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ORIGINAL PAPER

Distributing the European structural and investment funds from a conflicting claims approach

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Abstract In order to support economic development across all European Union regions, €351.8 billion –almost a third of the total EU budget– has been set aside for the Cohesion Policy during the 2014–2020 period. The distribution of this budget is made through five main structural and investment funds, after long and difficult negotiations among the EU member states. This paper analyzes the problem of allocating the limited resources of the European Regional Development Fund as a conflicting claims problem. Specifically, we attempt to show how the conflicting claims approach fits this actual problem, and we propose alternative ways of distributing the budget via (i) claims solutions or (ii) the imposition of bounds (guarantees) to each of the regions. By applying this approach we also show that there is a claims solution that performs better than the others by reducing inequality and promoting convergence to a greater degree. It is clear that political bargaining will always be part of the allocation process. However, having an intuitive initial proposal may help politicians to find the best agreement. To that effect, we propose

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the use of a claims solution as a way to find an initial proposal for future policy changes concerning the allocations of the EU structural funds.

Keywords European Regional Development Fund · Conflicting claims problems · Public budget distribution; EU convergence

Verteilung der europäischen Struktur- und Investitionsfonds aus einem kollidierenden Forderung Ansatz

Zusammenfassung Zur Unterstützung der wirtschaftlichen Entwicklung in allen Regionen der Europäischen Union wurden im Zeitraum 2014–2020 351,8 Mrd. EUR – fast ein Drittel des gesamten EU-Haushalts – für die Kohäsionspolitik bereitgestellt. Die Verteilung dieses Budgets erfolgt nach langen und schwierigen Verhandlungen zwischen den EU-Mitgliedstaaten über fünf große Struktur- und Investitionsfonds. In diesem Artikel wird das Problem der Allokation der begrenzten Mittel des Europäischen Fonds für regionale Entwicklung als widersprüchliches Anspruchsproblem analysiert. Konkret versuchen wir aufzuzeigen, wie der konfliktbehaftete Schadenansatz zu diesem realen Problem passt, und schlagen alternative Wege zur Verteilung des Budgets durch (i) Schadenslösungen oder (ii) die Auferlegung von Grenzen (Garantien) für jede der Regionen vor. Mit diesem Ansatz zeigen wir auch, dass es eine Lösung gibt, die andere in Bezug auf den Abbau von Ungleichheit und die stärkere Förderung der Konvergenz übertrifft. Natürlich werden politische Verhandlungen immer Teil des Zuteilungsprozesses sein. Ein intuitiver Erstvorschlag kann den politischen Entscheidungsträgern jedoch helfen, die beste Lösung zu finden. Zu diesem Zweck schlagen wir vor, mit Hilfe einer Schadenlösungslösung einen ersten Vorschlag für zukünftige politische Änderungen bei der Zuweisung von EU-Strukturfondsmitteln zu unterbreiten.

1 Introduction

The main objective of the European Union (EU) is to strengthen the social and economic cohesion of the EU regions, as well as to reduce the inequalities among them. In doing so, and in accordance with the objectives of the Europe 2020 strategy, the European Structural and Investment Funds (ESIF) are implemented through five main funds: the European Regional Development Fund (ERDF), the European Social Fund (ESF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund (EMFF).[1]

In order to support job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life, the Regional Policy has allocated €351.8 billion -almost a third of the total EU budget- to the Cohesion Policy funds for the 2014–2020 period. According to the Panorama Inforegio magazine, support from the EU's cohesion policy had led member states to experience a 5% growth in per capita gross domestic product. The bulk of Cohesion Policy

[1] https://cohesiondata.ec.europa.eu/funds.

funding, over 50%, is allocated to less developed European regions in order to help them to catch up and to reduce the economic, social and territorial disparities that still exist in the EU.[2]

Among all the aforementioned funds, the present paper focuses on the European Regional Development Fund (ERDF), which represents almost 44% of the total budget. These funds are allocated at the NUTS level 2, which is a regional classification providing a harmonized hierarchy of regions: the NUTS classification subdivides each member state into regions at three different levels, from larger to smaller areas. For practical reasons the NUTS classification generally mirrors the territorial administrative division of the member states, supporting availability of data and policy implementation capacity. Specifically, the NUTS regulation defines minimum and maximum population thresholds for the size of the NUTS regions: NUTS level 2 corresponds to regions with populations between 800,000 and 3,000,000 inhabitants. Taking into account this division, the regional eligibility for the ERDF is calculated on the basis of regional GDP per inhabitant (*per capita*), and NUTS level 2 regions are ranked and split into three different groups, according to their *per capita* GDP: $R1$ corresponding to the *most developed* regions, $R2$ which refers to *transition* regions, and $R3$ which includes the *less developed* regions.

Although the final decision on the way the budget is allocated is the result of a political bargaining process (between the European Commission and the Member States), an initial proposal is presented as a starting point. Nowadays, the European Commission proposes allocations using the so-called *Berlin method*. This is a methodology, devised in 1999, for allocating cohesion funds based on regional and national prosperity and unemployment. Our main objective is to propose a *new initial proposal* to distribute the ERDF budget. And we do it by using the *claims problem* approach.[3]

A claims problem involves a set of agents demanding a part of some (perfectly divisible) endowment. It is a conflicting claims problem if the endowment cannot honor all the claims in full. If we consider the ERDF budget as the endowment to be allocated, and the claims consist of the amounts required to develop some projects (mainly in infrastructures: airports, universities, hospitals, etc.) that regions could not afford individually, it is noteworthy that the available budget is not enough to satisfy all the claims that the regions have on it.

The most difficult and controversial part of our approach is to define the claim of each region. As the ERDF projects must be co-financed by the Member States (in a percentage that depends on the category of the region), it is up to these states to present the co-financed projects properly. An alternative way is to consider previous allocations and to observe the gap between the different region's Gross Domestic Product (normalised in *PPS* euros). Once the projects have been selected, or each

[2] http://ec.europa.eu/regional_policy/es/information/publications/panorama-magazine/2017/panorama-61-cohesion-policy-looks-to-the-future.

[3] These problems originated with the seminal paper by O'Neill (1982), appropriate for situations such as inheritance problems, divorces, or the failure of a company or a bank. The way to solve this kind of problems is through some well-known solution concepts, the so-called *claims rules*.

region's claim has been fixed, the conflicting claims problem is well defined and the ERDF budget must be rationed by using well-known claims rules.

As far as we know, the recent paper by Fragnelli and Kiryluk-Dryjska (2019) is the only reference analyzing the ERDF distribution as a conflicting claims problem. As mentioned in that paper "this approach has the great advantage that solutions may be obtained with a fast computation." In this context, we should also mention the papers by Kiryluk-Dryjska (2014, 2018) that propose a formal framework for rural development budget allocation by using fair division techniques. Conflicting claims problems have also been used to analyze other related economic and social problems: in the education sector Pulido et al. (2002) use this approach for obtaining an efficient allocation of the university funds; in the fishing sector, it is a useful tool for searching possible solutions to address fish shortages, by proposing fishing quotas among a number of agents within an established perimeter (Iñarra and Prellezo 2008; Iñarra and Skonhoft 2008; Kampas 2015); or, in the negotiations on CO2 emissions, a relevant issue nowadays, Giménez-Gómez et al. (2016) and Duro et al. (2020) propose an appealing distribution by analyzing this situation as a conflicting claims problem.

We consider the use of claims rules to propose an initial allocation for distributing the EU funds in order to achieve social cohesion and convergence among member states. In doing so, our first step is to formally introduce the distribution of the ERDF budget as a conflicting claims problem. Once this is implemented, we apply some of the usual claims rules and compare them from a convergence perspective (comparing changes in the inequality of regions once each of the proposals is applied). We define a *convergence ratio* to analyze this question. Our results show that the allocations proposed by all of the claims solutions reduce the divergence among regions. Moreover, we obtain that, among the analyzed claims solutions, the constrained equal losses performs better than the other ones and better than the current allocation, for the purpose of achieving the convergence objectives.

Even though the EU has made significant efforts to "regularize" and "rationalize" the formal process for policy-making and the procedures for the negotiation of regional development programmes, the empirical evidence suggests that the interactions remain very complex and uncertain (Conzelmann 1998). As mentioned in Dotti (2015) "first, the EU and the member states decide general policy goals, the total budget and regional eligibility criteria. Next, each member state designs its own regional development strategies, according to the general framework and with the support of the EC (European Commission). In the final step, national and regional authorities have to implement regional development programmes, as agreed during previous phases and under the supervision of the EC." Our proposal (the use of claims rules to solve the distribution problem) is about eliminating discretionary decisions and making the process of allocating the EU funds transparent.

There are many papers analyzing the importance of ESIF funds in order to achieve greater social cohesion and economic growth among the European Union countries, most of them looking for the results obtained through the policies applied. For instance, Rodríguez-Pose and Fratesi (2004) apply cross-sectional and panel data analyses to observe the impact of European Structural Funds in Objective 1 regions; also Puigcerver-Peñalver (2007) studies the impact of the ESIF funds on the eco-

nomic growth of the regions; Mohl and Hagen (2010) analyze the economic growth of the European Union countries, from a financial perspective, for the NUTS level 1 and NUTS level 2 regions; Bouayad-Agha et al. (2013) consider an econometric model to analyze the effect of the cohesion policies on the European economies; and Dall'Erba and Fang (2017) apply a meta-analysis with the objective of studying the impact generated by the ESIF funds on the development of the recipient regions.

Some recent papers deal with political issues of the governance of the funds and the political/economic challenges. Bouvet and Dall'erba (2010) advocate that the decision process involves interaction between the actors (European Commission and Member States). Bodenstein and Kemmerling (2012) point out that the process of the distribution of regional funds has been termed a two or three-level game and the bargaining occurs between the regional and national actors. Chalmers (2013) provides some evidence that constitutionally strong regions are better lobbying advocates for investment projects. In Charron (2016) it is argued that "the determination of Structural Funds is based on an interaction between a region's formal institutions (the level of a regional autonomy) and informal institutions (its government quality level)." Papp (2019) analyzes, for the case of Hungary, the electoral connection between legislators and voters, and the European Union's contribution to regime legitimization. Finally, Crescenzi et al. (2020) argue that "in a context of rising economic nationalism and Euroscepticism, the value added of a supranational Cohesion Policy of the European Union is constantly under scrutiny" and propose to explore new institutional and policy arrangements in order to offer more flexibility and that "EU policies need to buy-in 'national' policy agendas in a more timely and systematic manner, sharing responsibility for (and ownership of) key policy reforms." In this Eurosceptic scenario, the possibility of offering a neutral and fair initial point, as offered by the claims rules, could help to reach more consensual budget distributions. Moreover, the proposed claims rules can be supported by equity and fairness criteria.

The remainder of the paper is organized as follows. Next, Sect. 2 formally presents the notion of conflicting claims problem and some of the main solutions in the literature. Sect. 3 presents the ERDF conflicting claims problems and applies the different claims solutions to the EU data. Sect. 4 analyzes and compares the proposed allocations from the point of view of convergence, and Sect. 5 studies the problem of ensuring some guarantees (in awards and in losses) for all regions. Some final comments in Sect. 6 conclude the paper.

2 Conflicting claims problems

A *claims problem* appears whenever several (economic and/or social) actors, *the agents*, demand a part of some (perfectly divisible) *endowment*. It is a *conflicting claims problem* if the endowment cannot honor all the claims in full. The typical example is that of *bankruptcy*: a firm does not have enough assets to pay all its debts and the endowment (the assets of that firm) must be distributed among its creditors. Another example would be the division of an estate amongst several heirs, particularly when the estate cannot meet all the deceased's commitments.

Although some references to this situation appear in ancient literature (2000-year old Babylonian Talmud), modern literature begins with the seminal paper by O'Neill (1982), also originated in a Talmud rights arbitration problem. There are three simple methods for solving bankruptcy problems in practice: The proportional rule (divide the endowment proportionally to each agent's claim), the constrained equal-awards solution (divide the endowment equally among the agents, ensuring that no agent gets more than their claim), and the constrained equal-losses solution (divide the losses equally, i.e., the difference between the total claim and the endowment, ensuring that no agent ends up with a negative transfer). Apart from these solutions, we will also introduce one additional method obtained by combining them: the $\alpha^{\min}$ rule (Giménez-Gómez and Peris 2014). Next, we formally define the problem and rules.

We study problems where an *endowment* $E > 0$ must be divided among a group of *agents* $N = \{1, 2, ..., n\}$. Agents $i \in N$ are identified by their *claim* $c_i \geq 0$ on the endowment E. We will denote by $c = (c_1, c_2, ..., c_n)$ the vector of claims. The *aggregate claim* C is given by $C = \sum_{i=1}^{n} c_i$ and a *conflicting claims problem* appears whenever the aggregate claim is greater than the available endowment: $C > E$. The pair (E, c) represents the conflicting claims problem.

The question that arises is: how to divide the endowment among the agents? This question is answered by defining rules. A *claims rule* is a single valued function φ such that for each conflicting claims problem (E, c) it assigns an amount $\varphi_i(E, c)$ to each agent $i \in N$, fulfilling:

a) $0 \leq \varphi_i(E, c) \leq c_i$ (*non-negativity* and *claim-boundedness*); and

b) $\sum_{i=1}^{n} \varphi_i(E, c) = E$ (*efficiency*).

That is, the endowment E is completely distributed among the agents, and no agent receives neither a negative amount, nor an amount exceeding the corresponding claim. Some commonly used claims rules are:

- The **proportional** rule (P) is the most popular one, and it divides the endowment proportionally to the claim of the agents.

  For each (E, c) and each agent $i \in N$, $P_i(E, c) \equiv \lambda c_i$, where $\lambda = \frac{E}{C}$.
- The **constrained equal awards** rule (CEA) (Maimoindes 2000) equalizes the amount each agent receives, such that no agent receives more than their demand.

  For each (E, c) and each agent $i \in N$, $CEA_i(E, c) \equiv \min\{c_i, \lambda\}$, where λ is chosen so that $\sum_{i=1}^{n} \min\{c_i, \lambda\} = E$.
- The **constrained equal losses** rule (CEL) (Maimoindes 2000; Aumann and Maschler 1985) analyzes the problem from the point of view of losses (what

the agents do not receive with respect to their claims) and proposes equalizing losses, such that no agent receives a negative amount.

For each (E, c) and each agent $i \in N$, $CEL_i(E, c) \equiv \max\{0, c_i - \lambda\}$, where λ is chosen so that $\sum_{i=1}^{n} \max\{0, c_i - \lambda\} = E$.

- The $\alpha^{\min}$ rule (Giménez-Gómez and Peris 2014) guarantees a minimum amount to each agent: if possible, all agents first receive an amount that coincides with the lowest claim and then, the remaining endowment is distributed proportionally to the reduced claims (the initial claims minus the amount already received). If the endowment does not allow each agent to receive at least the lowest claim, then all agents receive the same amount. That is:

  For each (E, c),

$$\alpha^{\min}(E, c) \equiv \begin{cases} \frac{1}{n}E & \text{if} \quad E \leq nk, \\ k + P(E - nk, c - k) & \text{if} \quad E \geq nk, \end{cases}$$

  where $k = \min\{c_1, c_2, ..., c_n\}$.

2.1 The socially accepted properties: axiomatic analysis

To analyze the behavior of the aforementioned claims rules, we propose two separate sets of properties that solutions of conflicting claims problems should fulfill: what we call *minimal requirements* and *additional principles*.[4]

The ***minimal requirements*** should contain the basic properties: *equal treatment of equals*, *anonymity*, *order preservation* and *resource monotonicity*. Note that these principles ensure that there is no discrimination among the agents (regions), in the sense that only the claim matters, and the regions with larger claims would not receive a smaller allocation than those regions with smaller needs. Note that, as Table 1 depicts, all these properties are satisfied by the claims rules we presented.

Appart from these basic requirements, there are some ***additional principles*** that differentiate one claims rule from another. In particular, we consider the properties of *super-modularity*, *composition down* and *composition up*. Super-modularity requires that regions with larger claims experience a greater increase in the ERDF budget. Composition down and up analyze the coherence of the rules whenever the endowment (the budget) decreases or increases. Table 1 depicts which of the aforementioned principles are fulfilled by the proposed claims rules.[5]

Note that the proposed claims rules satisfy all the axioms and further analysis is needed to select one of them in a particular scenario. In Sect. 4 we will introduce

[4] See Rose et al. (1998) for further details and a comprehensive study of equity principles and their implications.

[5] For technical details about these properties we refer to Thomson (2019), among others.

Table 1 Principles and claims rules. The table shows which principles are satisfied by the claims rules considered. These results can be found in Thomson (2019)

Principles/Claims rules	P	CEA	CEL	$\alpha^{\min}$
Minimal requirements:				
Equal treatment of equals	Yes	Yes	Yes	Yes
Anonymity	Yes	Yes	Yes	Yes
Order preservation	Yes	Yes	Yes	Yes
Resource monotonicity	Yes	Yes	Yes	Yes
Additional principles:				
Super-modularity	Yes	Yes	Yes	Yes
Composition down	Yes	Yes	Yes	Yes
Composition up	Yes	Yes	Yes	Yes

some criteria to select just one of these rules in the context of the distribution of the ERDF budget.

3 The distribution of the ERDF as a conflicting claims problem

Before presenting our model, it it noteworthy to observe that although ERDF resources are allocated between three categories of regions (NUTS level 2), the allocation of each region also depends on other variables. According to European Commission guidelines, this allocation depends on the category of the region (level of development), the gap between the region's GDP and the average EU GDP, and the state in which the particular region is located. Additionally, some premiums are allocated to less developed and transition regions in order to promote employment, youth employment, increase of the education level, decrease of gas emissions, or for migration purposes.[6]

In what follows, we present a very simplified version of this scenario in which the *actors* are the three different categories of region in each country: less developed, transition and more developed regions. This defines 47 agents in the distribution problem. Our objective is to show how claims rules perform in this situation. A more complete analysis at regional level (without joining the regions of the same type in a country) could be carried out by using the conflicting claims approach at the cost of enlarging the number of agents involved in the claims problem to 256. As mentioned in Fragnelli and Kiryluk-Dryjska (2019), it is worthwhile to remark that the computational aspects may be easily dealt with. In any case, we propose the solution given by a claims rule as an initial distribution to be discussed by political actors. As mentioned in Bouvet and Dall'erba (2010) "political bargaining will always be part of the allocation process because there are too many potential recipient regions, and the decision process involves interaction between several levels of the political arena."

[6] https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=3DE07CC2-B76E-4F77-8F10-F8090A4F6649.

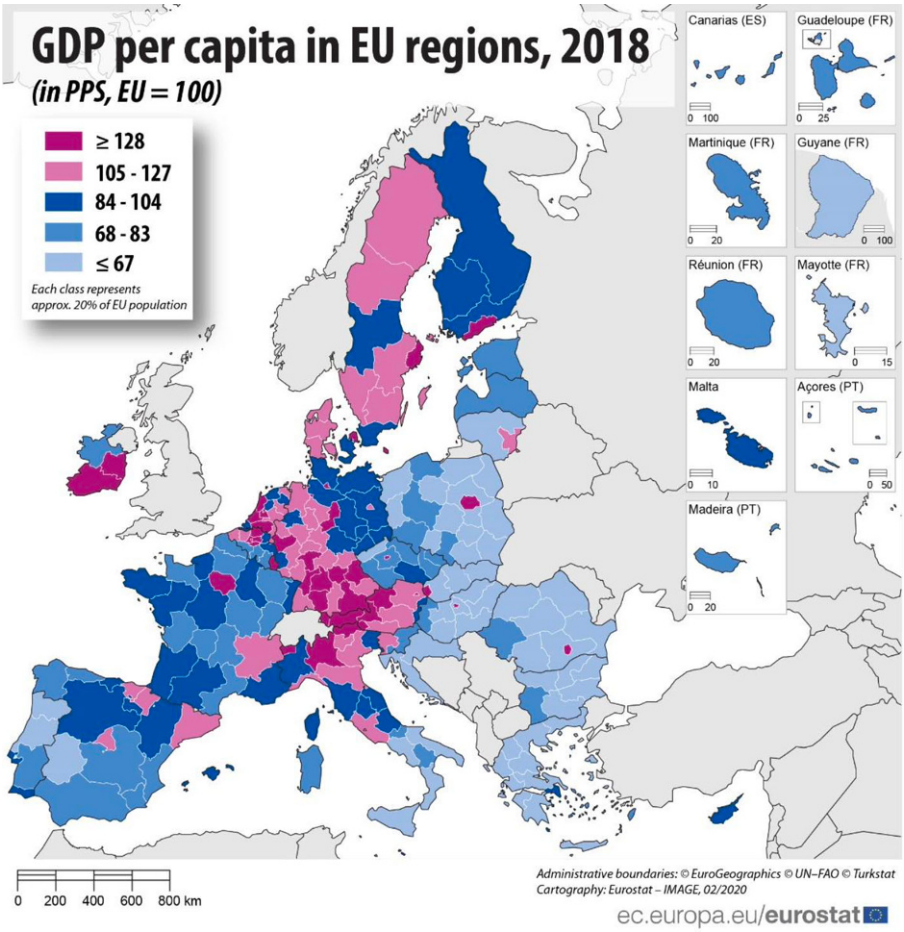

Fig. 1 EU GDP per capita in NUTS 2. Source: Eurostat, 2021

First, some stylized descriptive facts about the situation (regarding the regions' GDP) will be useful in our analysis. There are 256 NUTS2 regions in the EU. In 2018, regional GDP per capita, expressed in terms of purchasing power standards (PPS), ranged from 30% of the European Union (EU) average in Mayotte, an overseas region of France, to 263% in Luxembourg. As Fig. 1 depicts, there is considerable variation both between and within the EU Member States.

Although all EU countries belong to the so-called First World, there are notable differences in terms of regional GDP per capita. As Fig. 2 shows, 60% of the population which corresponds to the most developed regions (R1), generates 73% of the global GDP of the EU. While 27% of the population lives in the less developed regions (R3), in which 17% of the global GDP of the EU is generated.

Nowadays, in order to correct the above differences, the European Commission proposes allocations to the different regions using the so-called *Berlin method*. This is a methodology, devised in 1999, for allocating cohesion funds based on regional

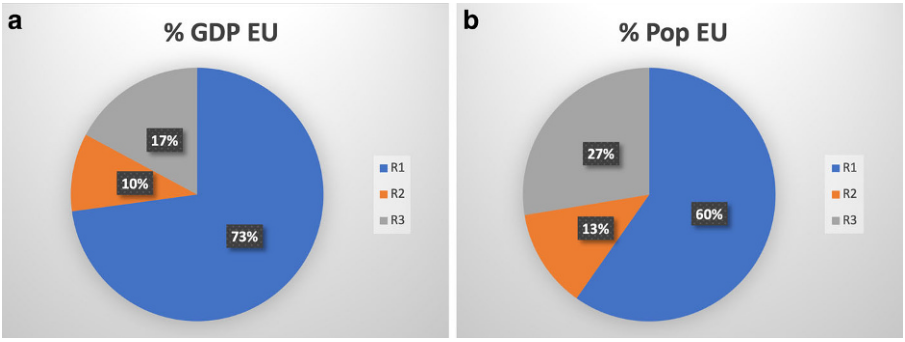

Fig. 2 GDP and population in the EU. Source: Eurostat, 2021

and national prosperity and unemployment. Although remaining consistent in focus, the criteria used in this method have evolved with each programming period to reflect new challenges and new policy objectives. The *Berlin Formula* key points are:[7]

- The eligibility of regions within the Cohesion Policy architecture (more, less developed or transition regions) is based on a reference period taking average economic data of three years.
- The methodology is largely based on regional statistics at NUTS level 2 regions.
- The different categories of regions (more, less developed and transition regions) are subject to different formulas for allocating funds.
- The methodology for allocating funds is publicly available. This, in theory, makes it the only EU policy based on shared management and pre-allocation to Member States that uses an objective formula.

Table 2 shows the data of the 47 regions that will define our problem: population, GDP per capita (expressed in terms of *purchasing power standards* [PPS]) and the allocation assigned using the Berlin method (both per capita and in total terms). Note that some countries do not contain all types of regions.[8]

To define a conflicting claims problem associated with the distribution of ERDF funds, we need to specify:

1. The agents.
2. The endowment.
3. The claim of each agent.

As mentioned, in our applied analysis the agents are the different types of regions in each country. These regions are differentiated by the corresponding Gross

[7] https://www.cpmr.org/pub/docs/366_cpmr_summary_of_berlin_formula_july_2015.pdf.

[8] The total 256 NUTS regions appear in Fig. 1. These regions are divided into three different types of regions: R_1, R_2, R_3. In order to simplify the exposition, we merge the regions of the same type in each country and so we obtain the 47 agents (regions). We indeed use the weighted average values in each agent we obtain merging regions.

Table 2 The agents: Nuts2 regions in each EU member state, population, GDP per capita, and current ERDF allocations per inhabitant and in total terms. Source: Eurostat, 2021

Country	Region	Population	GDP^h (*PPS* €)	ERDF allocation per inhabitant (€)	ERDF allocation (€)
Austria	R1	8,529,592	39,066	57.40	489,264,794
Austria	R2	292,675	27,300	160.60	46,997,285
Belgium	R1	8,166,294	40,252	36.30	296,454,193
Belgium	R2	3,232,295	23,594	203.12	656,555,114
Bulgaria	R3	7,050,034	15,435	506.05	3,567,667,612
Croatia	R3	4,105,493	16,412	1052.61	4,321,499,588
Cyprus	R1	864,236	27,100	347	299,898,560
Czechia	R1	1,294,513	58,000	244.80	316,938,431
Czechia	R3	9,315,542	23,238	1247.80	11,623,751,200
Denmark	R1	4,946,166	40,444	33.28	164,596,155
Denmark	R2	835,024	26,800	50.32	42,019,686
Estonia	R2	1,319,133	24,800	1407.41	1,856,562,743
Finland	R1	5,513,130	33,657	88.27	486,179,894
France	R1	46,780,936	34,915	67.63	3,163,893,035
France	R2	18,063,101	23,866	145.29	2,624,353,073
France	R3	2,182,187	19,400	1003.52	2,189,897,516
Germany	R1	69,552,916	39,042	61.35	4,267,345,327
Germany	R2	13,239,435	26,562	491.45	6,506,497,486
Greece	R1	4,097,323	27,534	418.96	1,716,630,309
Greece	R2	2,450,799	17,696	795.56	1,949,747,561
Greece	R3	4,193,043	15,723	1181.95	4,955,949,333
Hungary	R1	3,011,598	32,500	85.61	257,829,746
Hungary	R3	6,766,773	16,549	1551.54	10,498,950,944
Ireland	R1	4,830,392	57,500	85.04	410,775,098
Italy	R1	39,786,212	34,288	91.22	3,629,320,138
Italy	R2	3,271,865	22,981	276.97	906,217,153
Italy	R3	17.425.896	18.337	973,93	16,971,643,088
Latvia	R3	1,934,379	20,900	1241.36	2,401,252,452
Lithuania	R3	2,808,901	24,400	1246.54	3,501,411,767
Luxembourg	R1	602,005	79,300	32.40	19,502,403
Malta	R2	475,701	29,700	807.97	384,353,997
Netherlands	R1	17,181,084	39,200	29.70	510,282,703
Poland	R1	3,025,034	47,000	880.50	2,663,527,770
Poland	R3	34,951,653	19,152	1074.35	37,550,342,465
Portugal	R1	3,088,047	29,566	274.75	848,452,698
Portugal	R2	439,617	25,800	514.71	226,273,916
Portugal	R3	6,763,363	20,071	1417.42	9,586,507,283

Table 2 (Continued)

Country	Region	Population	GDP^h (*PPS* €)	ERDF allocation per inhabitant (€)	ERDF allocation (€)
Romania	R1	2,302,291	45,900	268.42	617,981,358
Romania	R3	17,231,190	16,422	586.62	10,108,099,341
Slovakia	R1	650,838	52,300	402.55	261,994,877
Slovakia	R3	4,792,282	18,166	1466.83	7,029,465,345
Slovenia	R1	977,163	31,600	467.36	509,292,519
Slovenia	R3	1,089,717	21,700	928.60	907,392,844
Spain	R1	31,407,979	30,660	253.62	7,965,810,858
Spain	R2	14,180,015	21,214	743.06	10,536,590,501
Spain	R3	1,070,453	20,100	1472.96	1,576,732,145
Sweden	R1	10,120,242	36,600	71.92	727,827,691

Domestic Product per inhabitant (GDP^h). The official website of the European Commission states that *"the ERDF aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions."* Therefore, the agents in this problem should be the different types of regions as described in the Official Journal of the European Union: *"Resources for the Investment (for growth and jobs goal) shall be allocated among the following three categories of NUTS level 2 regions:"*

$R1$: *More developed regions*: GDP^h is above 90% of the average of the EU-27.
$R2$: *Transition regions*: GDP^h is between 75% and 90% of the average of the EU-27.
$R3$: *Less developed regions*: GDP^h is less than 75% of the average of the EU-27.

The endowment E will consist of the ERDF budget to be allocated to all regions in the EU (in absolute terms). This budget is decided by the European Council and the European Parliament and covers a 7-year programming period. During the 2014–2020 programming period, the EU will spend over €350 billion on cohesion policy. That is equal to 32.5% of the overall EU budget. Around €199 billion is allocated to the European Regional Development Fund. This includes €10.2 billion for European Territorial Cooperation (ETC) and €1.5 billion of special allocations for outermost and sparsely populated regions.[9]

In our simulation, we use the ERDF budget as the endowment; that is, an amount of 188,008 million euros, which corresponds to the allocated budget without considering the European Territorial Cooperation and other special allocations. Note that the actual budget is 182,150 because we have removed United Kingdom from our analysis, since it does not belong to the EU anymore. When we analyze absolute budgets, we measurement the claims and allocations in millions of euros, M€. When we analyze the *per capita* distribution, the unity of measure is the euro, €.

[9] According to the European Commission proposals, in the 2021–2027 programming period, around €200.6 billion will be allocated to the ERDF.

Finally, the claim c_i of each type of region in each country remains to be decided. This is the more difficult and controversial part in defining the conflicting claims problem. As mentioned, the ERDF projects must be co-financed by the Member States, so it is up to these states and the European Parliament through several negotiations to decide which projects deserve to be properly co-financed.

An alternative way that we use to present our simulation, is to make the claim depend on the difference between the GDP per inhabitant of the regions (expressed in terms of *purchasing power standards* [PPS]). More precisely, on the gap between the greatest GPD per capita and that of the specific region. Then, for each agent i in our allocation problem, $i = 1, 2, ..., 47$, we define the claim per capita as a linear function:

$$c_i = \delta + \epsilon \left(\text{GDP}_*^h - \text{GDP}_i^h \right) \quad \delta \geq 0, \ \epsilon \in [0,1]$$

where:

- GDP_*^h is the greatest GDP per capita in the EU regions (Luxembourg);
- δ is a common amount per inhabitant that all regions receive (that can be interpreted as a minimal allocation); and
- ϵ is a coefficient that can be interpreted as a *convergence speed* fixed by the Member States.

For our computations, we fix δ as the allocation per inhabitant obtained by the region with the highest GDP per inhabitant (Luxembourg). That is, this region claims to receive the same amount as before, and other regions will claim this amount plus a part of their GDP gap. We set the ϵ coefficient at 2.5%; so, from Table 2 we obtain

$$c_i = 32.40 + 0.025 \left(79{,}300 - \text{GDP}_i^h \right).$$

The above expression gives rise to a minimum claim per inhabitant (after Luxembourg which is 32.40 €) of 546.90 €, which corresponds to R1 region in the Czech Republic. The maximum claim is that of R3 region in Bulgaria, that rises up to 1629 €. It should be noted that the way we have defined claims makes the regions with lower GDP per inhabitant have a higher claim; that is, the claim decreases with the GDP per capita of the region in question. In Table 3 we can find the claims of all regions.[10]

Once the problem of distributing the ERDF budget among the EU regions has been translated into a conflicting claims problem, as formulated in claims per inhabitant in each region, we need to adapt the claims rules introduced in Sect. 2 to the *per capita* analysis:[11]

[10] Note that ϵ is a coefficient that can be interpreted as a convergence speed fixed by the Member States. We set 2.5% for the sake of illustration. It is not based on past data.

[11] This adaptation is somewhat related to the *weighted constrained claims rules* (Casas-Méndez et al. 2011).

Table 3 Claims, current allocations, and proposals according to the different rules, in € *per capita*

Country	Region	Claim	Current	*P*	*CEA*	*CEL*	$\alpha^{\min}$
Austria	R1	1038	57.4	335.79	408.73	178.90	339.78
Austria	R2	1332	160.6	430.93	408.73	473.05	429.67
Belgium	R1	1009	36.3	326.20	408.73	149.25	330.72
Belgium	R2	1425	203.1	460.89	408.73	565.70	457.99
Bulgaria	R3	1629	506	526.86	408.73	769.67	520.32
Croatia	R3	1605	1052.6	518.96	408.73	745.25	512.86
Cyprus	R1	1337	347	432.54	408.73	478.05	431.20
Czechia	R1	565	244,8	182,70	408,73	0	195,13
Czechia	R3	1.434	1.247,8	463,77	408,73	574,59	460.70
Denmark	R1	1004	33.3	324.65	408.73	144.45	329.26
Denmark	R2	1345	50.3	434.97	408.73	485.55	433.49
Estonia	R2	1395	1407.4	451.14	408.73	535.55	448.77
Finland	R1	1173	88.2	379.53	408.73	314.13	381.11
France	R1	1142	67.6	369.35	408.73	282.68	371.50
France	R2	1418	145.3	458.69	408.73	558.90	455.91
France	R3	1530	1003.5	494.80	408.73	670.55	490.03
Germany	R1	1039	61.4	335.99	408.73	179.51	339.97
Germany	R2	1351	491.4	436.89	408.73	491.50	435.31
Greece	R1	1327	419	429.03	408.73	467.20	427.89
Greece	R2	1573	795.6	508.58	408.73	713.16	503.05
Greece	R3	1622	1181.9	524.53	408.73	762.48	518.12
Hungary	R1	1202	85.6	388.88	408.73	343.05	389.95
Hungary	R3	1601	1551.5	517.85	408.73	741.83	511.81
Ireland	R1	577	85	186.74	408.73	0	198.95
Italy	R1	1158	91.2	374.43	408.73	298.36	376.29
Italy	R2	1440	277	465.85	408.73	581.04	462.67
Italy	R3	1556	973.9	503.39	408.73	697.12	498.15
Latvia	R3	1492	1241.4	482.67	408.73	633.05	478.57
Lithuania	R3	1405	1246.5	454.37	408.73	545.55	451.83
Luxembourg	R1	32.4	32.4	10.48	32.40	0	32.40
Malta	R2	1272	808	411.52	408.73	413.05	411.34
Netherlands	R1	1035	29.7	335.79	408.73	175.55	338.76
Poland	R1	840	880.5	271.64	408.73	0	279.17
Poland	R3	1536	1074.4	496.81	408.73	676.76	491.93
Portugal	R1	1276	274.8	412.61	408.73	416.41	412.36
Portugal	R2	1370	514.7	443.05	408.73	510.55	441.13
Portugal	R3	1513	1417.4	489.37	408.73	653.77	484.90
Romania	R1	867	268.4	280.54	408.73	8.05	287.57
Romania	R3	1604	586.6	518.88	408.73	745	512.78
Slovakia	R1	707	402.6	228.79	408.73	0	238.68
Slovakia	R3	1562	1466.8	505.18	408.73	702.65	499.84

Table 3 (Continued)

Country	Region	Claim	Current	P	CEA	CEL	$\alpha^{\min}$
Slovenia	R1	1225	467.4	396.16	408.73	365.55	396.82
Slovenia	R3	1472	928.6	476.21	408.73	613.05	472.46
Spain	R1	1.248	253,6	403,76	408,73	389,04	404,00
Spain	R2	1485	743.1	480.1	408.73	625.21	476.17
Spain	R3	1512	1473	489.14	408.73	653.05	484.90
Sweden	R1	1100	71.9	355.77	408.73	240.55	358,62

- The *per capita* proportional rule P^h equalizes the portion of the claim that is satisfied,

$$P_i^h = \frac{c_i^h}{\sum_{j=1}^n c_j^h}\lambda, \lambda \text{ such that } \sum_{i=1}^n p_i P_i^h = E.$$

- The *per capita* CEA^h rule equalizes the awards (constrained to no one receiving more than her claim),
$CEA_i^h = \min\left\{c_i^h, \lambda\right\}, \lambda$ such that $\sum_{i=1}^n p_i CEA_i^h = E$.

- The *per capita* CEL^h rule equalizes the losses (constrained to no one receiving a negative amount),
$CEL_i^h = \max\left\{0, c_i^h - \lambda\right\}, \lambda$ such that $\sum_{i=1}^n p_i CEL_i^h = E$.

- The *per capita* $\left(\alpha^{\min}\right)^h$ rule ensures a minimum amount per capita to all regions and uses the *per capita* proportional rule to share the remaining estate (if any), with respect to the unsatisfied claim.

$$\left(\alpha^{\min}\right)_i^h = \begin{cases} \dfrac{1}{\sum_{i=1}^n p_i} E & \text{if} \quad E \leq k \sum_{i=1}^n p_i, \\ k + P_i^h\left(E - k\sum_{i=1}^n p_i, c^h - k\right) & \text{otherwise,} \end{cases}$$

where $k = \min\left\{c_1^h, c_2^h, ..., c_n^h\right\}$ and n is the number of agents.

Table 3 shows the distribution of the budget proposed by the different claims rules (per inhabitant in each region).

Although the criteria for the allocation of ERDF funds are applied by region, the main negotiations in the different bodies of the European Parliament take place between representatives of the Member States. That is why it is interesting to observe the allocation of these funds at the country level. Table 4 contains the distribution of ERDF funds by country, depending on the solution chosen, and comparing these with the current distribution. It also shows the percentage of the funds allocated to each country.

By observing the data in Tables 3 and 4, the way in which the ERDF budget is distributed varies from one proposal to another. On the one hand, we have the

Table 4 Absolute allocations of ERDF funds by country: current allocations and proposals according to the different rules (in M€). The figure given between brackets is the percentage of the funds allocated to each country

Country	Current		*P*		*CEA*		*CEL*		$\alpha^{\min}$	
Austria	536.26	(0.29%)	2990.30	(1.64%)	3605.90	(1.98%)	1664.43	(0.91%)	3023.98	(1.66%)
Belgium	953.01	(0.52%)	4153.60	(2.28%)	4658.91	(2.56%)	3047.36	(1.67%)	4181.13	(2.30%)
Bulgaria	3567.67	(1.96%)	3714.38	(2.04%)	2881.54	(1.58%)	5426.21	(2.98%)	3668.28	(2.01%)
Croatia	4321.50	(2.37)%	2130.59	(1.17%)	1678.03	(0.92%)	3059.63	(1.68%)	2105.53	(1.16%)
Cyprus	299.90	(0.16%)	373.82	(0.21%)	353.24	(0.19%)	413.15	(0.23%)	372.66	(0.20%)
Czechia	11,940.69	(6.56%)	4556.74	(2.50%)	4336.62	(2.38%)	5352.62	(2.94%)	4544.31	(2.49%)
Denmark	206.62	(0.11%)	1968.98	(1.08%)	2362.93	(1.30%)	1119.93	(0.61%)	1990.53	(1.09%)
Estonia	1856.56	(1.02%)	595.11	(0.33%)	539.17	(0.30%)	706.46	(0.39%)	591.99	(0.33%)
Finland	486.64	(0.27%)	2092.38	(1.15%)	2253.37	(1.24%)	1731.82	(0.95%)	2101.10	(1.15%)
France	7978.14	(4.38%)	26,643.93	(14.6%)	27,395.44	(15.0%)	24,782.70	(13.6%)	26,683.47	(14.7%)
Germany	10,773.84	(5.91%)	29,153.27	(16.0%)	33,839.48	(18.6%)	18,992.84	(10.4%)	29,409.23	(16.2%)
Greece	8622.33	(4.73%)	5203.71	(2.86%)	4390.21	(2.41%)	6859.19	(3.77%)	5158.57	(2.83%)
Hungary	10,756.78	(5.91%)	4675.35	(2.57%)	3996.69	(2.19%)	6052.90	(3.32%)	4637.67	(2.55%)
Ireland	410.78	(0.23%)	902.04	(0.50%)	1974.31	(1.08%)	0.00	(0.00%)	961.01	(0.53%)
Italy	21,507.18	(11.8%)	25,193.38	(13.8%)	24,721.44	(13.6%)	25,919.76	(14.2%)	25,165.68	(13.8%)
Latvia	2401.25	(1.32%)	933.67	(0.51%)	790.63	(0.43%)	1224.56	(0.67%)	925.74	(0.51%)
Lithuania	3501.41	(1.92%)	1276.29	(0.70%)	1148.07	(0.63%)	1532.40	(0.84%)	1269.15	(0.70%)
Luxembourg	19.50	(0.01%)	6.31	(0.00%)	19.50	(0.01%)	0.00	(0.00%)	19.50	(0.01%)

Table 4 (Continued)

Country	Current		*P*		*CEA*		*CEL*		$\alpha^{\min}$	
Malta	384.35	(0.21%)	195.76	(0.11%)	194.43	(0.11%)	196.49	(0.11%)	195.67	(0.11%)
Netherlands	510.28	(0.28%)	5750.65	(3.16%)	7022.38	(3.86%)	3016.17	(1.66%)	5820.26	(3.20%)
Poland	40,213.87	(22.1%)	18,186.09	(9.98%)	15,552.10	(8.52%)	23,654.01	(13.0%)	18,038.20	(9.90%)
Portugal	10,661.23	(5.85%)	4778.73	(2.62%)	4206.22	(2.31%)	5932.01	(3.26%)	4746.89	(2.61%)
Romania	10,726.08	(5.89%)	9586.80	(5.26%)	7983.86	(4.38%)	12,855.80	(7.06%)	9497.91	(5.21%)
Slovakia	7291.46	(4.00%)	2569.88	(1.41%)	2224.75	(1.22%)	3367.28	(1.85%)	2550.70	(1.40%)
Slovenia	1416.69	(0.78%)	906.04	(0.50%)	844.79	(0.46%)	1025.26	(0.56%)	902.61	(0.50%)
Spain	20,079.13	(11.0%)	20,013.10	(11.0%)	19,070.57	(10.5%)	21,783.55	(12.0%)	19,959.85	(11.0%)
Sweden	727.83	(0.40%)	3600.08	(1.98%)	4136.42	(2.27%)	2432.44	(1.34%)	3629.36	(1.99%)

'most egalitarian' proposal, given by *CEA* rule. This is a *conservative approach*, in the sense that the situation before and after the budget is allocated does not vary so much. At the other extreme, the *CEL* proposal is the most *groundbreaking* one, in the sense that it promotes serious changes in the previous status quo. The proportional P and the $\alpha^{\min}$ proposals are located somewhere between both approaches. In order to choose one proposal from all the obtained allocations, the following section compares the different claims rules in terms of convergence and equity.

4 Convergence among regions

As already mentioned, one of the main objectives of the EU through the ERDF is to promote convergence between regions of different types. In this section we analyze how the introduced rules promote this convergence and compare the effectiveness of the allocation proposed by each of these rules. Note that by effectiveness we mean the faster path to achieve convergence among regions.

To do this, we define a *divergence ratio* that attempts to capture the differences among regions in terms of GDP^h. Let us consider two agents (two types of regions in some member states) α and β such that:

- $p_\alpha < p_\beta$, where p_k stands for the GDP^h of region k.
- $c_\alpha > c_\beta$, where c_k stands for the (*per capita*) claim of region k.

That is, region α is less developed than region β and, consequently, the (*per capita*) claim of this region is greater than that corresponding to the most developed region.

We define the *divergence ratio* of (the less developed) region α *versus* (a more developed) region β as the quotient:

$$d_{(\alpha,\beta)} = 1 - \frac{p_\alpha}{p_\beta}$$

Note that $d_{(\alpha,\beta)}$ is always greater than 0 and the *ideal convergence* will arrive whenever all divergence ratios are equal to 0.

From an initial divergence ratio, convergence initiatives will promote the reduction of such a ratio. To study the impact of the allocation on convergence across regions, trying to capture the effect of assigning an amount $x > 0$ to a region with a given GDP^h, p, we assume that this allocation originates a new GDP^h, $\widehat{p}$, that can be defined as a function of the allocated amount and the previous purchasing power standard:

$$\widehat{p} = p + F(p,x) \quad \text{where function } F \text{ fulfills} \quad F(p,x) \geq 0,\ \frac{\partial F}{\partial x} > 0,\ \frac{\partial F}{\partial p} \leq 0$$

We are stating that, when p is fixed, the new GDP^h strictly increases as x increases. The negativity in the other partial entails that a fixed amount x provides the greatest increase in GDP^h for less developed regions.

Note that the present work only intends to show a new way of distributing the ERDF funds. Thus, we only analyze the effect that our proposal has on GDP in a very simplified way. For further analysis see, for instance, Becker et al. (2010). The easiest way of defining function $F(p,x)$ is to only consider an additive effect of the allocation; i.e., that the post-GDP^h can be estimated simply as the initial GDP^h added to the proposed allocation. This entails defining $F(p,x) = x$, so $\widehat{p} = p + x$. But this is a rather simplistic approach, as it omits possible multiplier effects that would stem from investment spending initiated with ERDF funds. A more general case is to consider quasi-linear functions. A possible example appears in the following expression:[12]

$$F(p,x) = \delta p + v(x) \quad v'(x) > 0 \ \text{(increasing) and} \ v''(x) \leq 0 \ \text{(concave)}, \ \delta < 0$$

Independently of the way in which we define function $F(p,x)$, we observe that the divergence ratio before the allocation is greater that the ratio after the allocation, when the rule for assigning the ERDF funds provides larger allocations to regions with larger claims. To show this fact, we denote by $d^0_{(\alpha,\beta)}$ the divergence ratio before the allocation and $d^1_{(\alpha,\beta)}$ the ratio after the allocation. Then, if $x_\alpha \geq x_\beta$

$$1 - d^1_{(\alpha,\beta)} = \frac{p_\alpha + F(p_\alpha, x_\alpha)}{p_\beta + F(p_\beta, x_\beta)} \geq \frac{p_\alpha + F(p_\alpha, x_\beta)}{p_\beta + F(p_\beta, x_\beta)} > \frac{p_\alpha}{p_\beta} = 1 - d^0_{(\alpha,\beta)}$$

that implies that $d^1_{(\alpha,\beta)} < d^0_{(\alpha,\beta)}$.

It is noteworthy that each of the proposed claims rules satisfies the so-called *order preservation* property; that is, the larger the claim, the larger the resources allocated by the claims rule. Therefore, the proposed claims rules always reduce the divergence ratio.

On the other hand, it is easy to observe that $c_\alpha > c_\beta$ implies that the application of the *CEL* rule always provides an allocation to the less developed region that is greater or equal than the one provided by other rules:

$$CEL_\alpha > \varphi_\alpha \qquad \text{for} \quad \varphi = P, CEA, \alpha^{\min}$$

for α such that GDP$^h_\alpha$ is low so,

$$d^1_{(\alpha,\beta)}(CEL) < d^1_{(\alpha,\beta)}(\varphi) \qquad \text{for} \quad \varphi = P, CEA, \alpha^{\min}$$

that is, the rule that best promotes convergence is *CEL*.

The above fact can also be deduced by using an additional equity criterion: *Lorenz dominance*, a useful tool to check whether a solution is more favorable to smaller claimants relative to larger claimants.[13]

[12] These kinds of functions have the property that the marginal rate of substitution (MRS) between p and x only depends on the allocation x.

[13] The Lorenz criterion is a key concept in the literature on income distribution. See, e.g., Sen (1973).

Formally, let $\mathbb{R}^n_{\leq}$ be the set of positive n-dimensional vectors $x = (x_1, x_2, ..., x_n)$ such that the entries are ordered from small to large; i.e., $0 < x_1 \leq x_2 \leq ... \leq x_n$. Let x and y be in $\mathbb{R}^n_{\leq}$. We say that x *Lorenz dominates* y, denoted by $x \succ_L y$, if for each $k = 1, 2, ..., n-1$

$$x_1 + x_2 + ... + x_k \geq y_1 + y_2 + ... + y_k \quad \text{and} \quad \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} y_i.$$

If $x \succ_L y$ and $x \neq y$, then at least one of these $n-1$ inequalities is a strict inequality. Given two claims rules, φ and ψ, it is said that φ *Lorenz dominates* ψ, $\varphi \succ_L \psi$, if $\varphi(E, c) \succ_L \psi(E, c)$, for each conflicting claims problem (E, c). Bosmans and Lauwers (2011) obtain a Lorenz dominance comparison among several claims rules:

$$CEA \succ_L \alpha^{\min} \succ_L P \succ_L CEL$$

So, the *CEA* rule distributes the budget in the most egalitarian manner possible, maintaining the existing differences before the budget was allocated. On the contrary, the *CEL* rule provides the less egalitarian distribution of the funds. Then, if one of the objectives is to reduce the previous inequalities, our results indicate that the *CEL* rule may be most appropriate.

5 Establishing guarantees

An interesting focus in the conflicting claims problems literature addresses the possibility of ensuring a minimum amount for each agent (each region in our application), or to limit the maximum amount they can receive. These amounts will depend on the available budget and on the quantity that each region claims. The minimum amounts that agents (regions) should receive are known as *lower bounds* (or *guarantees*).

- The **fair** lower bound (F) (Moulin 2002) establishes that all regions should receive at least the amount assigned to each of them in an equal division, or their full claim. Formally,

  For each $(E, c) \in \mathcal{B}$ and each $i \in N$,

  $$F_i(E, c) = \min\left\{c_i, \frac{E}{n}\right\}.$$

If we analyze the problem from the point of view of losses (the unsatisfied part of the claim), ensuring a lower bound in losses is equivalent to establishing an upper bound in awards.To define what we name the fair upper bound in awards, we denote by L the aggregate losses, that is $L = \sum_i c_i - E$.

- The **fair** upper bound (U) establishes that all regions should incur the same loss, restricted to the fact that no region may end up with a negative allocation. Formally,

Table 5 For each country, the percentage of the ERDF budget assigned by fair lower and upper bounds

%	**Austria**	**Belgium**	**Bulgaria**	**Croatia**	**Cyprus**	**Czechia**	**Denmark**	**Estonia**	**Finland**
F	1.98%	2.55%	1.58%	0.92%	0.19%	2.38%	1.30%	0.30%	1.24%
U	4.14%	5.34%	3.31%	1.92%	0.41%	4.97%	2.71%	0.62%	2.58%
Current	0.29%	0.52%	1.96%	2.37%	0.16%	6.56%	0.11%	1.02%	0.27%
	France	**Germany**	**Greece**	**Hungary**	**Ireland**	**Italy**	**Latvia**	**Lithuania**	**Luxembourg**
F	15.02%	18.55%	2.41%	2.19%	1.08%	13.58%	0.43%	0.63%	0.01%
U	31.42%	38.82%	5.04%	4.58%	2.26%	28.36%	0.91%	1.32%	0.28%
Current	4.38%	5.91%	4.73%	5.91%	0.23%	11.81%	1.32%	1.92%	0.01%
	Malta	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Slovakia**	**Slovenia**	**Spain**	**Sweden**
F	0.11%	3.85%	8.51%	2.31%	4.38%	1.22%	0.46%	10.46%	2.27%
U	0.22%	8.05%	17.80%	4.82%	9.16%	2.55%	0.97%	21.87%	4.74%
Current	0.21%	0.28%	22.08%	5.85%	5.89%	4.00%	0.78%	11.02%	0.40%

For each $(E, c) \in \mathcal{B}$ and each $i \in N$,

$$U_i(E, c) = \max\left\{0, c_i - \frac{L}{n}\right\}.$$

As the population is very different from one country to another, we need to compute these bounds in *per capita* terms and then we obtain the lower and upper bound by multiplying for each country population. Then,

$$\frac{E}{n} = 408.22\,€ \qquad \frac{L}{n} = 853.97\,€$$

Table 5 shows the result (in percentages) that the bounds assign to each country of the ERDF budget.

Note that, for most of the countries, the current allocation does not remain within the lower and the upper limits. Nevertheless, the claims rules provide allocations within the ranges obtained for many countries (compare with Table 4). The fair lower and upper bounds must be understood as the desirable limits within which the proposals for the allocation of funds must be found. Among the cases in which current allocations do not meet these restrictions, it is interesting to look at the Netherlands, Denmark or Sweden (among others), receiving an amount below the recommended minimum. At the other extreme are Poland or Hungary, which receive an amount above the maximum proposed by the fair upper bound.

6 Conclusions

The European Union tries to promote the social and economic cohesion of the Member States, as well as to reduce the inequalities among them. To achieve this objective, the EU uses several financial instruments, one of which is the European Regional Development Fund (ERDF).

We suggest a way to obtain an initial proposal for the distribution of the ERDF budget, that is based on defining a conflicting claims problem. To define this problem, we easily identify the agents (*the EU NUTS level 2 regions*) and the endowment (*the ERDF budget to be allocated*). To complete the construction of the model, it is only necessary to define the *claim* of each region, a matter of political approach. This part is related to the political aspect of the distribution of cohesion funds in the EU and is beyond the scope of this paper, although we suggest a way to proceed: let the regions propose (co-financed) projects and select the credible/viable ones.

Once the conflicting claims model is completed, any of the rules defined to solve claims problems (claims rules) can be used to obtain a meaningful distribution of the ERDF budget. We use four claims rules to show the performance of our model: the proportional rule, the constrained equal awards rule, the constrained equal losses rule, and the $\alpha^{\min}$ rule. We show that all these rules promote convergence among regions and reduce inequalities. Among the analyzed rules, the one that performs best (promoting convergence) is the one that proposes the most unequal (*per capita*) distribution of the ERDF budget: the constrained equal losses rule.

We propose a simulation exercise in which the claims are defined in a linear way by adding a fixed (subsistence) amount with a factor that depends on the per capita gap between the GDP of different regions. Although this assumption may have some logic, the obtained (simulated) numbers are only used to illustrate how allocations are decided according to the claims rules and observe the behavior of such a distribution.

As mentioned, our empirical exercise only tries to compare current allocations with the proposals obtained through claims rules. Although it is a very simplified scenario, our empirical results have two remarkable features:

1. The results do not drastically differ from current allocations.
2. It promotes (theoretical) convergence better than the current allocation.

We propose the application of claims rules (the *CEL* rule, in particular) to obtain an initial proposal to be discussed by Member States.

As done in Fragnelli and Kiryluk-Dryjska (2019), a national-level analysis of the application of claims rules can be an interesting on-going research. This study may have two possible lines:

- To analyze the distribution of the ERDF allocated to a Member State among the different regions in this country (NUTS 3 analysis).
- To analyze the distribution of the ERDF allocated to a Member State among the different programs in this country (unemployment, youth unemployment, education, migration, etc.). In Fragnelli and Kiryluk-Dryjska (2019) this kind of study is carried out for Poland.

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