
EU-15 (1995-2003)	Austria, Finland, Sweden
EU-25 (2004-2006)	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia
EU-27 (2007-2020)	Bulgaria, Romania
EU-28	Croatia

Source: own elaboration

For further robustness checks, we replicated the estimation of M4 excluding entrants from different periods. According to results presented Table A5, our base estimates are robust to the exclusion of subgroups of initial and entrant countries. The most dramatic change emerges when Spain and Portugal, or the core EU-9 countries are dropped from the analyzed data (see columns 1 and 3 in Table A6), with important reductions and increases in the absolute value of coefficients associated with the shares from agricultural and remaining funds. However, their estimated marginal effects (-0.93 and -0.39, -0.61 and -0.12 respectively) still show a predominance of structural funds in the estimated marginal valuation of the remaining countries.

Table A6 Estimates of the EU bargaining process excluding groups of countries

	No EU-9	No EU-10	No EU-12	No EU-15	No EU-25	No EU-27	No EU-28
s^{sf}							
s^{agr}	-6.759*** (-8.55)	-8.848*** (-13.52)	-11.15*** (-17.04)	-8.703*** (-14.25)	-8.213*** (-13.94)	-8.173*** (-13.69)	-8.627*** (-13.97)
s^r	-1.385*** (-3.47)	-3.236*** (-10.01)	-4.750*** (-14.07)	-3.259*** (-10.51)	-2.976*** (-9.90)	-3.025*** (-10.04)	-3.207*** (-10.32)
$lnInc$	0.827*** (6.07)	-0.059 (-0.55)	-0.172* (-1.66)	-0.013 (-0.13)	-0.133 (-1.11)	-0.001 (-0.01)	-0.011 (-0.11)
s^{tdg}	17.748*** (16.24)	20.119*** (18.72)	25.143*** (23.89)	19.756*** (19.36)	18.251*** (16.32)	18.867*** (18.98)	19.586*** (19.14)
sg^{sf}	-0.891*** (-2.73)	-1.076*** (-5.16)	-1.005*** (-5.06)	-1.007*** (-5.07)	-0.904*** (-4.41)	-1.065*** (-5.55)	-1.021*** (-5.25)
<i>Intercept</i>	-6.759*** (-8.55)	-1.774*** (-12.21)	-1.650*** (-11.86)	-1.796*** (-12.59)	-2.006*** (-10.93)	-1.773*** (-13.13)	-1.813*** (-13.10)
ρ^{12}	0.012*** (4.35)	0.015*** (7.76)	0.020*** (9.10)	0.016*** (7.83)	0.014*** (7.35)	0.016*** (7.85)	0.016*** (8.60)
ρ^{13}	0.000 (0.18)	0.001 (0.39)	0.002 (0.68)	-0.001 (-0.32)	0.004* (1.74)	0.002 (0.89)	0.001 (0.59)

ρ^{23}	0.032*** (2.80)	0.022*** (4.92)	0.030*** (5.99)	0.023*** (4.87)	0.023*** (4.58)	0.025*** (4.90)	0.026*** (5.16)
Base estimation controls and instruments							YES
Two-way Mundlak FE							YES
Obs.	394	759	729	721	629	771	791

A4. Temporal autocorrelation

When errors are serially correlated, standard statistical inference is no longer valid (Cameron and Trivedi, 2005). Several analyses in the context of EU budget bargaining have highlighted the potential presence of temporally correlated residuals in data. Most of them have assumed the presence of AR(1) processes in the residuals and corrected them using Prais–Winsten transformations of data (Rodden, 2002; Aksoy and Rodden, 2009; Schneider, 2011; 2013; and Mikulaschek, 2018), which consists of partially-differencing both dependent and explanatory variables including an autocorrelation parameter estimated by means of FGLS (Greene, 2018). While this method is only valid for linear models, we need a different approach for our fractional probit context. In a similar fashion, we modify the expected conditional value of the share of structural funds as if it followed a Dynamic Probit Model (Wooldridge, 2005)

$$E(s_{it}^{sf} | \cdot) = \Phi(\rho s_{it-1}^{sf} + f(s_{it}^{agr}, s_{it-1}^{agr}, s_{it}^r, s_{it-1}^r, \mathbf{Z}_{it}, \mathbf{Z}_{it-1}) + u_i)$$

where $-1 \leq \rho \leq 1$ is the autocorrelation coefficient. Additionally, we estimate panel-robust standard errors that only assume cross-sectional independence, a method that also controls temporal autocorrelation (Cameron and Trivedi, 2005).

Table A7 shows the estimates for both approaches, showing that the two key explanatory variables (s^{agr} and s^r) remain significantly different than zero when standard errors are only clustered by countries, as well as when the fractional probit model follows a dynamic specification. Additionally, the dynamic model yields slight changes in estimated coefficients, with marginal effects not changing the initial valuations (-0.66 and -0.35 in structural funds after a 1 p.p. increase in received agricultural and remaining funds). Therefore, accounting for serial autocorrelation does not seem to change either the significance, or the ordinality of item valuation from our base estimates.

Table A7 Estimates of the EU bargaining process accounting for temporal autocorrelation

	M4 SE Clustered	M4 AR(1) SE Clustered
s^{sf}		
s^{agr}	-8.703*** (-5.30)	-6.959*** (-4.05)
s^r	-3.239*** (-3.47)	-3.745*** (-4.57)
$lnInc$	-0.006 (-0.02)	-0.101 (-0.57)

s^{tdg}	19.702*** (6.31)	17.599*** (6.92)
sg^{sf}	-1.026*** (-2.70)	-0.616* (-1.71)
$s^{sf}(lag)$		4.611*** (6.64)
$s^{agr}(lag)$		6.807*** (10.51)
$s^r(lag)$		2.978*** (4.41)
$lnInc(lag)$		0.114 (0.39)
$s^{tdg}(lag)$		-15.138*** (-6.75)
$sg^{sf}(lag)$		0.510* (1.88)
<i>Intercept</i>	-1.816*** (-6.11)	-2.212*** (-9.39)
ρ^{12}	0.016*** (2.72)	0.012*** (3.28)
ρ^{13}	0.001 (0.25)	0.001 (0.32)
ρ^{23}	0.026*** (2.65)	0.026*** (2.66)
AIC	973.419	970.887
Base estimation controls and instruments		YES
Two-way Mundlak FE		YES
Observations	799	733

Notes: *t* statistics in parentheses. Standard errors clustered by countries. * $p < .10$, ** $p < .05$, *** $p < .01$