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**MASTER THESIS**

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| **Šiltnamio efektą sukeliančių dujų emisijų mažinimo tikslų pasiskirstymo vertinimas Europos Sąjungoje** | **Assessment of the Distribution of Greenhouse Gas Emission Reduction Targets in the EU** |

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# INTRODUCTION

***Relevance of the topic***

The world is set to face catastrophic consequences imposed by climate change if insufficient action is taken to mitigate it. Agreeing on how the effort in cutting greenhouse gas emissions (emissions) should be shared among the countries has been a widely contentious topic since the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Article 3 of the UNFCCC recognized that climate change mitigation should be based on the equity principle which is defined as *differentiated responsibilities and respective capabilities.* Since then, effort-sharing academic literature has produced various interpretations and corresponding approaches on how the Gordian knot of climate equity could be resolved.

Even today this question has maintained its relevance as the world seems to be unable to establish a long-standing effort-sharing mechanism that would result in sufficient global emission reduction trajectory (den Elzen et al. 2022). Different climate negotiation rounds result in new proposals from the scholars or country representatives for updated effort-sharing arrangements pulling the sheets from one corner of the bed to the other.

The European Union (EU) is no exception. In 2023 the EU has increased its collective emission reduction target to 40% by 2030 (compared to 2005 levels) in the non-Emission Trading System sector. The established target raises suspicion whether the effort-sharing among the EU Member States in the non-Emission Trading System sector is fair and in line with the UNFCCC equity principle as neither relevant legislation nor EU institutions disclose the methodology how the effort-sharing targets were set. Moreover, starting in 2027, most sectors currently outside the Emission Trading System, including no-ETS sectors, will be incorporated into Emission Trading System 2 (ETS2), which will financially reward countries with emissions below the cap and impose taxes fees on those exceeding the set emission limits. This sets a compelling basis for an inquiry to compare current EU emission reduction arrangements in the light of other established effort-sharing approaches which could reveal valuable insights for future commitment negotiations.

***The level of exploration of the topic***

The topic of emission reduction effort-sharing has gained extensive attention from scholars over the course of around the last three decades. The debate largely revolves around different

approach propositions and how the equity principle enshrined in the UNFCCC can be interpreted and operationalized that would result in effective climate change mitigation. Studies often include more than one approach to manipulate the feasibility of climate change policy in different parameter settings. However, the scholarly debate tends to focus largely on fair distribution of the emissions reduction on a global scale, considering the EU as a single unit, also overlooking unique EU's unique two-pillar system towards climate change mitigation which comprise Emissions Trading System (ETS) and non-ETS sectors. Moreover, literature most often focuses on analysis what climate what climate targets could be instead of testing whether currently established ones are fair.

***The novelty of the thesis***

At least one study by Steininger et al. (2022) has attempted to tackle the EU's effort-sharing question in the non-ETS sector. The research went beyond effort-sharing literature with an attempt to develop a novel approach. However, the thesis instead focuses on applying more established effort-sharing literature approaches to compare their results with the EU emission reduction targets. Furthermore, the thesis acknowledges a unique EU circumstance for climate change mitigation – EU funding support for climate change mitigation which considerably lowers true or net effort-sharing burden for some countries. Research accordingly adjusts emission targets of EU Member States based on which part of emission reduction effort is funded through country own means and which through external funding from EU which allows for better comparability with other effort-sharing approaches applied.

It is important to note that key research outputs were already in presented in the International Conference on Accounting, Audit, and Analysis (Cancingeris, 2024).[1]

***The problem of the thesis***

The problem of the thesis is defined by the following two questions:

1. What would be the differences between EU emission reduction targets and those distributed using other prominent effort-sharing approaches in the non-ETS sector?

2. What is the net effort-sharing burden for each EU Member state if the impact of EU financial support was removed?

***The aim of the thesis***

[1] Conference participation certificate can be found in Annex 6 of the research.

The main purpose for executing such research is to test to whether current distribution of emission reduction targets in the EU is fair and in line with the equity principle established in the UNFCCC which is defined as c*ommon but differentiated responsibilities and respective capabilities*. Also, to inform decision makers and taxpayers where do their countries stand in climate change mitigation and whether their efforts are sufficient or inadequate indicating of need for EU emission targets adjustment.

***The objectives of the thesis***

1. To provide an overall context of global climate change mitigation arrangements and how the EU framework fits in it.
2. To review scholarly debate on effort-sharing approaches and compare them with the current EU framework.
3. To select the most relevant effort-sharing approaches and adjust their methodologies for EU circumstances to make emission target distributions comparable against each other.
4. Determine methodology for EU emission target adjustment (net emission targets) based on EU funding each Member State receives for climate change mitigation.
5. To collect relevant data samples for each EU Member State.
6. To apply chosen research methodology to reveal the differences between selected effort-sharing approaches and current EU distribution of national targets and evaluate the impact of EU funds.
7. To present the findings, discuss their implications and provide recommendations for climate negotiators and inform society.

***The methods of the thesis***

Research applies two effort-sharing approaches discussed in the literature review: Green Development Rights (GDR) and Equality. The GDR framework is selected as it combines both responsibility and capability variables, most accurately addressing UNFCCC equity principle, while Equality approach clearly reveals emission differences among countries, and is useful to provide a clear comparison with both the EU and GDR targets.

Variables and data sources used to apply GDR approach:

1. GDP per capita (PPS) in EUR: Eurostat

2. Gini coefficient: Our World in Data

Variables and data sources for both GDR and Equality approach:

3. Population data: Eurostat

4. Greenhouse gases emissions ($CO_2$ equivalent) in the non-ETS sector: European Environment Agency

***The description of the structure of the thesis***

The structure of the thesis is divided into the following chapters:

**1. Scholarly debate on the climate change mitigation and effort-sharing.** Provides overview of global and EU climate change mitigation arrangements, scholarly debate on effort-sharing approaches and discusses their relevance to EU framework and identifies research gaps.

**2. Methodology of emission reduction distributions.** Chapter defines research aim, provides rationale on the selection of approaches, adjusts their methodologies to EU circumstances and outlines methodology for EU emission targets adjustments based on EU funding each Member State receives for climate change mitigation.

**3. Assessment of the distribution of emission reduction targets.** Presents the research findings, explains different outputs of approaches applied and outlines their implications.

**4. Conclusions and recommendations.** Summarizes the research, concludes with the key-takeaways, and provides recommendations.

# 1. SCHOLARLY DEBATE ON THE CLIMATE CHANGE MITIGATION AND EFFORT-SHARING

## 1.1. From global emission reduction commitments to EU national targets

In order to hold the increase of global average temperature below 1.5°C or at least 2°C of pre-industrial levels, a threshold whose crossing would result in catastrophic consequences for the human and ecological systems due to climate change, the world has to undertake an enormous task in reducing its net anthropogenic greenhouse gas emissions (IPPC, 2020). Aiming for a 1.5°C goal, cumulative global emissions would have to decrease by 45% until 2030 and reach net zero by 2050 compared to 2010 levels. To limit global warming under 2°C, emissions are required to decline by 25% in 2030 and become net zero in 2070 (IPPC, 2018).

These ambitious yet necessary targets call for close global cooperation for effective climate change mitigation as emissions affect everyone irrespective of the source of pollution. By far the most foundational attempt for the global community to agree on the scale of the threat for our civilization and cooperate to mitigate it is the establishment of the United Nations Framework Convention on Climate Change (UNFCCC) (1992).

The UNFCCC as an international agreement set a basis for administrative arrangements, core objectives, responsibilities, financial mechanism, and the establishment of national emissions inventories and removals for global climate change mitigation. The recurring theme across the whole document is the equity principle which is defined as *common but differentiated responsibilities and respective capabilities* among countries for emissions reduction efforts (UNFCCC Article 3, 1992). To put it simply, UNFCCC recognized that climate change mitigation efforts should be led by the developed countries who have historically emitted the highest volumes of CO2 (responsibility) and at the time of signing enjoyed the highest standards of living (capability).

The UNFCCC acquired a more tangible meaning with the signing of the Kyoto Protocol (1998) which began the implementation of the UNFCCC measures. It set forth legally binding national and regional emission reduction targets (5% global cumulative emission reduction by 2012 compared to 1990 levels) that went beyond previously envisaged stabilization of emissions to 1990 levels (UNFCCC, 2000).

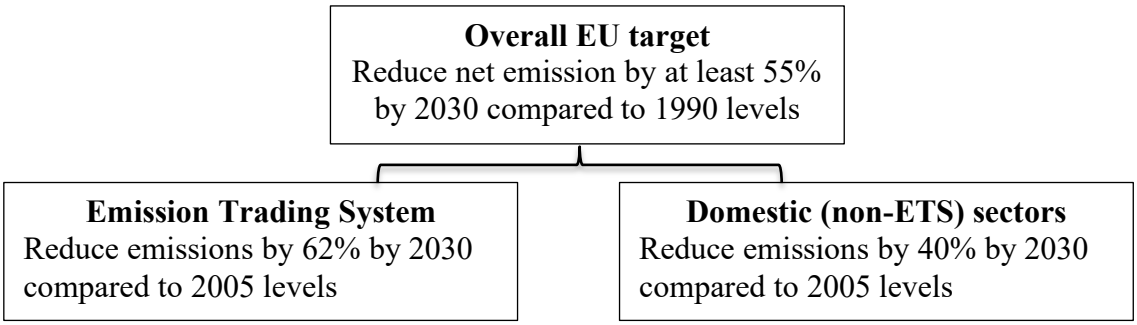
It was superseded by the Paris Agreement (2015) (currently under implementation) which brought about certain adjustments, among which came the bottom-up approach for countries to set their own emission reduction targets or nationally determined contributions (rather than top-down determined by the Kyoto Protocol targets) with a cumulative global goal to limit global temperature increase below 2°C and to pursue 1.5°C pre-industrial level.

### 1.2. Distribution of national greenhouse gas reduction targets in the EU

Under the Paris Agreement, the EU has set among the most ambitious in the world nationally determined contribution upon which it is committed to reduce its emissions by 55% until 2030 compared to 1990 levels (European Climate Law, 2021). The EU's cumulative contribution is divided into national legally binding targets and distributed to each EU-27 Member State. The EU distinguishes itself from the rest of the world through its unique approach towards effort-sharing for climate change mitigation. It consists of two pillars: non-Emission Trading System (Effort Sharing Regulation, 2023) and Emissions Trading System (ETS) (2023), which have set different emission goals present in Figure 1.

**Figure 1**

*EU framework and goals for climate change mitigation until 2030.*




Source: made by author based on the Effort Sharing Regulation (2023) and Emission Trading System Directive (2003).

The ETS covers emissions from installations in the energy and manufacturing industry which amount to around 40% of total EU emissions (Marcu et al. 2022). Each year a lowered EU wide total emissions cap for installations covered by the ETS is set. Accordingly, a fixed number of emission allowances distributed to companies can be traded in the emissions market. Companies whose emissions exceed the granted allowance cap have an option either to cut their

emissions, buy additional allowances from other companies in the emissions market or pay fines (Emission Trading System, 2023). Installations with excess allowances have an option to sell them to other companies or keep them for the next year.

Conversely, the Effort Sharing Regulation or the non-ETS pillar covers the rest of the sectors that are not included in the ETS, such as domestic transport, agriculture, small industry, and waste. While individual companies are responsible for emission reduction in the ETS, Member State governments are assigned such responsibility in the non-ETS sector.

Although the EU's overall climate change mitigation ambition is commendable, its internal distribution of effort-sharing targets within the Effort Sharing Regulation (2023) suffers from transparency issues. Neither relevant legislation nor EU institutions in sufficient detail disclose the methodology how the effort-sharing targets are set. European Commission only vaguely describe that national effort-sharing targets are casted by the three core elements: 1. Fairness; 2. Cost-efficiency; 3. Environmental integrity[2].

Based on European Commission communication, fairness is understood as capacity to act and expressed largely through GDP per capita metric. Higher income per capita Member States are obliged to reduce more emissions compared to lower income countries. Moreover, the 2030 emission reduction targets are limited within a range of -10% and -50% compared to 2005 levels (Effort Sharing Regulation 2023). These limits are set to address cost-efficiency as, for example, the marginal utility in reducing first 10% of emissions is more easily attainable than the next 10%. However, it is important to note that countries who also just start limiting their emissions, also suffer from higher startup costs due to delayed decarbonization (EIB, 2021). Concerning the environmental integrity element, Member States are allowed to apply certain flexibilities in connection to ETS and land use, land-use change, and forestry sectors, such as transferring unused emission to the non-ETS target achievement (Runge-Metzger & van Ierland, 2019).

Figure 1 depicts the distribution of national EU emission reduction targets for 2030 in the non-ETS sector that reflect the parameter settings described above. As the GDP per capita increases, so does the Member State's commitment for climate change mitigation efforts. The targets are locked within a -10% to -50% interval. However, two red-dotted countries Malta (19%) and Ireland (42%) fall out of the overall trend. An educated guess for the deviation of Ireland's lower effort-sharing target compared to its income level could be its unnaturally bloated GDP. As for the Malta's case it already has one the lowest per capita emissions in the EU (UNFCCC, 2024)

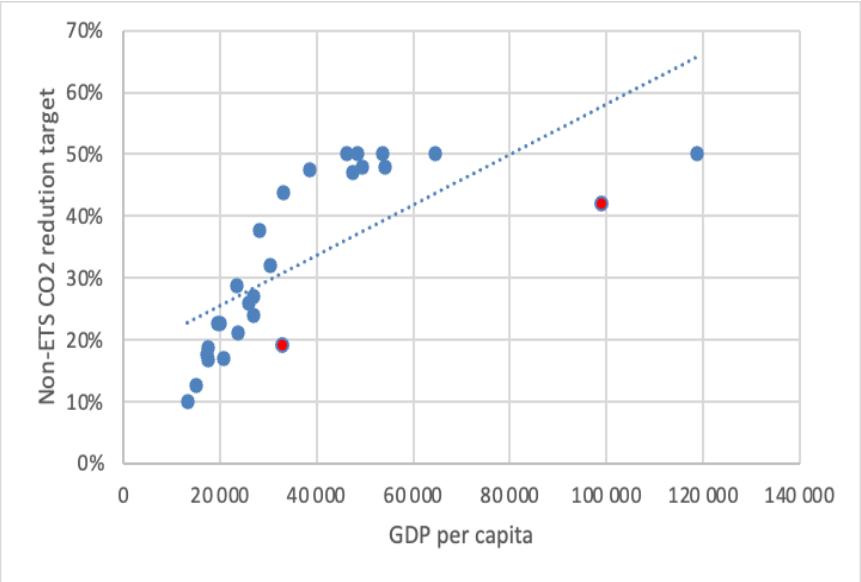
[2] Based on the European Commission working paper which is not publicly available and was provided by the Ministry of Environmental Protection of the Republic of Lithuania.

Although this level of detail allows to get an overall sense on how emission reduction targets are determined, it by no means establishes an in depth understanding why the targets established are the way they are, why certain countries significantly deviate from other countries in terms of income and reduction target relationship and whether they are truly fair and in line with the *common but differentiated responsibilities and respective capabilities* principle.

One could argue that these effort-sharing arrangements are fair as all of the EU Member states had to agree upon them. However, the reality is far more nuanced as the negotiations processes and resulting outcomes are embedded in *path dependencies, side deals, power struggles or domestic politics* (European Scientific Advisory Board on Climate Change, 2023; Steininger et al., 2022). Sheer number of the EU Member States required to adopt unilateral decision requires a high degree of willingness to sacrifice own interest for common compromise. This sets a compelling basis for an inquiry whether currently established EU effort-sharing targets in the non-ETS sector are distributed in a fair manner if compared to other leading scholarly approaches on fair distribution of climate change mitigation targets.

**Figure 2**

*2022 GDP per capita (EUR) relationship to national 2030 emission reduction targets in the non-ETS sector for EU-27 based on Effort Sharing Regulation (2023) compared to 2005.*




Source: Eurostat; Effort Sharing Regulation (2023).

In summary, the EU has established one of the most ambitious nationally determined contribution target under the Paris Agreement (-55% until 2030 compared to 1990 levels). While

this commitment shows leadership and sets an example for countries or regions, it is unclear whether the distribution of this commitment in the non-ETS sector among EU Member States is fair and in line with *common but differentiated responsibilities and respective capabilities* principle. It is problematic to make a proper assessment of the EU's current approach as its methodology is not publicly available. Therefore, to make sense of the current EU setup, the following sections of the research will overview scholarly debate on the leading effort-sharing approaches, compare their features, discuss their relevance or suitability, and apply them to simulate our own distribution of national emission reduction targets. The results are then compared to current national EU targets (adjusted based on EU funding and unadjusted) to provide valuable insights where does the EU stands in terms of fair distribution of effort-sharing.

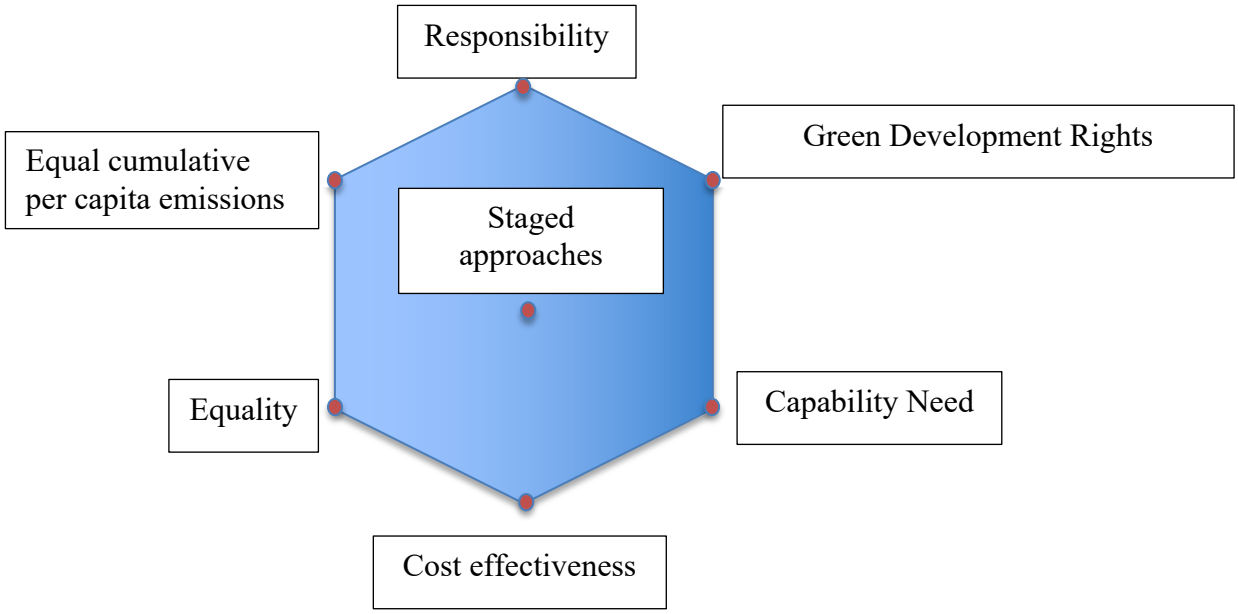
### 1.3. Scholarly debate on climate change mitigation effort-sharing

The academic literature over the course of around three decades developed and proposed a plethora of interpretations of fairness and developed corresponding effort-sharing approaches on climate change mitigation. The debate in broader terms can be categorized into four main dimensions that emphasize the relevance of different parameters, most notably: responsibility, equality, capability, and cost-efficiency. These main categories have become equity benchmarks and are applied together within the same studies for comparability (Hohne et al. 2014; Pan et al. 2017; Robiou Du Pont et al. 2017; van der Berg et al. 2020; Sælen et al., 2019; Leimbach et al. 2019; Xunzhang et al. 2017). This categorization also includes hybrid approaches that combine two or more parameters (see Figure 2). The emphasis on different parameters result in different outcomes concerning the reduction of emissions.

Another relevant distinction is the way different approaches set the emission targets over time (van der Berg et al. 2020). As a rule, effort-sharing approaches determine national/regional emission allowances divided into different periods of time based on specific global reduction pathways. Accordingly, emissions reduction occurs in stages. However, more recently focus on carbon budgets has started to gain prominence which essentially means that each country is assigned a carbon budget it can deplete until a specific date (Raupach et al. 2014). The main advantage of the carbon budget compared to the staged approach is that countries can choose their own individual reduction pathways.

**Figure 3**

*Categorization of leading effort-sharing approaches in the academic literature.*




Source: made by author based on Hohne et. al. (2014) categorization.

### 1.3.1. Equality

Equality strand of literature determine national emissions allowances on an equal per capita basis. This approach, first developed in the first part of the 1990s by the Global Commons Institute and proposed by the Indian government in 1995, is also often referred to as the Contraction and Convergence (Global Commons Institute, 2004). Under this approach a global cumulative emissions target in year $T_2$ is determined. Accordingly, all countries must work their way through so that their emissions converge at the same time to a global per capita emissions target in the year $T_1$. In order to achieve this, high emitting countries have to reduce their emissions until they reach a specific per capita emissions threshold, while below per capita threshold emitting countries have room for emissions increase.

Due to its simplicity this approach is useful in applying it in global climate change mitigation policy in economic models testing the feasibility of achieving global cumulative greenhouse gas reduction targets or manipulating the effect of climate mitigation policy change in other aspects (den Elzen et al., 2005; van Vuuren et al., 2010; Onigkeit et al., 2009; Leimbach & Giannousakis, 2019). It is usually applied also taking into consideration the cost-efficiency element. This combination reveals the need for a global emission trading mechanism so high

emitting countries with high emissions abatement costs could buy emissions allowances from countries with spare emission allowances. Countries that sell their emission allowances could in turn channel the acquired capital to fund their climate mitigation policies as they develop economically.

While a large part of this strand of literature focuses on per capita emissions among countries, some studies take a more nuanced approach taking into account the equality aspect of emissions distribution within countries. Chakravarty et al. (2009) assuming a direct relationship between per capita emissions and national income distribution proposed to determine national emission reduction targets based on a country's cumulative excess emissions that exceed a universal per capita emission threshold. These parameter settings result in higher responsibility targets for lower income and emissions countries as emissions of high-emitting individuals in low-income countries are not distributed across the whole population in part solving a free-rider problem.

### 1.3.2. Responsibility

Although its origins can be tracked down to earlier periods, the responsibility approach started to garner most of its attention with its introduction by the Brazilian delegation during the Kyoto protocol negotiations in 1997 (Friman, 2007). The main rationale behind this approach is that emissions reduction burden should be attributed to countries in accordance with their past cumulative emissions. Since the most developed countries have emitted the highest share of global emissions, they should carry most if not all the burden to mitigate climate change. Accordingly, the original Brazilian proposal included emissions reduction burden sharing only for Annex 1 countries (developed countries and economies in transition) that would be based on their historical cumulative emissions from 1840 (den Elzen, 2004; Kyoto Protocol, 1998).

Although the approach was not adopted, it received significant support from developing countries. It also started to gain attention from the scholars of the effort-sharing realm of literature. However, only a small number of studies attempted to attribute emissions reductions targets solely on historical emissions (Berk and den Elzen, 2001; den Elzen, 2004; den Elzen and Lucas, 2005; & Giannousakis, 2019; Sælen et al. 2019). More often historical responsibility is included as one of the variables upon which distribution of burden sharing targets are determined (covered in the following sections).

### 1.3.3. Equal cumulative per capita emissions

First introduced by Bode (2003), the main aim of the equal cumulative per capita emissions approach was to combine Responsibility (Brazilian approach) and Equality (contraction and convergence) as separate elements in estimating fair national/regional shares for the reduction of greenhouse gas emissions.

Equal cumulative per capita emissions approach takes issue with the Equality framework as the starting point in time when developed countries begin to cut their emissions towards global convergence level does not consider their historical emissions. Since economic activity expressed in GDP terms is the most significant driver for greenhouse gas emissions volumes, overlooking historical emissions of developed countries puts developing countries under disadvantage as they receive relatively lower cumulative (historical and future greenhouse gas emissions combined) emission rights budgets (IPCC, 2022). Accordingly, application of this approach results in more stringent and steeper emissions reductions targets for developed and looser responsibility for developing countries

ECCE is also used as a policy variable in economic models to project emission pathways and allowance trajectories (Nabel et al., 2011; Williges et at. 2022). Moreover, it also advocates for cost-efficiency and highlights the need for an international emissions trading mechanism, capital and technology transfers from developed to developing countries.

### 1.3.4. Green Development Rights

First proposed by Bear et al. (2008) Green Development Rights (GDR) framework aims to directly address UNFCCC *common but differentiated responsibilities and respective capabilities* principle for climate change mitigation burden sharing. The GDR framework builds upon an issue that effective climate change mitigation is not feasible without the involvement of developing countries whose emissions increase with their rising economic development. However, it would be naive to expect that developing countries would prioritize climate change at the expense of development. To address it, in a similar vein to Chakravarty et al. (2009), the approach proposes to focus on individuals rather than states as income or emissions within countries is distributed unequally. However, the main difference is that the GDR framework puts right to development instead of rights to emissions as its crux.

Right to development is understood as a standard of living threshold below which individuals are exempt from the burden for emission reduction. The threshold stands somewhere in between the basic human needs and affluent levels of consumption. One could draw a similarity

to Maslow's hierarchy of needs as an individual is more susceptible to care more about its surroundings only after he satisfies his basic physiological needs. Although subject of discussion and variation across different studies that apply GDR (Holz et al. 2018) or borrow aspects of it, i.e. Höhne et al. (2008), the development threshold is operationalized at $US 7500 per capita per year (PPS adjusted).

National obligations for climate change mitigation are derived from cumulative income (capability) and emissions from fossil fuel consumption since 1990 (responsibility) of individuals who exceed the development threshold. GDR also assumes a direct relationship between per capita emissions and national income distribution to determine cumulative emissions above development threshold. Capability and responsibility variables are combined into a single Responsibility and Capacity index in which both variables are assigned the same or slightly varying weights.

Compared to other approaches in Bear et al. (2008) study, applying GDR results in higher burden for developed and developing countries. Burden sharing targets also highly depend on assumptions projected for future greenhouse emissions and reduction pathways in different stabilization scenarios. Another point for consideration is that GDR ignores the cost-efficiency factor as it allows for negative emission allowances. This is likely to result in discontent grievances from developed countries, especially those with comparatively high emission reduction costs if emissions trading is not exhibited.

### 1.3.5. Capability Need

Capability or ability to pay element (usually expressed by income level) has been a central theme to determine effort-sharing since the early days of climate negotiations (Jacoby et al., 1999). The significance of the capability factor in the climate negotiations cannot be overstated as implementation of climate change mitigation measures is only feasible with a sufficient arsenal of tools, most prominently funding.

It is reflected in the UNFCCC with country classification into groups based on their level of economic development. The classification comprises Non-Annex 1, Annex 1 and Annex II groups. Developing countries fall into the Non-Annex 2 category, while developed countries fall into the Annex II group. A distinction of economies in transition that include Central and Eastern European states is also made as they do not plainly fall (or at least used to) into one of the categories. Accordingly, both economies in transition and Annex II countries combined into one group are considered as Annex I countries. Although all of the Annex I countries were assigned an obligation to reduce their emissions in the Kyoto Protocol, economies in transition were given

certain flexibilities. Moreover, ability to pay has had a strong influence not only on current (as observed in 1.2. section) but also on the historical distribution of national emission reduction targets across the EU (Jacoby, 1999).

Due to its already wide scale practical application, capability approach has not garnered extensive attention or influence in the effort-sharing academic literature. It is more often used as one of the variables in other approaches or a proxy variable to determine individual emissions within countries (Baer et al. 2007; Baer et al., 2008; Höhne et al. 2008; Chakravarty et al. 2009).

Recurring theme across all of the studies observed that use this approach is its application as one of the policy options in economic models to simulate the feasibility of different climate change mitigation that also involve cost-efficiency and different stabilization scenarios elements as sub-models (den Elzen, 2005; Jacoby, 2008; Knopf, 2012). In a similar vein to other effort-sharing approaches, capability approach sets a threshold level below which countries are exempt from contributing to climate change mitigation efforts. In simplistic terms, when a country exceeds the income threshold, its emission reduction rate is determined by subtracting its per capita income by the per capita income threshold. Reduction rate is then adjusted with the initial grace period, near-term and long-term reduction rate parameters. Although the use of parameter settings is subject to different applications among different authors.

Due to its simplicity the approach overlooks unequal income distribution within countries, thus allowing high-emitting individuals to piggyback on low-emitting individuals without consequences. However, it also does not adjust emission targets on historical responsibility targets.

### 1.3.6. Staged approaches

Staged approaches among the effort-sharing academic literature can be viewed as compromise alternatives that combine features of other different approaches. Among this stream of literature two main sub-approaches standout: Multistage and Triptych sectoral approach.

First, the Multistage approach assigns CO2 reduction burden to countries based on different stages with differentiated types and levels of commitments. Höhne (2005) has defined four main stages upon which commitments are differentiated. They include the following: 1. No commitments; 2. Enhanced sustainable development; 3. Moderate absolute target; 4. Absolute reduction target. In which stage a particular country falls into depends on parameter settings. Each stage has a preset entry threshold that can be expressed in various units of measurement, such as emissions, GDP per capita, etc. Accordingly, the least developed countries that do not exceed

second stage threshold(s) are exempt from any burden towards global climate change mitigation. The level of commitment for a country increases as it reaches further stages.

Apart from the benefits such as gradual involvement of developing countries in climate change mitigation efforts and flexibility to establish different effort-sharing approaches in each of the stages (for example the Triptych sectoral approach for the stage 4), the multistage approach suffers from certain drawbacks. First and foremost, it would be challenging to establish such a multifaceted mechanism as it requires a high number of decisions from many different parties. Second, global greenhouse gas emission stabilization scenarios are based on current projections of future growth of economies. Accordingly, if the projections fail to be fulfilled and certain countries reach further stages too late, it could leave a gap of unresolved emissions (Höhne, 2005).

Second, the main aim of the Triptych sectoral approach is to reflect on different national circumstances to determine the most optimal emission reduction obligations. First developed by Blok et al. (1997) and later upgraded by other scholars, such as Phylipsen et al. (1998), Höhne et al., (2005), den Elzen et al., (2007), this sub-approach originates as a reaction to previous propositions of possible national/regional effort-sharing mechanisms that were deemed either too complex and insufficiently transparent or overly broad and simplistic to convince all of the negotiating parties. By addressing structural economic differences while also keeping the framework simple, its ambition is to stand as a middle-ground between two opposite extremes of other approaches.

The Triptych sectoral approach derives emissions from the three main sectors: power-producing sector; internationally oriented energy-intensive industry; domestic sectors. Hence the Triptych. This sub-approach recognizes each country's differences in population size, standard of living, economic structure, levels of energy efficiency, fuel mix in the energy generation and that they are embedded in different climate settings. All these criteria significantly affect emission volumes and reduction potential in the three sectors. Therefore, it is important to look at each sector's emissions through the lens of these settings and adjust emission reduction targets accordingly. For example, a country whose economic structure is largely based on heavy industry, consumes more energy compared (thus emits more emissions) to a country whose economic structure is focused on services. Accordingly, assigning absolute emission reduction burden obligations to both countries overlooking these features would potentially hinder the international competitive advantage of the country with a higher share of the economy based on the heavy industry (Phylipsen et al., 1998).

The Triptych sectoral approach has inspired the current climate change mitigation framework of the EU which divides ETS (includes power-producing sector; internationally

oriented energy-intensive industry) and non-ETS (domestic) sectors. However, currently the ETS sector climate change mitigation is implemented through cap-and-trade mechanism and the domestic sector national targets are most likely to be determined on the GDP per capita, instead of emissions per capita basis.

A reasonable point of critique for the Triptych sectoral approach is that it ignores the historical responsibility aspect which would be deemed as unjust from developing countries' perspective. However, if applied globally, industrialized economies are assigned the greatest share of burden to reduce emissions compared to developing countries (Höhne et al., 2008). Moreover, by some it is also regarded as a rather complex approach which still requires a fair share of assumptions to project future production volumes (den Elzen et al., 2007).

### 1.3.7. Cost-efficiency

Cost-efficiency is generally not regarded as a separate approach per se, however, it holds an important place within the effort-sharing literature to test the practical feasibility of different approaches (den Elzen et al., 2005, den Elzen, 2005; Jacoby, 2008; Knopf, 2012; Hof et al. 2017). Also, to manipulate climate mitigation policy change in other aspects (Onigkeit et al., 2009). For example, Bye et al. (2019) research measures the cost implications for Norway to achieve national emission reduction in the non-ETS sector targets if it joined EU's Effort Sharing Regulation. Since the Effort Sharing Regulation offers various flexibility options, the research compares different scenarios with varied assumptions to find the most optimal solution. To do so, a global version of the multi-sector computable general equilibrium model, SNOW1 is applied.

The main rationale to include this element is that at a certain point domestic capacity for emission reduction is exhausted (can become unreasonably costly). Therefore, when it becomes too expensive for a country to continue domestic climate change mitigation, it is reasonable to adjust policy or explore other options, such as emission trading mechanisms. What could be considered as too expensive depends on decision makers in the climate negotiations.

On the other hand, if cost-efficiency would be considered as a sole approach, a global marginal abatement cost threshold which matches overall greenhouse gas emission stabilization goal would have to be established. Countries upon reaching the threshold would be exempt from further domestic burden of greenhouse gas reduction (Peterson and Kepler, 2007), while countries below the threshold would be obligated to continue with their efforts. Unsurprisingly, this option is highly contested from an equity perspective. As cost-efficiency is the sole criterion, it would

overburden developing countries to reduce their emissions despite their degree of capacity and overlook both current and historical responsibility of developed countries.

### 1.4. Key take-aways and further discussion

There is no political nor academic consensus which set of rules and principles should be applied in deciding how effort should be shared among the countries for climate change mitigation. Although it is important to admit that the authors of the proposed approaches allegedly had no aspirations to establish a universal model of truth, but rather to introduce decision makers with possible alternatives to facilitate the climate negotiation process.

Different approaches vary on a scale of complexity on the one side, and simplicity on the other. While complex approaches better address national circumstances, complexity requires application of more sophisticated models, access to specific data and assumptions. It poses transparency and management risks to convince all the parties in the negotiations to support such frameworks (Phylipsen et. al, 1998). On the other hand, although simple approaches may appear more obvious and intuitive, they suffer from being overly broad which may result in unreasonably higher or lower relative effort distribution.

However, how does this all translate to a previously raised question where the EU effort-sharing targets stand in the scholarly debate about fair distribution of climate change mitigation targets? As mentioned previously, the EU's case is a unique one as it loosely applies at least two of the listed approaches.

The two-pillar system of ETS and non-ETS draws inspiration from the Triptych sectoral approach which divides the economy into domestic sector (non-ETS), power-producing sector (ETS) and internationally oriented energy-intensive industry (ETS). The main difference from the Triptych sectoral approach is that the reduction of emissions is implemented through cap-and-trade systems across the whole EU (Emission Trading System, 2023). As the ETS assigns emission allowances to installations instead of states and the reduction of emissions occurs essentially without government interference, the fairness question loses its relevance. However, it persists in the non-ETS or domestic sector. As observed in the previous sections, the distribution of national emission reduction targets is supposedly based on GDP per capita which is most closely matched by the Capability Need effort-sharing approach. It also involves cost-efficiency dimension as lower income countries are assigned a minimum commitment threshold of 10% and higher income countries are exempt from further emission reduction beyond 50% compared to 2005 levels.

**Table 1**

*Sample review of main effort-sharing approaches*

| Approach | Description | Operationalization | Author(s) |
|---|---|---|---|
| Capability need | Based on the ability to pay for climate change mitigation. Rarely used as a sole approach. More often included in other researches as one of the variables or proxy variables to determine individual emissions within countries. | GDP per capita | Jacoby et al., 1999; den Elzen, 2005; Jacoby, 2008; Knopf, 2012 |
| Cost-effectiveness | Generally not regarded as a separate approach, however, included in many researches to test the feasibility of various other effort-sharing approaches. | Scenario simulation applying economic models based cost per units of emission reduction | Bye et al., 2019; den Elzen et al., 2005; Onigkeit et al., 2009; den Elzen, 2005; Jacoby, 2008; Knopf, 2012; Hof et al. 2017 |
| Equal cumulative per capita emissions | Hybrid version of Equality and Responsibility approaches. | Emissions per capita + historical emissions | Bode 2003; WBGU 2009; Nabel et al. 2011; Pan et al. 2014 |
| Equality | Each individual has the same emission allowance for the target year. Countries whose individuals on average exceed the allowance have to cut their emissions and those that do not exceed the threshold have a right to emit more. | Emissions per capita | Den Elzen et al., 2005; Onigkeit et al., 2009; Chakravarty et al. 2009; van Vuuren et al., 2010; Raupach et al. 2014 |
| Responsibility | Emissions reduction burden attributed to countries in accordance to their past cumulative emissions. Rarely applied as a sole approach. More often included in other approaches as one of the variables. | Historical emissions<br>Population | Berk and den Elzen, 2001; den Elzen, 2004; den Elzen and Lucas, 2005 |
| Green Development Rights | Establishes a development threshold below which individuals are exempt from contribution towards climate change mitigation regardless of the country they live in. Combines both responsibility (also historical) and capability to determine country's emission reduction targets based on cumulative emissions and income of individuals above the threshold. | GDP per capita<br>Population<br>Emissions<br>Gini coefficient | Bear et al. 2008; Höhne et al. 2008; Holz et al. 2018 |
| Staged approaches | Assigns burden to countries based on different development stages with differentiated types and levels of commitments (Multistage) or reflect on different national circumstances in industry, energy generation and domestic sectors to determine the most optimal emission reduction obligations (Triptych sectoral) | Emissions per capita<br>GDP per capita<br>Population<br>Emissions in different sectors<br>Emissions per unit of value added<br>Average temperature<br>Energy consumption | Blok et al. 1997; Phylipsen et al., 1998; Höhne et al., 2005; den Elzen et al., 2007; Höhne et al., 2008 |

Source: made by author based on the literature review performed in 1.3. section.

While this overview provides us with a better sense on structural parameter setting differences of effort-sharing approaches, their application and resulting outcome differences remains unclear. Scholarly literature overview revealed its limitations in the research pursue of the question whether the current EU effort-sharing targets are fair and in line with the *common but differentiated responsibilities and respective capabilities* principle. First, studies as a rule focus on propositions for global/regional effort-sharing distribution overlooking EU's unique two pillar system of ETS and non-ETS. Second, the EU either in international formats for climate change negotiations or among scholars is generally viewed as a single unit. This does not allow for proper assessment on an EU scale only. For example, Höhne et al. (2007) only differentiates between EU27, Germany and the United Kingdom. In a similar vein, Berk et al. (2001), den Elzen et al. (2004), Knopf et al. (2012), van den Berg et al. (2020), Pan et al. (2014), Pan et al. (2017) considers only the EU or Western Europe as a whole. Phylipsen et al. (1998), Oneigeit et al. (2009), Bear et al. (2008); Höhne et al., (2008) although divides the EU into different groups, the division is more or less binary, contrasting Western vs. Central and Eastern Europe.

Only Steininger et al. (2022) to my existing knowledge has attempted to tackle the EU's effort-sharing of emission reduction question in the non-ETS sector. The research went beyond effort-sharing literature with an attempt to develop a novel approach that involves equality, responsibility and capability principles that are defined through sub-variables to each of the categories. For example, capability is expressed not only through ability to pay, but also through renewable growth capacity and government effectiveness sub-variables. Although one could argue that the ability to pay or GDP per capita and government effectiveness are reciprocal. Nonetheless, the research focused on informing decision makers on alternatives how effort-sharing could be distributed across the EU during the negotiations for future commitments, but not on comparing whether established targets from the equity perspective of existing approaches.

Moreover, when one considers equity and effort-sharing in the scope of the EU it is critical to look not only at universally accepted units of measurements such as GDP or emissions per capita, but also at the EU wide fiscal redistribution of mechanism - Multiannual Financial Framework (MFF). MFF is a 7-year period EU's budget which currently comprises 1.211 trillion Eur for 2021-2027.[3] Current period is also supplemented by the Next Generation EU package of 0.806 billion Eur for green and digital recovery investments and reforms after the Covid-19

[3]https://commission.europa.eu/strategy-and-policy/eu-budget/long-term-eu-budget/2021-2027/whats-new_en?prefLang=lt

pandemic until 2026. Solidarity as a cornerstone of the European project dictates that the substantial part of the MFF is distributed for economic and social cohesion of EU regions (Cohesion policy funds). It simply means that economically lagging Member States or regions receive EU funding to enhance their social and economic development. Significant part of those funds is dedicated towards climate change mitigation and adaptation efforts. Accordingly, accurate assessment of equity and effort-sharing distribution in the non-ETS sector calls for EU funding support adjustment for EU Member States which to existing knowledge has not been attempted in the effort literature so far.

To summarize, there is no universal standard how fairness in effort-sharing for climate change mitigation should be interpreted. Different scholars propose different approaches that results in different emission reduction target distribution outcomes. Scholarly literature overview revealed some key parameter settings similarities and differences of the current EU effort-mechanism vis-a-vis other leading approaches. While these approaches provide overall guidance where does EU stands in terms of fair distribution of emission reduction targets, existing research does not deliver sufficient basis on effort-sharing approaches outcomes comparison to current EU targets in non-ETS sectors mainly for three reasons: 1. Existing research overlooks division of ETS and non-ETS sectors; 2. Existing research commonly views EU as single regional unit, not allowing for country-to-country comparisons within the EU; 3. Literature most often focuses on analysis what climate what climate targets could be instead of testing whether currently established ones are fair.

Moreover, when one considers fairness and effort-sharing within the EU, it is essential to adjust targets based on its internal fiscal redistribution mechanisms, such as Next Generation EU and Cohesion policy funds that support Member State efforts to achieve climate targets.

Accordingly, the rest of the research focuses on determining methodology to apply effort-sharing approaches, comparing the outcomes with both adjusted EU (based on EU funding inflows for climate change effort) and unadjusted targets, discussion of the findings and conclusions.

# 2. METHDOLOGY OF EMISSION REDUCTION DISTRIBUTIONS

**The aim of the empirical research:** to simulate the distribution of national EU emission reduction targets in non-ETS sector by applying leading effort-sharing approaches, and to compare the outcomes with currently established EU targets.

The main purpose for executing such research is to test to whether current distribution of emission reduction targets in the EU is fair and in line with the equity principle established in the UNFCCC which is defined as *common but differentiated responsibilities and respective capabilities*.

Given the broad scope of potential approaches and their numerous variations, the study focuses on two prominent methods for simulating target distribution:

1. **Green Development Rights (GDR):**
   This approach directly aligns with the *common but differentiated responsibilities and respective capabilities* principle, as it incorporates both responsibility and capability variables.
2. **Equality:**
   This method is straightforward, clearly reveals emission differences among countries, and is useful to provide a clear comparison with both the current EU targets and the GDR approach.

Recognizing that EU financial support mechanisms, such as *Cohesion Policy* or *Next Generation EU* considerably alleviate financial burden on some member states, the research will also adjust current EU targets based on the funding support volumes each country receives for climate change mitigation. This adjustment will offer a clearer picture of the net effort-sharing burden assigned to each country and allow for a more accurate comparison with the selected approaches as they do not account for such unique circumstance. Therefore, **the research is designed to answer the following questions:**

1. What are the differences between currently established EU emission reduction targets and those distributed using GDR and Equality approaches in the non-ETS sector?

2. What is the net effort-sharing burden for each EU Member state if the impact of EU financial support was removed?

The following sections elaborate on the methodology of the selected approaches, net effort-sharing burden calculations, key assumptions, limitations and data sources.

### 2.1. The method for target distribution

To make the outcomes from approaches applied as comparable to current EU emission targets, it is important to set some common rules based on the arrangements of climate change mitigation in the EU.

**1**. **Timeframe.** 2 different emissions reduction commitment periods are used for target distribution: 1. **2011 – 2020**; 2. **2021 – 2030.** The period selection is based on the EU commitment periods governed by Effort-sharing Decision (2009) for 2011 – 2020 commitment period, Effort Sharing Regulation (2018) for 2021 – 2030 commitment period and Effort Sharing Regulation (2023) for 2024 – 2030 commitment period. The latter two commitment periods overlap because under Effort Sharing Regulation, targets established in 2018 were valid in 2021 – 2023 until their amendment in 2023. Therefore, 2021 – 2030 commitment period in the research is divided into 2 subperiods: 1. 2021 – 2023 (based on targets established in 2018); 2. 2024 – 2030 (based on targets established in 2023).

**2**. **Emissions pathway.** In a same manner as in Effort-sharing Decision (2009), Effort Sharing Regulation (2018) and Effort Sharing Regulation (2023), the emissions are limited or reduced on linear annual trajectory from the $T_1$ of the commitment period until $T_2$ when the emissions target is reached. No flexibilities, such as allowances to buy surpluses annual emissions are accounted because they are not relevant for this specific theoretical assessment.

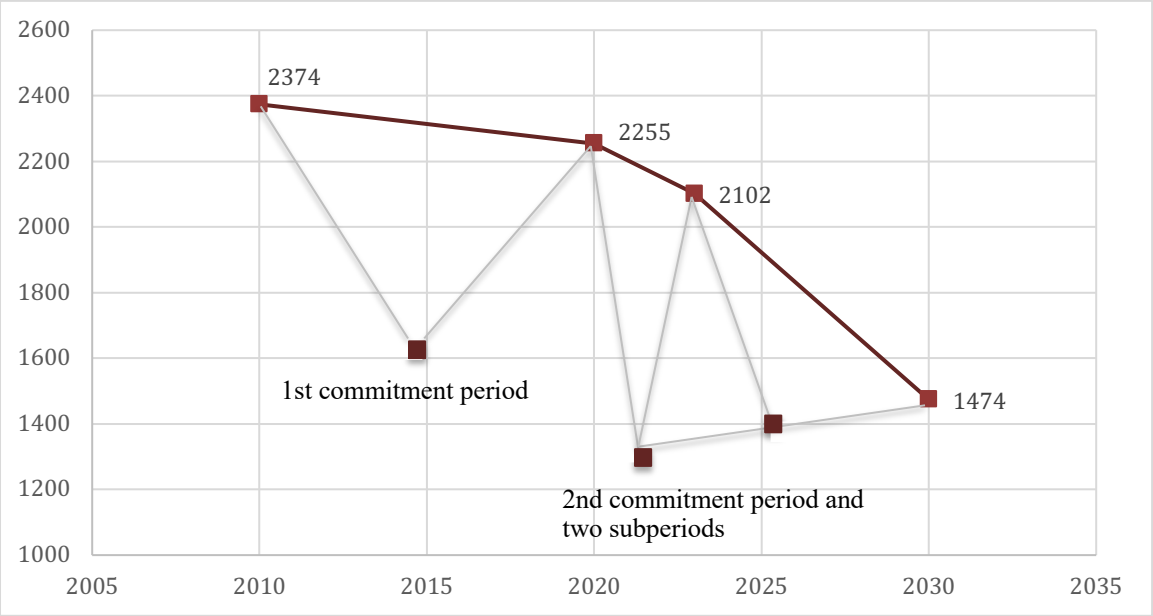
**3. Emissions to be reduced:** 1. 2011 – 2020 reduce emissions by 20% compared to 1990 levels; 2. 2021 – 2030 (established in 2018) reduce emissions by 30% until 2030 compared 2005 levels. Set trajectory is valid only for 2021 – 2023; 3. 2024 – 2030 reduce emissions by 40% until 2030 compared to 2005 levels.

**4. Measurement:** All greenhouse gasses (CO2 equivalent) in the non-ETS sector in million tonnes.

To summarize, the selected methods are used to simulate target distribution for 2 different commitment periods based on the linear emission reduction / limit trajectory (see Figure 4). Each commitment has an increasing overall ambition of emissions reduction while country effort-sharing burden for each country is measured through all greenhouse gasses (CO2 equivalent) in the non-ETS sector. Y axis in Figure 4 displays nominal value targets that must be reached for the whole EU within target years based on the commitment periods.

**Figure 4**

*EU emission reduction pathway and commitment periods in non-ETS: Y axis: all greenhouse gases C02 equivalent; X axis: years.*




Source: Made by author based on European Environment Agency data.

### 2.1.1. GDR application

Research applies GDR version as proposed by Bear et. al. (2007). The approach distributes emission reduction obligations to countries based on their citizens' individual emissions and income that are above the development (standard of living) threshold. Although subject to arbitrariness and variation across different studies, the development threshold in Bear et. al. (2007) is operationalized at $US 7500 per capita per year (PPS adjusted). Adjusting it to inflation from 2008 to 2023 levels and converting $US to EUR, the development threshold would be around EUR 10,000. Concerning the emissions, assumption is made that individual emissions behave analogously to the income level. Therefore, individual emission distribution is equated in proportion to income distribution.

Application of this approach essentially means that even poorer countries with very low emissions on average must contribute to climate change mitigation efforts. This is due income of individuals within countries is distributed unequally. Therefore, it would be fair for those individuals above the development threshold to contribute to global climate change mitigation efforts despite the country income and emission averages in the countries they live in are low.

Since this approach encompasses both income (capability) and emissions (responsibility) to determine national emission reduction commitments, a Responsibility (R) and Capability (C) Indicator (RCI) is established after calculating each country's R and C before separately.

To calculate C, income distribution within a country is approximated based on a continuous log-normal distribution. This model is used because it is positively skewed to the right, therefore, making it applicable for non-negative variables, such as income, stock price, etc. Moreover, this model has been proved accurate and reliable in preceding studies for income distribution estimations (Lopez & Serven, 2006).

To apply log-normal distribution, two main parameters are used: **per capita income (GDP per capita PPP)** and **Gini coefficient.** The higher the Gini coefficient, the more unequally income within a country is distributed and vice versa. To calculate the whole country's capacity another data element is required: **population**.

R calculation is used using the same data elements as for C, however, adjusting it to cumulative per capita CO2 emissions.

After both C and R are calculated, expressed as a sum of income and emissions of all country's individuals above the development threshold, RCI is established via the following formula: $RCI = C^a * R^b$, where a and b are the weightings that satisfy $a + b = 1$. Weightings can be determined based on how important we view capability or responsibility as determinants for climate change mitigation efforts. Baer et. al. (2007) set a as 0.6 and b as 0.4. Accordingly, research applies the same weightings.

In summary, RCI calculation requires 4 data elements: 1. Population; 2. Per capita income (PPP adjusted), expressed as GDP per capita in $; 3. Gini coefficient; 4. Cumulative per capita CO2 emissions from fossil fuels. Based on the relevance of the EU, the research instead of GDP per capita (PPP) in $ uses GDP per capita (PPS) in EUR, as PPS and EUR are measurement standards in the EU. Concerning CO2 emissions, instead of using data only of emissions from fossil fuels, research suits all greenhouse gas emissions (CO2 equivalent) as such measurement standard is used establishing national greenhouse emission reduction targets in the EU.

#### 2.1.1.1. GDR formula

The calculation steps for RCI can be laid out in the order provided below.

To define national capacity we have the following integral:

$$C = P \int_{\mathrm{yDT}}^{\infty} dy(y - \mathrm{y}DT) f(y, \bar{\mathrm{Y}}, \mathrm{G}) \quad (1)$$

where $P$ is the population, y$DT$ is the development threshold (EUR 10,000), $\bar{Y}$ is the income per capita, G is the Gini coefficient, while the log-normal income distribution is defined through:

$$f(y, \bar{Y}, G) = \frac{1}{\sqrt{2\pi^2(G)}} \exp\left[-\frac{1}{2\sigma^2(G)}\left(ln\frac{y}{\bar{Y}} + \frac{\sigma^2(G)}{2}\right)^2\right] \quad (2a)$$

where dependence of G is contained in the variance

$$\sigma^2(G) = 2\left[N^{-1}\left(\frac{1+G}{2}\right)\right]^2 \quad (2b)$$

and $N^{-1}$ is the inverse of the cumulative normal distribution. To retrieve it, we convert cumulative probability to corresponding Z score.

Concerning the responsibility, we follow the same logic but using emission data. To define national responsibility, we have the following integral:

$$R = P \int_{yDT}^{\infty} dy(e(y) - eDT) f(y, \bar{Y}, G) \quad (3a)$$

where e is emissions at a given level of income and e$DT$ is threshold which are proportionate to income threshold. Assuming that emissions are proportionate to income, where E is the average per capita historical emissions, we have

$$R = P \int_{yDT}^{\infty} dy \frac{E}{\bar{Y}}(y - yDT) f(y, \bar{Y}, G) \quad (3b)$$

As $f(y, \bar{Y}, G)$ is the log-normal distribution, we can calculate both C and R via the following formulas:

$$C = P \times \{\bar{Y}\{1 - N[\frac{1}{\sigma(G)}(\ln\frac{yDT}{\bar{Y}} - \frac{\sigma^2(G)}{2})]\} - yDT\{1 - N[\frac{1}{\sigma(G)}(\ln\frac{yDT}{\bar{Y}} + \frac{\sigma^2(G)}{2})]\}\} \quad (4a)$$

$$R = P\frac{E}{\bar{Y}} \times \{\bar{Y}\{1 - N[\frac{1}{\sigma(G)}(\ln\frac{yDT}{\bar{Y}} - \frac{\sigma^2(G)}{2})]\} - yDT\{1 - N[\frac{1}{\sigma(G)}(\ln\frac{yDT}{\bar{Y}} + \frac{\sigma^2(G)}{2})]\}\} \quad (4b)$$

Finally, we can establish RCI via

$$RCI = R^a \times C^b, \text{ where } a = 0.6 \text{ and } b = 0.4 \quad (5)$$

When we are aiming to distribute national emission reduction targets for the whole region (in our case EU), we are required to multiply each country's RCI by the number of its population in beginning of the commitment year. After we execute this step, we get national RCIs which then must be summed for the whole EU. Each country's national RCI as a share of the whole EU RCI will reflect country's national emission reduction target.

### 2.1.2. Equality application

Using Equality approach, national emissions allowances are determined on an equal per capita basis. When the overall regional / global target for emission reduction is set for year $T_2$, countries must converge their per capita emissions to target year from year $T_1$. This method is also frequently referred to as Contraction and Convergence as countries with lower per capita emissions than a set target in $T_2$ are allowed to increase their emissions, while countries with above per capita emissions are obliged to reduce them. When all the country emissions converge in $T_2$, then, if a new and more ambitious target is set in $T_3$, emissions are further being reduced on an equal per capita basis.

One important caveat of this approach is to decide at what point in time country per capita emissions converge. Having in mind that the EU distributed emission reduction targets in 2 stages, the research applies 1 emission convergence points for 2 different target distribution outputs: 2020 from 2011 – 2020 commitment period, after which emissions in all EU countries are reduced proportionally.

#### 2.1.2.1. Equality calculation

Drawing from WBGU (2009), national emissions reduction targets are determined as follows:

$$\int_{T1}^{T2} Enat.(t)dt = Cnat = Ceu(p)\ \frac{Mnat.(Tm)}{Meu(Tm)} \quad (1)$$

Where $Ceu(p)$ are total EU emissions in target year $T_2$, $Mnat.(Tm)$ is national population in reference year / beginning of the commitment period, $Meu(Tm)$ is total EU population in reference year / beginning of the commitment period. When the national target is determined, each country must work its way through to limit / reduce its emission on a linear trajectory in it achieves its target in $T_2$.

To summarize, Equality approach offers a relatively straightforward avenue to determine national emission reduction targets taking two key parameters: population and emissions. These parameters are used to establish targets in a such a way, so overtime country-to-country emission differences would convergence and the climate goals would be achieved.

### 2.2. Role of EU funding support schemes towards climate change mitigation

To answer the second research question, research takes latter commitment period (2021–2030) targets and adjusts them based on the funding support each country receives for climate

change mitigation. The rationale to select only one commitment period lies behind data availability.

To determine net effort-sharing burden for each EU Member State, research juxtaposes total public funding required to achieve climate targets vs. total emissions to be reduced. Then, depending to what extent public funding needs are covered from EU funding support for climate change mitigation, based on the total funding need vs. total emissions to be reduced ratio, determines net effort-sharing burden.

The approach is performed through the following steps:

**1. Acquisition of data on the funding needs for the whole EU to achieve 2030 emission reduction targets.** Rationale on acquiring EU-wide figures is based on the absence of reliable country-level data. Although EU Member States were obliged to craft national energy and climate plans where they would indicate their specific investment needs, the figures provided are incomplete and inconsistent (European Court of Auditors, 2021).

Based on European Commission (2020) and Darvas & Wolff (2021) estimate, there is a need of €1040 (2015 prices) billions of annual investments for EU to achieve its 2030 goal of 55% emission reduction by 2030 compared to 1990 levels. Adjusting it to 2020 price level, the investment need would increase to €1104 billion.[4] Meanwhile McKinsey (2020) drawing from its cost-efficient emission reduction pathway modeling, estimate somewhat lower investment needs, amounting €840 billion annually. Klaaßen & Steffen (2023) meta-analysis on 628 time series from 57 studies, confirms McKinsey (2020) estimates in energy and transport sectors, amounting €389 billions and €378 billions respectively. Accordingly, research assumes total EU funding needs for the 2021-2030 period to be **€972 billion annually** – an average between Mckinsey (2020) and European Commission (2020) estimates in 2020 price level.

**2. Determining the ratio between public and private funding needs.** As from the previous step we only find out overall funding needs to achieve emission targets covering both public and private sectors, it is important to determine only public funding need to estimate monetary burden for taxpayers. It is largely due to different motivations of public vs. private investment. While private investment focuses on investment that generate returns or allows to avoid losses, public investment (at least in theory) aims to establish necessary conditions to spur private capital, close existing market gaps and more swiftly achieve climate targets (Demertzis et al. 2024). Therefore, only the public funding needs should be considered as monetary effort-sharing burden.

[4] https://www.in2013dollars.com/europe/inflation/2015?endYear=2020&amount=1040

Darvas & Wolff (2021) estimates public-private ratio to be within the range of 1:5 to 1:4. In comparison, European Investment Bank (EIB) (2021) assessment on Member States self-reported figures, identifies higher overall public funding need intensity, highly prominent in Central and Eastern Europe, however, these self-reported figures should be viewed with grain of salt as they are often inconsistent and lack clear methodological justification.

The higher public funding needs in Central and Eastern Europe can be explained through the following: 1. Delayed decarbonization, resulting in higher costs to catch up (EIB, 2021); 2. Inappropriate policy (regulation, taxation, carbon pricing) which does not produce sufficient incentives for private investment to be viable (Darvas & Wolff, 2021).

Accordingly, it would be sensible to project higher public-private funding need ratio for CEE compared to the rest of the EU. Therefore, based on the Darvas & Wolff (2021) estimation, ratio of 1:4 to Central and Eastern Europe (2004 EU enlargement and post enlargement countries) and 1:5 to the rest of the EU. Based on this ratio application, total public funding need per annum would amount €204 billion (Central and Eastern Europe – €47 billion + rest of the EU – €157 billion). Although on the lower end, this figure is in line with Baccianti (2022) assessment which estimates a public funding need range between €168 billion to €333 billion.

Moreover, public-private funding need differentiation is instrumental in determining non-ETS sector funding needs. As a rule of thumb, practically all public funding needs for climate change mitigation stem from non-ETS sector as the public funding for installations / companies covered by the ETS is limited by rather strict EU state aid rules. If such support is provided, it is done through specially designed funding schemes by the European Commission, such as Modernization fund, financed through the auctioning of ETS allowances. Alternatively, if a Member State intends to provide aid for an entity higher than €200,000, it must initiate a notification procedure with European Commission and wait for approval which can be a long and burdensome bureaucratic process (General Block Exemption Regulation, 2014). Practically, if such support is granted, it should not disincentivize installations / companies under ETS from reducing emission on their own means and disrupt fair and free market competition. Accordingly, although public funding for ETS sector is possible, it is designed to be minimal. Therefore, for simplicity, research will assume that all the public funding needs for climate change mitigation are intended to fund non-ETS sector measures.

**3. Estimating public funding needs for each EU Member State.** Country-level public funding needs are assumed to be a part of the overall EU public funding needs determined on the ratio between Member State and overall EU emission reduction amount for 2021-2030. An important limitation of this method is that it only provides us with overall estimations as both

country-level overall funding needs and public-private funding ratio may vary among countries. However, this alleged inaccuracy is likely to be partly contained applying different public-private funding need ratios to CEE and the rest of the EU. Trying to come up with more reliable estimations would require another whole research.

**4. Estimating each Member State EU funding support amounts for climate change mitigation for 2021-2030.** Using data provided by EU institutions on various funding programmes, research summarizes country-level EU funding support amounts for climate change mitigation and compares them with the overall public funding needs. Funding programmes based on ETS proceeds, loans financing and open calls are excluded.

**5. Adjusting national emission reduction targets.** The adjustment is made by changing current EU targets based on emissions reduced through EU funding support.

In summary, research uses €972 billion as an overall funding need per annum for EU to achieve its 2030 climate targets. To determine which part of overall need comes from public funding, research applies 1:4 public-private funding ratio for CEE and 1:5 for the rest of the EU. Each Member State overall and public funding needs are determined on the ratio between Member State and overall EU emission reduction amount for 2021-2030. Then, research estimates overall each Member State funding amounts from EU support and compare them to overall public funding needs for climate change mitigation throughout 2021-2030. Based on this outcome, we adjust current national emission reduction targets.

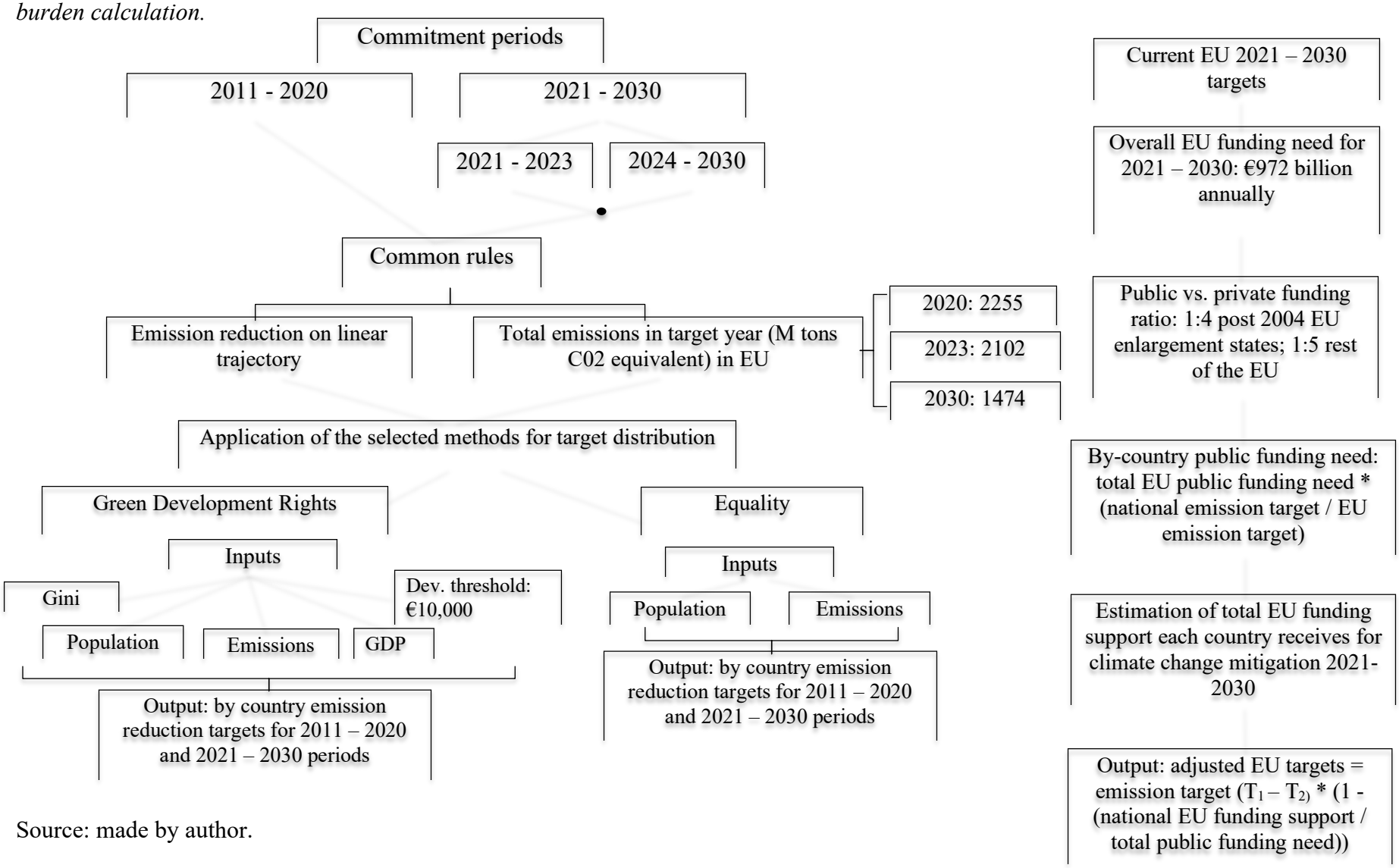
### 2.3. Method summary and data sources

To summarize the whole methodology to answer the research questions, it aims to perform both: 1. Apply selected approaches for EU emissions target distribution; 2. Make the research output as comparable to current EU targets as possible. Research does it by fitting the application of the selected approaches to real EU circumstances through setting the same timeframe (commitment periods) and common rules, such as emission reduction trajectory and total emission targets (see Figure 5).

At the same time, research also adjusts current EU emission reduction targets in terms of EU funding support each country receives to determine net effort-sharing burden as selected approaches do not account for this circumstance (see Figure 5). Accordingly, the comparison without control of EU funding support intervening variable would not be fair.

**Figure 5**

*Graphical representation of the research parts and sequence of steps (top to bottom): left - emission target distribution; right - net effort-sharing burden calculation.*




Source: made by author.

**Table 2**

*Variables and sources: emission target distribution*

| Emission target distribution | | |
|---|---|---|
| **Method** | **Variables** | **Data Source** |
| **Green Development Rights** | GDP per capita, EUR (PPS) | Eurostat[5] |
| | Gini coefficient | Our World in Data[6] |
| **Green Development Rights; Equality** | All greenhouse gasses (CO2 equivalent) in the non-ETS sectors in tonnes | European Environment Agency[7] |
| | Population | Eurostat[8] |

Source: made by author.

**Table 3**

*Variables and sources: net effort-sharing burden calculation*

| Net effort-sharing burden calculation | |
|---|---|
| 1. Overall EU funding need to achieve 2030 climate targets | European Commission (2020); McKinsey (2020); Klaaßen & Steffen (2023) |
| 2. Ratio between public and private funding needs | Darvas & Wolff (2021); EIB (2021); Baccianti (2022) |
| 3. All greenhouse gasses (CO2 equivalent) in the non-ETS sectors in tonnes | European Environment Agency[9] |
| 4. EU funding support amounts for climate change mitigation | European Commission;<br>Cohesion data[10];<br>Becker et al. (2022) |

Source: made by author.

Research uses a wide range of data sources for methodological framework execution. Table 2 depicts variables for the selected methods' application for emission target distributions and their corresponding sources. Table 3 displays sources to calculate net effort-sharing burden.

[5]https://ec.europa.eu/eurostat/databrowser/view/nama_10_pc/default/table?lang=en&category=na10.nama10.nama_10_aux

[6] https://ourworldindata.org/what-is-the-gini-coefficient

[7] https://www.eea.europa.eu/en/datahub/datahubitem-view/e9ce7eb8-8439-4f2f-96f8-279a36c5fa7a

[8] https://ec.europa.eu/eurostat/databrowser/view/demo_pjan/default/table?lang=en&category=demo.demo_pop

[9] https://www.eea.europa.eu/en/datahub/datahubitem-view/e9ce7eb8-8439-4f2f-96f8-279a36c5fa7a

[10] https://cohesiondata.ec.europa.eu/stories/s/4jua-76d5

The next part of the research focusses on the empirical analysis which is followed by discussion of the findings and conclusions.

# 3. ASSESSMENT OF THE DISTRIBUTION OF EMISSION REDUCTION TARGETS

## 3.1. General observations and extremes of 2020 target distribution

Based on the methodological framework outlined in the preceding sections, the first aim of the empirical analysis is to outline the differences between EU emission reduction targets and those distributed using GDR and Equality approaches in the non-ETS sector. Accordingly, the empirical section of the research first covers 2020 and then 2030 target distributions. Then, the focus shifts on answering the second research question: **what is the net effort-sharing burden for each EU member state to achieve 2021 – 2030 targets if the impact of EU financial support was removed?** Eventually, research compares the adjusted targets with the targets of other approaches.

Before diving deeper into analysis of research outputs, it is important to point out the challenge of comparing different outputs. The EU either in public communication or in legal acts display emission reduction targets as a percentage change in target year $T_2$ (2020 or 2030) compared to reference year $T_0$ (2005). While this method depicts figures in an easy-to-understand manner, comparing only target year with a reference year overlooks more complex dynamics of emissions movements between the two points in time. For example, one country's emission reduction pathway could be aligned in a such way that throughout 2011 – 2020 emissions could increase and start to contract in the following, 2021 – 2030 commitment period. Overlooking these emission dynamics may not provide a fully accurate picture of emission reductions. Correspondingly, comparing outputs from methods deployed with EU targets, it is useful to also include total emission budgets for whole commitment periods.

Left side of Table 4 depicts each EU member state % differences of Equality and GDR approaches total emission budgets for the 2011 – 2020 commitment period vs emission budgets based on EU targets. Negative values marked in light red show lower emission budgets compared to EU, while positive values marked in light green work in reverse.

Right side of Table 4 is based on the same research outputs, however, they show percentage change of emissions for each of the framework in 2020 vs 2005. And although both approaches to measure emission effort-sharing burden mirror each other, the differences are far less pronounced with emission budget measuring method. For example, for Malta there is a 106% points gap between Equality and EU targets, however, if we extend our measurement to a period of 10-year emissions, sum the whole budget and compare totals, we find that Equality approach allows to

emit 35% more emissions compared to EU target. Accordingly, the research applies both measurement methods interchangeably.

**Table 4**

*Percentage differences of Equality and GDR total emissions (denominators) vs EU emissions (nominator) and distribution of targets among 3 frameworks as a percentage change in 2020 compared to 2005.*[11]

| | Overall budgets 2011-2020 | | Percentage change in 2020 compared to 2005 | | |
|---|---|---|---|---|---|
| | Equality vs EU | GDR vs EU | Equality | EU | GDR |
| **AT** | -5% | 1% | -23% | -16% | -14% |
| **BE** | -10% | 6% | -29% | -15% | -5% |
| **BG** | 15% | -12% | 58% | 20% | -2% |
| **HR** | 8% | -7% | 29% | 11% | -2% |
| **CY** | 3% | 3% | 2% | -5% | 1% |
| **CZ** | -15% | -8% | -15% | 9% | -5% |
| **DK** | -7% | 6% | -30% | -20% | -11% |
| **EE** | -1% | -4% | 9% | 11% | 3% |
| **FI** | -2% | 5% | -19% | -16% | -7% |
| **FR** | -1% | 3% | -15% | -14% | -9% |
| **DE** | 2% | 3% | -10% | -14% | -9% |
| **EL** | -3% | -6% | -8% | -4% | -14% |
| **HU** | -1% | -13% | 9% | 10% | -12% |
| **IE** | -25% | 5% | -51% | -20% | -11% |
| **IT** | 2% | 0% | -10% | -13% | -12% |
| **LV** | 8% | -7% | 35% | 17% | 3% |
| **LT** | 13% | -9% | 44% | 15% | -1% |
| **LU** | -53% | 6% | -74% | -20% | -10% |
| **MT** | 35% | -3% | 111% | 5% | -1% |
| **NL** | -9% | 8% | -30% | -16% | -2% |
| **PL** | -4% | -3% | 6% | 14% | 8% |
| **PT** | 7% | -8% | 16% | 1% | -12% |
| **RO** | 9% | -19% | 39% | 19% | -12% |
| **SK** | 7% | -7% | 29% | 13% | 0% |
| **SI** | -9% | -5% | -10% | 4% | -4% |
| **ES** | 6% | 0% | 0% | -10% | -11% |
| **SE** | 15% | 2% | 12% | -17% | -14% |

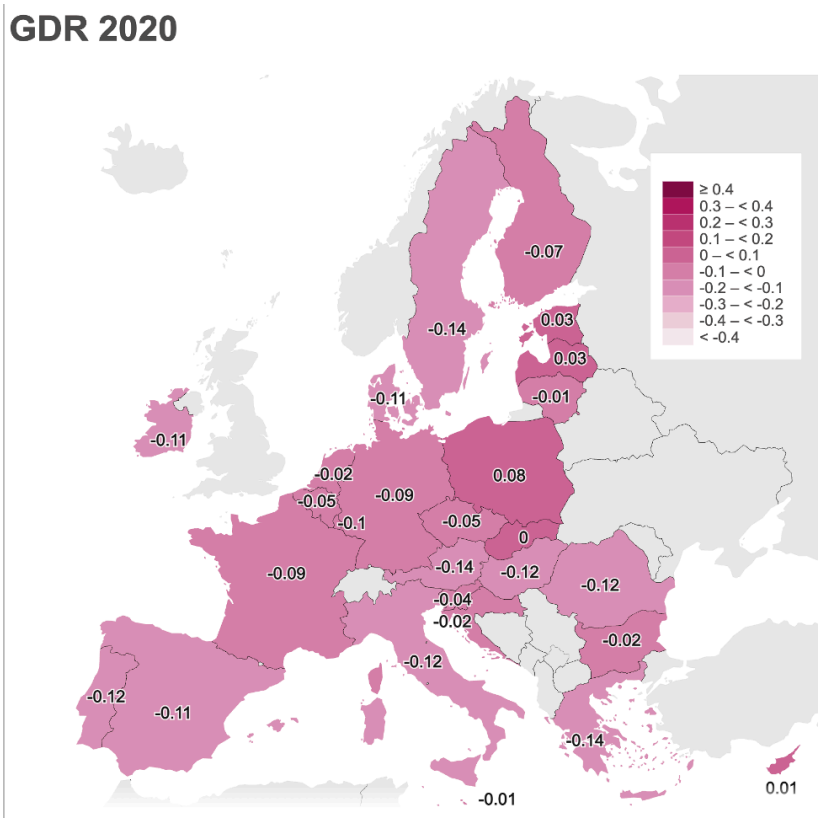
Source: made by author based on the research output.

[11] Country full name list with abbreviations used can be found in Annex 1.

Drawing from Figures 6 a – c and Table 4, a rather clear pattern emerges from the three emission reduction target distributions. The EU's 2011–2020 commitment period targets act as a midpoint between the GDR and Equality approaches. While the Equality approach generally allows significant emission increases for the Eastern bloc of the EU, the GDR approach conversely assigns emission contractions. This leads to higher variance under the Equality approach and a more even distribution under GDR across the EU.

**Figure 6 a**

*2020 emission reduction targets as percentage change compared to 2005 levels based on GDR approach.*




Source: made by author based on IMAGE interactive map generator.

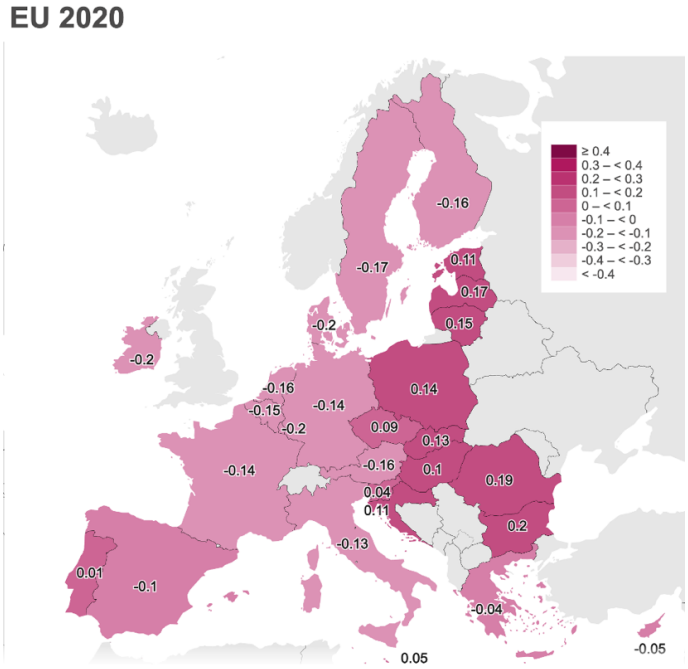
More even distribution under GDR is a result of suspension from any emission increases, as targets are derived from national income per capita and emissions above the development threshold. Given that the per capita income of all EU countries exceeded this threshold, no increases are permitted. However, as shown in the Figure 6 a, GDR does allow emission increases

for Cyprus, Poland, Latvia, and Estonia. This results from a measurement quirk where 2020 emissions are compared to 2005, without accounting for 2010 emissions—the baseline for simulations for the 2011–2020 period. For instance, Latvia's emissions increased from 8.07 Mt CO2 in 2005 to 8.56 Mt CO2 in 2010, and then were required to reduce to 8.35 Mt CO2 by 2020 (see Annex 2 for country emission data). Therefore, comparing 2005 and 2020 alone might misleadingly suggest an increase was allowed.

On the other hand, the Equality approach (Figure 6 c) assigns even more room for emission increases for most 2004 enlargement and post enlargement states[12]—including Spain, Portugal, Sweden, and Italy—compared to GDR or EU targets. This outcome stems from these countries' relatively lower per capita emissions, allowing for smaller reductions or higher increases until regional convergence is reached in target year 2020 (see Annex 3 for country per capita emission data). In contrast, higher per capita emission countries—such as the Netherlands, Belgium, Austria, Czech Republic, Ireland, and Denmark—face stricter reduction requirements to meet the convergence target.

**Figure 6 b**

*EU 2020 emission reduction targets as percentage change compared to 2005 levels.*

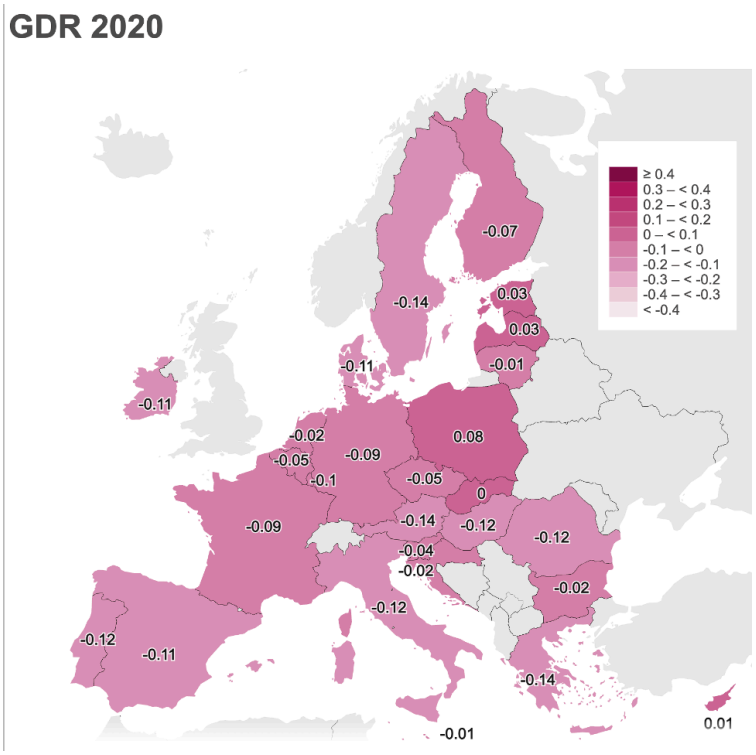



Source: made by author based on IMAGE interactive map generator.

[12] 2004 EU enlargement states include: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland Slovakia, Slovenia. Post 2004 enlargement: Bulgaria, Romania, Croatia.

**Figure 6 c**

*2020 emission reduction targets as percentage change compared to 2005 levels based on GDR approach.*




Source: made by author based on IMAGE interactive map generator.

The most extreme case for emission increases under the Equality approach is Malta (110% compared to 2005). With the lowest per capita emissions in 2005 (2.495 tons CO2), Malta is allowed more than double the room for increases while still meeting its the EU's 2020 convergence target (5.11 tons CO2 per capita). On the opposite end, Luxembourg, with 21.685 tons CO2 per capita in 2005, is set for a 75% reduction until 2020. Such large-scale changes highlight the approach's limitations in handling outliers because emission increases or decreases of this a scale over a 10-year period are far from feasible or demanded. However, the approach feasibility would increase if the convergence point in time was extended, for instance until 2030. This way emission reductions or increases could be more increment and better planned. Another solution for this problem would be emission trading mechanism under non-ETS which would allow low emitting countries to sell their surplus emissions to countries that went beyond their assigned emission thresholds.

Continuing with the same extreme cases of Malta and Luxembourg under GDR, the emissions target gap dramatically close. Luxembourg's target is lowered to -10%, while Malta is assigned -1% emission reduction obligation. An interesting feature of GDR is that it rewards higher per capita emission countries and punishes lower per capita emission ones. It occurs due to lower emission countries' obligation to decrease their emissions instead of permission to increase under Equality approach which lowers the overall effort needed from high emitting countries for EU to achieve its overall emissions target.

In summary, EU targets act as a middle ground, with the **Equality approach** allowing emission increases for lower-emission countries, especially in Eastern Europe, while the **GDR approach** imposes more uniform reductions based on income and emissions thresholds, resulting in a more balanced distribution. The extreme cases outlined reveal limitations of both frameworks, suggesting the need for extended timelines or mechanisms like emission trading to address disparities and support more gradual and feasible transitions across EU countries.

### 3.1.1. Winners and losers of 2020 target distribution

Despite the contrasting focus of the GDR and Equality approaches which usually results in that either one of the approaches is more favorable to particular country compared to EU targets, Cyprus, Germany, Italy and Sweden—benefit more under both of these frameworks than under EU target distribution (see Table 4). This anomaly can be explained as follows: although Cyprus, Germany, and Italy had per capita incomes above the EU average, as emission targets became more evenly distributed among the whole EU under GDR, the overall amount of emissions to be reduced for higher income countries decreased (see Annex 4 for GDP per capita data). Additionally, their below-average per capita emissions enabled them to secure lower reduction targets under the Equality approach likewise. This suggests that this group of countries was **assigned more unfavorable EU emission reductions targets having in mind their similar economic development levels with peer countries and lower capita emissions.**

On the other side of the spectrum, we have Slovenia, Poland, Hungary, Greece, Estonia and Czechia— countries that would be worse off if any of the applied approaches would have been used instead of EU set targets (see Table 4). The explanation for this case is inverse to Cyprus, Germany, Italy and Sweden. Slovenia, Poland, Hungary, and Greece held comparatively higher per capita emissions while their economic development was behind the more prosperous side of the EU.

These dynamics lead to an observation that if we split EU into two higher (above GDP per capita) and lower income (below GDP per capita) groups, **unbalanced targets distribution among countries in these groups become evident in terms of per capita emissions**. For example, concerning lower income group, comparison of Poland and Lithuania cases proposes that Lithuania should be rather dissatisfied with how the targets in EU were attributed. While with rather similar levels of economic development, Lithuania held 25% lower emissions per capita than Poland in 2005 and 31% lower in 2010, yet Poland was still assigned emission increase allowance very similar to that of Lithuania (see Annexes 3 and 4 for per capita emissions and GDP data). In the higher income group, as an illustrative example we have Sweden and Denmark, that in 2010 had 31,953 EUR and 32,546 EUR per capita incomes respectively. However, Sweden's per capita emissions stood at 4,732 (CO2), while Denmark's at 7,454 (CO2). Yet Denmark was attributed only 3% points higher emission reduction target.

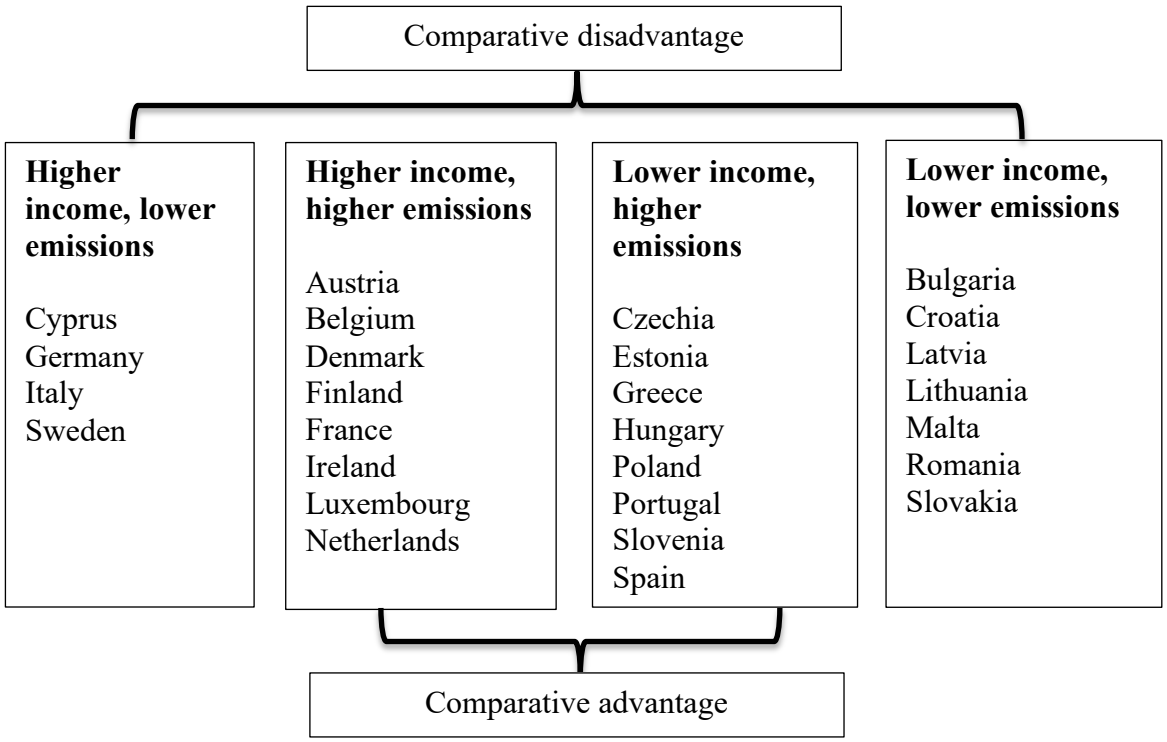
Sweden's case is in the league of its own which calls for additional attention. Sweden is the only country among older and higher income EU member states which was assigned emission reduction targets under the EU framework but would have been allowed to increase its emissions until 2020 under the Equality approach. This is because Sweden's per capita emissions in 2005 (4.732 tons of CO2) were below the 2020 convergence point (5.11 tons of CO2 per capita). Interestingly, Sweden had lower per capita emissions in both 2005 and 2010 compared to many post-2004 EU enlargement countries. This challenges the common assumption that emission levels strongly correlate with economic development. Sweden's case strongly highlights that the EU's 2020 targets prioritized economic development over emissions levels, as otherwise Sweden would have received significantly more lenient targets if emissions alone had been more emphasized.

These dynamics allows to categorize countries into four diverging clusters: 1. Countries with higher income and lower emissions; 2. Countries with higher income and higher emissions; 3. Countries with lower income and higher emissions; 4. Countries with lower income and lower emissions. Figure 7 illustrates this division. Above EU average income countries in 2010 are depicted as higher income group, while below EU average income countries are considered as lower income group. In terms of emissions, division for higher income group is made based on overall EU emissions per capita, while for the lower income only for the emissions per capita below or above within the group average. As a result, higher emission groups with both higher and lower per capita incomes versus lower emission groups were assigned more favorable 2020 EU emission reduction targets. This results in higher emission countries comparative advantage against lower emission ones in terms of *responsibility* variable in climate change mitigation.

Although it is important to note that some of the countries in the clusters, like Portugal and Spain are borderline countries in terms of emissions and GDP and could as well be assigned to other clusters.

**Figure 7**

*EU country clusters based on emissions and income per capita.*




Source: made by author based on the research outputs.

To sum up, GDR and Equality outcomes revealed clusters of countries to whom 2020 EU targets are commodious and to whom they are rather stringent. EU 2020 targets appear to be the least favorable to higher income, lower emissions group, and most favorable to lower income, higher emissions countries. If only economic development and emissions are taken into the picture, EU 2020 targets are also more favorable to higher income, higher emission countries and less favorable to lower income, lower emissions member states. In essence this in general terms proves in the beginning of the research raised expectation that EU setting its 2020 emission reduction targets prioritized economic development versus per capita emissions, as generally countries with similar economic per capita output are attributed similar targets, despite their variance in emissions.

### 3.1.2. Key take-aways from 2020 target distribution

To summarize the 2020 target distributions, a few key take-aways standout. First, EU targets balance out rather high disparities between GDR and Equality targets. This implies of a EU's attempt to consolidate diverging interests what concerns *responsibility* and *capability* in deciding to what extent each country should bear the burden of climate change mitigation. However, even this attempt to find balance comes with a price that there are still winners and losers as there is a group of countries who would benefit more from application of both GDR and Equality approaches instead of EU target outputs and vice versa. A helpful way to categorize countries on a scale how well their national interests on emission reduction obligations are aligned is to divide them into four clusters based on income and emissions. As analysis showcased, higher emission countries generally benefit more from EU set targets than lower emission ones which implies that the EU framework does not sufficiently addresses *responsibility* aspect of climate equity.

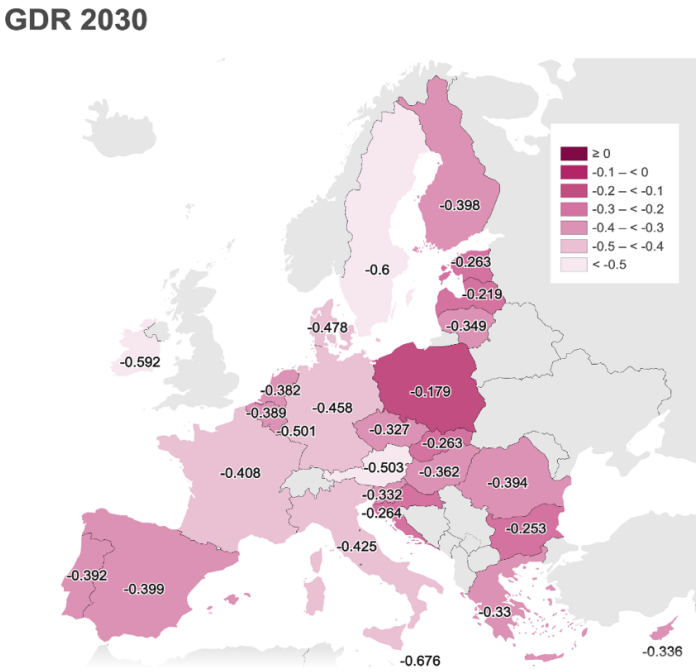
## 3.2. General observations and extremes of 2030 target distribution

Continuing from the simulated emission targets from 2020 and using these midpoint country emissions to further simulate 2030 targets, we get a similar picture. However, the emission targets in 2030 as a percentage change of 2005 emission levels are now less varied for lower emission, lower income states across all three frameworks compared to 2020 targets (see Figures 8 a – c). This results from lower emission countries increased emissions during 2011-2020 and more balanced emission reduction pathway throughout 2021-2030 commitment period under Equality approach under which in 2020 all the countries reached per capita emission convergence point and began to decrease their emissions with same volume and trajectory.

However, the main trends under Equality and GDR frameworks remain the same. The EU target distribution remains a midpoint between the two approaches applied. Drawing from previous section clusters of countries, higher income, higher emission member states still face lower emission targets under GDR and higher under Equality approach compared to EU framework. All the countries across EU, except for Malta under Equality approach, must reduce their emissions compared to 2005 emission levels and no more emission increases are allowed. Malta and Luxembourg remain on the extremes. Once again, these extremes are most notable under Equality approach.

**Figure 8 a**

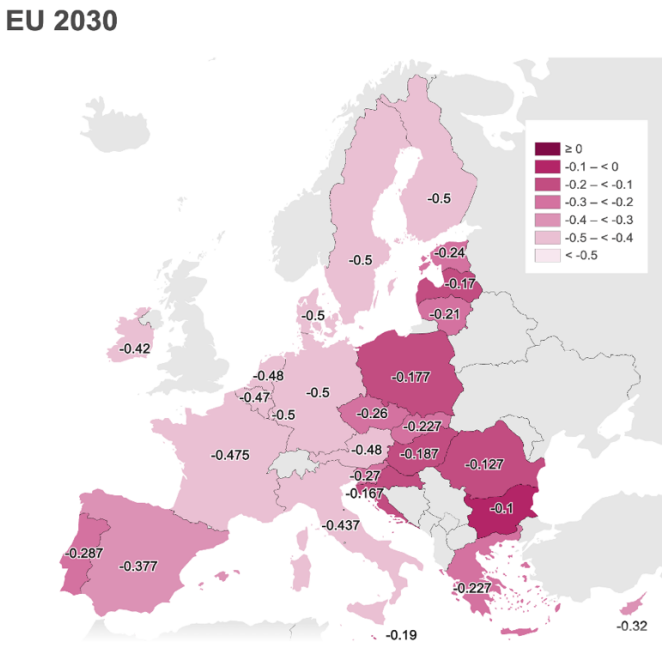
*2030 emission reduction targets as percentage change compared to 2005 levels based on GDR approach.*




Source: made by author based on IMAGE interactive map generator.

**Figure 8 b**

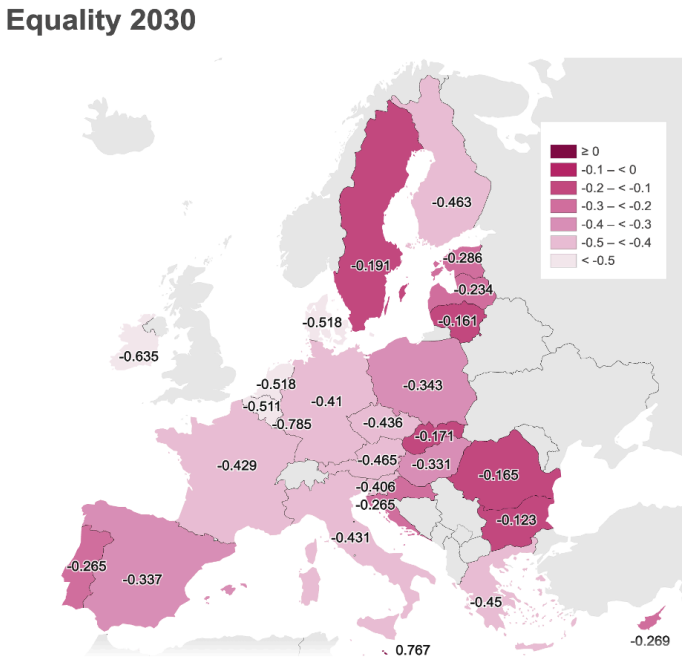
*EU 2030 emission reduction targets as a percentage change compared to 2005 levels.*




Source: made by author based on IMAGE interactive map generator.

**Figure 8 c**

*2030 emission reduction targets as percentage change compared to 2005 based on Equality approach.*




Source: made by author based on IMAGE interactive map generator.

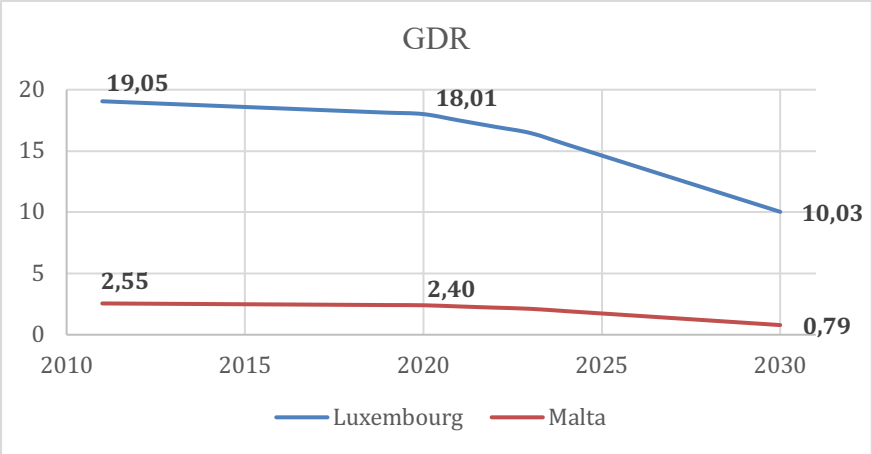
Figures 9 a - c graphically depict emission reduction pathways throughout 2011-2030 period based on emissions per capita for Malta and Luxembourg. These two extremes are also helpful to illustrate emission reduction pathway for the rest of the countries as displaying 27 countries in one graph is challenging. The emissions per capita difference in target year 2030 between the two countries is most prominent under GDR framework. It is less pronounced under EU and non-existent under Equality approach. The graphs also reveal that there is a general convergence trend between the two countries under both GDR and EU frameworks. Under current EU emission reduction projections, it would take till around early 2040s for per capita emissions to converge.

The high emission per capita disparities between two extremes makes it a challenge to set realistic yet fair targets. Drawing from Equality framework emission pathway, it would be unrealistic to demand Luxembourg to cut down on its emission on such velocity and on such a

scale. While looking at Malta and Luxembourg per capita emissions in 2030, 13 times under GDR and 5 times under EU framework higher emissions in Luxembourg do not look sufficiently fair from Malta's either. However, it is worth to point out that Luxembourg holds a unique position in EU as a transport transit hub and high transport fuel sales for non-residents which bloat its emission per capita figures (EPRS, 2021).

**Figure 9 a**

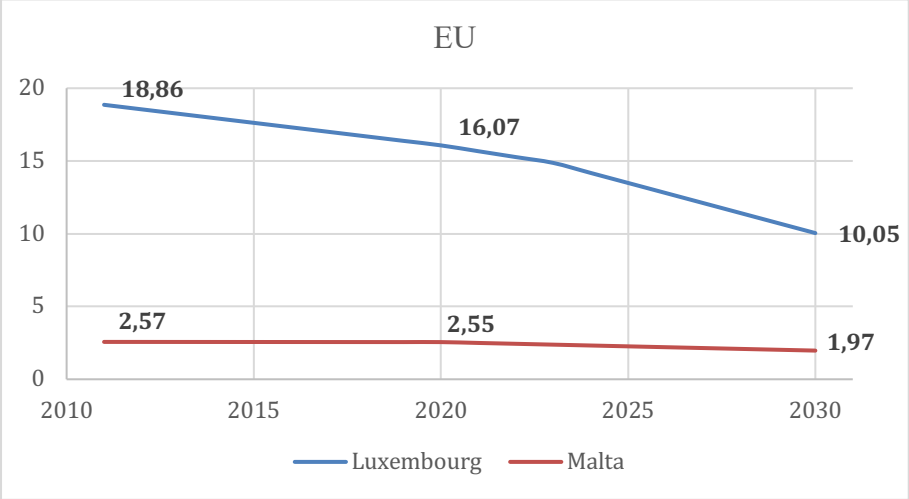
*Emission reduction pathways under GDR for 2011-2030.*




Source: made by author based on the research output. Y axis: emissions per capita. X axis: years.

**Figure 9 b**

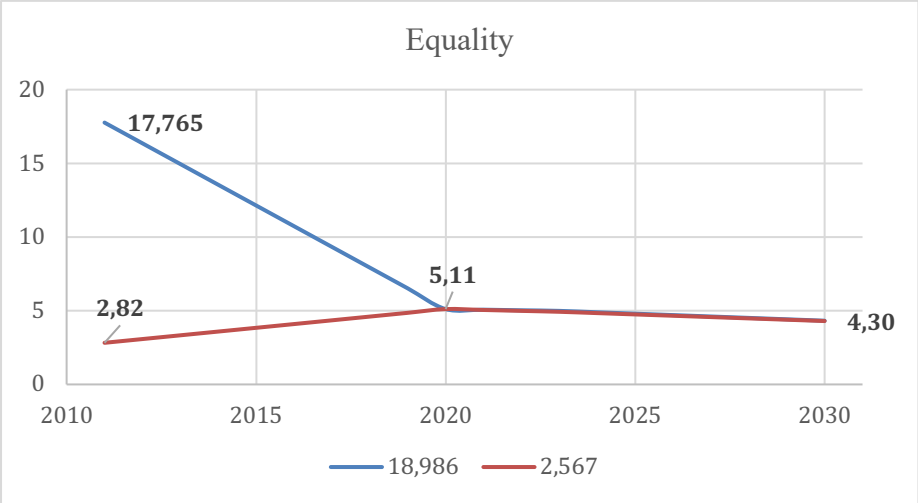
*Emission reduction pathways under EU for 2011-2030.*




Source: made by author based on the research output. Y axis: emissions per capita. X axis: years.

**Figure 9 c**

*Emission reduction pathways under Equality for 2011-2030.*




Source: made by author based on the research output. Y axis: emissions per capita. X axis: years.

In summary, the 2030 emission targets for EU countries continue trends from 2020, with lower-income, lower-emission states facing less variation in targets due to increased emissions during 2011–2020 and balanced reductions throughout 2021-2030 under Equality framework. Comparison of the two extreme cases reduction pathways throughout 2011-2030 period reveal challenges in addressing unique circumstances in all the countries and combining them into one fair for all approach.

### 3.2.1. Winners and losers of 2030 target distribution

List of countries who would benefit more from both Equality and GDR approaches compared to EU targets would be supplemented by Finland and France, while subtracted by Sweden (see Table 5). In terms of GDR, the trend of more favorable targets for Finland and France would continue. However, the dynamics would change under the Equality approach. This outcome occurs due to their relatively lower emissions per capita in both 2005 and 2010 when compared to other higher income, higher emissions cluster countries. For example, in 2010 Finland's and France's emissions per capita stood at 6,24 (CO2) and 5,786 (CO2) respectively (see Annex 3). Meanwhile, the country average for all other higher income, higher emission countries (excluding Luxembourg) stood at 7,08 (CO2). As for the Sweden in terms of higher emission reduction target under GDR, the outcome can be explained as follows: it already held relatively low emissions in

the beginning of 2011-2020 commitment period and since it was attributed further emission reductions, its overall emission budget for 2021-2030 became lower than that of EU's.

**Table 5**

*Percentage differences of Equality and GDR total emissions (denominators) vs EU emissions (nominator) and distribution of targets among 3 frameworks as a percentage change in 2030 compared to 2005.*

| | Overall budgets 2021-2030 | | Percentage change in 2030 compared to 2005 | | |
|---|---|---|---|---|---|
| | Equality vs EU | GDR vs EU | Equality | EU | GDR |
| AT | -5% | 0% | -46% | -48% | -50% |
| BE | -16% | 11% | -51% | -47% | -39% |
| BG | 14% | -21% | -12% | -10% | -25% |
| HR | 3% | -13% | -26% | -17% | -26% |
| CY | 7% | 3% | -27% | -32% | -34% |
| CZ | -30% | -13% | -44% | -26% | -33% |
| DK | -10% | 8% | -52% | -50% | -48% |
| EE | -4% | -5% | -29% | -24% | -26% |
| FI | 0% | 13% | -46% | -50% | -40% |
| FR | 2% | 8% | -43% | -48% | -41% |
| DE | 8% | 6% | -41% | -50% | -46% |
| EL | -18% | -13% | -45% | -23% | -33% |
| HU | -9% | -26% | -33% | -19% | -36% |
| IE | -63% | -7% | -63% | -42% | -59% |
| IT | 2% | 1% | -43% | -44% | -42% |
| LV | 5% | -10% | -23% | -17% | -22% |
| LT | 14% | -18% | -16% | -21% | -35% |
| LU | -176% | 7% | -78% | -50% | -50% |
| MT | 52% | -39% | 77% | -19% | -68% |
| NL | -15% | 15% | -52% | -48% | -38% |
| PL | -14% | -3% | -34% | -18% | -18% |
| PT | 8% | -16% | -27% | -29% | -39% |
| RO | 7% | -38% | -16% | -13% | -40% |
| SK | 10% | -9% | -17% | -23% | -26% |
| SI | -19% | -9% | -41% | -27% | -33% |
| ES | 8% | -2% | -34% | -38% | -40% |
| SE | 31% | -5% | -19% | -50% | -60% |

Source: made by author based on the research output

List of the countries that would be worse off from the two approaches applied compared to EU targets would be supplemented by Ireland and Austria. Ireland's higher target under Equality approach continues as per 2020 targets, however, it substantially increased under GDR approach. Over a decade Ireland experience unprecedented economic growth and continued with relatively high emissions. This resulted in higher than usual responsibility and capacity index which bloated its 2030 target.

Meanwhile Austria, faced a slight increase in emission reduction target under GDR compared to EU targets. The increase is less obvious and requires more in-depth evaluation. If we compare Austria with the Netherlands, Austria in 2010 was behind the Netherlands in terms of per capita economic output and held lower emissions per capita. Naturally, responsibility and capacity index throughout two decades was higher in Netherlands and lower in Austria. For example, based on 2022 data for 2024-2030 emission reduction simulation under GDR, Austria's responsibility capacity index was 2727 and the Netherlands 3002. However, Austria still received assumingly higher emission reduction target compared to the Netherlands. This occurs for the reason as for Sweden. Austria's beginning of the 2011-2020 commitment period per capita emissions were significantly lower than those of the Netherlands, 6,13 CO2 and 7,562 CO2 respectively. Accordingly, as Austria for 2011-2020 period was attributed similar emission reduction target to the Netherlands in nominal terms under GDR, while having lower per capita emissions, its overall emission budget for 2021-2030 with further reductions became lower than that of EU's.

The same partition of countries into clusters based on their emission and income levels as per 2020 targets would not make much sense for 2030 targets as EU in 2020 to a considerable degree converged on both income and emission levels. Although differences persist, they are much less pronounced.

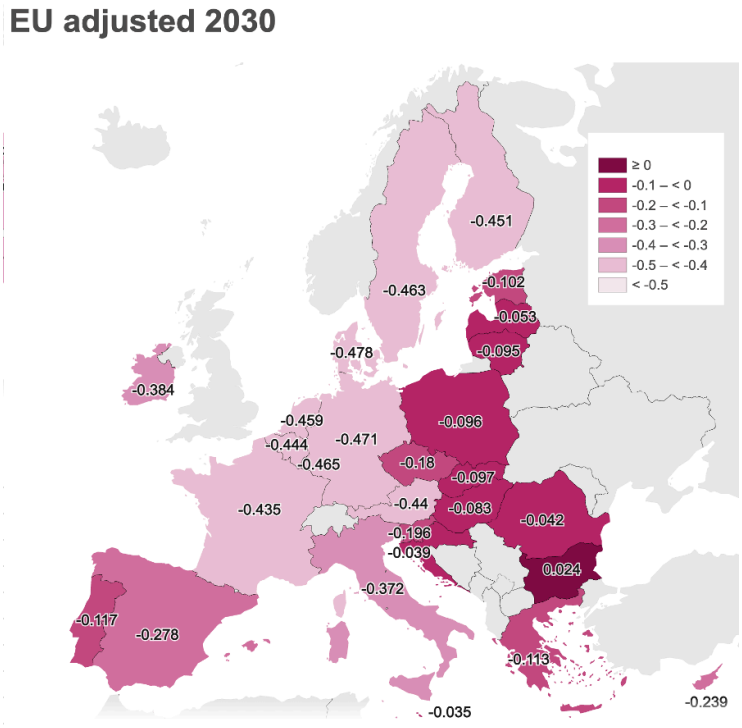
In summary, 2030 emission targets did not significantly shuffle the deck of countries to whom EU targets are more favorable than Equality and GDR approaches and vice versa. The changes that occurred hold similar explanatory basis as for 2020 targets: countries that faced unfavorable EU targets compared to two other approaches applied did so due relatively lower emissions. On the other hand, countries that attributed more accommodating EU targets compared to Equality approach, did so due to higher emissions. Moreover, it is important to highlight that under GDR comparing countries with similar economic development but varied emission levels, lower emissions states are assigned comparatively less favorable targets.

### 3.2.2. Impact of EU funds on 2030 target distribution

Based on the methodological framework laid in 3.1.2. section, Table 6 presents the main by country data points and outputs for 2030 EU target adjustment based on the EU funding each member state receives for climate change mitigation. More detailed information about funding sources can be found in Annex 5. Second column from the left displays total emissions each member state is attributed to reduce over 2021-2030 commitment period. Column 3 shows the annual funding required to achieve the target and 4 indicates EU funding support amounts. Knowing these two amounts we can determine which part of emission reduction effort is set to be achieved internal means and which through external sources. Columns 7 and 8 show current and adjusted net emission reduction targets.

**Figure 10**

EU 2030 net emission reduction targets as a percentage change compared to 2005.




Source: made by author based on IMAGE interactive map generator.

Figure 10 represents the adjusted net emission reduction graphically which reveals a rather straightforward pattern. Net emission reduction targets are significantly lower for Eastern bloc which involves other 2004 and post enlargement EU members and Southern EU states: Spain, Portugal and Greece. It is a result of rather generous EU funding these countries receive through various funding programmes.

**Table 6**

*Net emission reduction target adjustments for the 2030.*

| 1. Country | 2. Total emissions to reduce (Mt. tons CO2) | 3. Annual public funding need EUR (billions) | 4. Annual EU funding EUR (billions) | 5. EU funding coverage | 6. Net emission reductions | 7. Current EU reduction target | 8. Net reduction target |
|---|---|---|---|---|---|---|---|
| **AT** | 17,88 | 4,45 | 0,55 | 12,5% | 15,655 | -48% | **-44%** |
| **BE** | 25,26 | 6,29 | 0,52 | 8% | 23,190 | -47% | **-44%** |
| **BG** | 7,25 | 2,25 | 0,93 | 41% | 4,242 | -10% | **2%** |
| **HR** | 4,76 | 1,48 | 0,68 | 46% | 2,571 | -17% | **-4%** |
| **CY** | 1,12 | 0,35 | 0,10 | 30% | 0,784 | -32% | **-24%** |
| **CZ** | 22,07 | 6,87 | 1,57 | 23% | 17,042 | -26% | **-18%** |
| **DK** | 12,12 | 3,02 | 0,22 | 7% | 11,229 | -50% | **-48%** |
| **EE** | 2,20 | 0,68 | 0,27 | 39% | 1,335 | -24% | **-10%** |
| **FI** | 11,56 | 2,88 | 0,41 | 14% | 9,903 | -50% | **-45%** |
| **FR** | 131,41 | 32,71 | 3,88 | 12% | 115,838 | -48% | **-44%** |
| **DE** | 168,95 | 42,06 | 3,41 | 8% | 155,259 | -50% | **-47%** |
| **EL** | 11,64 | 2,90 | 1,76 | 61% | 4,571 | -23% | **-11%** |
| **HU** | 13,54 | 4,21 | 1,53 | 36% | 8,616 | -19% | **-8%** |
| **IE** | 10,43 | 2,60 | 0,42 | 16% | 8,739 | -42% | **-38%** |
| **IT** | 104,54 | 26,02 | 5,53 | 21% | 82,339 | -44% | **-37%** |
| **LV** | 2,74 | 0,85 | 0,29 | 34% | 1,801 | -17% | **-5%** |
| **LT** | 4,02 | 1,25 | 0,40 | 32% | 2,735 | -21% | **-9%** |
| **LU** | 3,03 | 0,75 | 0,09 | 12% | 2,669 | -50% | **-46%** |
| **MT** | 0,24 | 0,08 | 0,05 | 65% | 0,085 | -19% | **-3%** |
| **NL** | 38,82 | 9,66 | 0,62 | 6% | 36,320 | -48% | **-46%** |
| **PL** | 58,27 | 18,13 | 4,65 | 26% | 43,309 | -18% | **-10%** |
| **PT** | 13,96 | 3,48 | 1,99 | 57% | 5,947 | -29% | **-12%** |
| **RO** | 23,75 | 7,39 | 1,98 | 27% | 17,390 | -13% | **-4%** |
| **SK** | 7,68 | 2,39 | 0,87 | 36% | 4,891 | -23% | **-10%** |
| **SI** | 3,63 | 1,13 | 0,27 | 24% | 2,758 | -27% | **-20%** |
| **ES** | 65,96 | 16,42 | 5,88 | 36% | 42,351 | -38% | **-28%** |
| **SE** | 14,10 | 3,51 | 0,40 | 11% | 12,501 | -50% | **-46%** |

Source: made by author based on the sources listed in 2.1.2. section.

In all of these cases, with an exception of Malta, net emission targets are lower than those set under Equality approach which generally attributed considerably lower targets for lower emission states. Even Malta's case does not look as extreme, as 65% of its emission reduction effort is covered from EU funding which results in 3,5% net emission reduction compared to 2005.

The targets are also more or less balanced in a sense that actual Central and Eastern Europe per capita emissions in 2020 have considerably converged. Drawing from table 7, per capita emission difference from highest (marked in red) and lowest (marked in green) emitting countries decreased by around 1/3. Interestingly, Bulgaria net emission target reveals that it is actually free from emission reduction on its own means, while it has to hold its increase up to 3% until 2030 compared to 2005 levels. This is in line with the lowest per capita Bulgaria's emissions and generally least advanced economic output.

**Table 7**

*Actual emissions per capita in 2005 and 2020 in 2004 enlargement and post enlargement EU member states, excluding Malta.*

| | **2005** | **2020** |
|---|---|---|
| **BG** | 3,154 | 3,423 |
| **HR** | 3,989 | 4,397 |
| **CY** | 5,602 | 4,791 |
| **CZ** | 6,176 | 5,549 |
| **EE** | 4,638 | 4,416 |
| **HU** | 4,676 | 4,585 |
| **LV** | 3,604 | 4,447 |
| **LT** | 3,365 | 5,020 |
| **PL** | 4,816 | 5,391 |
| **RO** | 3,514 | 4,147 |
| **SK** | 4,003 | 3,744 |
| **SI** | 5,852 | 5,257 |
| **Low - high difference** | 3,022 | 2,125 |

Source: European Environment Agency.

Meanwhile for the older Western-Northern European states net emission adjustment is much less significant due lower EU funding inflows. When one considers that this group of states is net-payer in terms overall contributions to EU budget and inflows to their countries, it would be a reasonable observation that these countries instead of increasing further their own expenditure aiming do decrease emissions beyond 50% (maximum EU 2030 target) and lowering EU funding support contributions, they stop at 50% and channel the funds to the rest of EU where there each EUR goes a longer way in terms of emission reduction potential. If we combine both GDR and Equality approaches for above 50% emission targets, the list would include Sweden, Ireland, Luxembourg, the Netherlands, Belgium and Denmark.

In summary, EU funding support has a significant effect on climate change mitigation obligation for 2004 and post 2004 EU member states and Southern EU where fund funding volumes cover the largest part of public funding required to achieve attributed targets. EU funding also puts EU targets as the most appealing ones compared to other approaches to these sub-EU regions. An although older and more prosperous Western-Northern European states would still benefit more under GDR targets, EU funds, although to a less significant extent than to the rest of the EU, softens the disparities to net EU targets.

### 3.3. Discussion

The performed analysis revealed some interesting insights of the fairness of the EU framework for distribution of emission reduction targets. First, EU framework acts as midpoint between the two other diverging approaches applied which signals of a compromise in an arduous task to strike a balance in climate equity. However, every compromise may not leave everyone happy or unsatisfied to the same extent and the comparison of target distributions of the three frameworks is a case in point. Regarding 2020 targets, lower emission countries were attributed very similar percentage change targets compared to 2005 levels to higher emission countries. It showcases that EU really put forward economic development over country per capita emission levels distributing climate effort-sharing obligations which in theory could have been used to bargain for better emission targets for lower emission countries. Focusing largely on economic output metrics and overlooking emissions really goes against *polluter pays* principles, based on which EU Emission Trading System is created.

Nevertheless, 2030 target distributions revealed a less diverging picture among countries as over the 2011 – 2020 commitment period per capita emission levels considerably converged. The convergence also came with economic development likewise. It signals that although

differences in terms of fairness may have been less manageable in the beginning of overall EUs attempt to mitigate its impact on climate change, they are set to balance over time.

The most significant research output which is too often overlooked is the impact of EU funds to cushion the alleged grievances over the transition period. As the research has revealed, EU 2030 net emission reduction targets is the best deal most of the countries can get if compared to other two approaches applied. Although one could still argue that lower income and higher emission countries still held comparative advantage against lower income lower emission states as both groups received similar in proportion EU funding inflows for climate change mitigation.

# CONCLUSIONS AND RECOMMENDATIONS

Assessment of current EU framework for climate change mitigation has revealed a lack of methodological transparency in evaluating whether EU emission reduction targets are fair and aligned with the *differentiated responsibilities and respective capabilities* principle.

In response, this research overviewed scholarly debate on climate change mitigation effort-sharing which led to the following observations:

1. There is a wide range of proposals how the *differentiated responsibilities and respective capabilities* principle could be defined and operationalized.
2. Neither political nor academic consensus exists on the most optimal approach for climate equity. Instead, most research applies multiple benchmark approaches to assess emission reduction distributions from different perspectives.
3. Scholarly debate largely focuses on global effort-sharing, treating EU as a single regional entity, which prevent for country-to-country comparisons within the region.
4. Most of the literature emphasizes what climate targets could be rather than assessing the fairness of currently established targets.
5. Existing research overlooks EU's unique framework for climate change mitigation, most prominently division between Emission Trading System and domestic, non-Emission Trading System, sectors.
6. Existing research does not acknowledge existence and likely impact of EU funding for supporting emission reductions.

Recognizing these gaps, research examined EU emission reduction target distributions against two prominent effort-sharing approaches: Green Development Rights (GDR) and Equality. To ensure comparability, both approaches were adapted to the EU climate framework arrangements, including the same emission reduction commitment periods (2011 – 2020 and 2021 – 2030), linear emission reduction trajectories, and identical nominal reduction amounts. Additionally, 2030 EU emission targets were adjusted based on the EU funding allocated to Member States for climate change mitigation.

The research output has revealed some interesting insights in terms of where EU stands with fairness and equitable distribution of emission reduction targets. EU targets tend to fall between GDR and Equality approaches. Typically, one approach allows more emissions than EU

targets, while the other demands less. Generally, GDR favors higher income and higher emission countries, while Equality benefits lower emission ones.

However, this generalization also comes with exceptions. There is one country group to which both approaches would attribute more favorable than EU targets and one group to which both of approaches would set worse targets. The first group involves countries with generally lower emissions per capita and higher income, the latter group comprise of Member States with lower income and higher emissions. This pattern can be explained as follows:

1. GDR assigns more lenient targets to higher income countries as lower income ones cannot increase their emissions since all of the EU countries starting from 2010 had higher per capita income than development threshold. Accordingly, higher income countries are left lower amount of emissions to be reduced than in set EU targets.

2. Equality approach imposes higher reductions on high emission countries while allowing increases for lower emission ones.

This reveals a deficiency in the EU framework through the lense of fairness defined as *differentiated responsibilities and respective capabilities.* As EU framework awards higher emission countries and punishes lower emission ones, it seems not to sufficiently address the *responsibility* aspect of fairness. As for the income, although GDR output differ from EU targets, there is a direct relationship with the emission reduction targets: lower income Member States receive lower emission reduction targets to higher income ones are attributed to higher targets. It indicates that even though EU targets seem to aim strike a balance, there is still room for adjustment.

Notably, the research also revealed that EU funds help to significantly alleviate possible discontent from countries who may feel dissatisfied the way emission reduction targets are distributed. As a rule, highest beneficiaries of EU funding are lower income countries. As the emission target adjustment has showcased, they often must reduce less than half of the emissions with their own means while the rest is covered through EU funding. However, even with this funding cushion one could argue that lower income, higher emission countries held a comparative advantage against lower income, lower emission Member States as both groups received more or less proportional EU funding volumes largely based on their economic development level and size. The EU funds also to some extent close the target gap for higher income countries in terms of differences between GDR and EU targets. However, it is much less significant.

One important limitation of the research is that it did not adjust EU 2020 emission reduction targets based on EU funding support and only did it for 2030 targets due to absence of data to make similar calculations as for 2030 targets. This output likely could have put EU 2020

targets in a more favorable light to all countries compared to two other approaches applied. However, the adjustment would probably be less significant compared to 2030 targets as EU during 2011 – 2020 put less emphasis on climate change mitigation. Also, adjusting 2030 targets without employing more comprehensive economic models with a rather simplistic approach indicates of a lower reliability of the research output. However, a more in depth and methodologically meticulous approach for better estimation for both commitment periods targets could be an interesting basis for future research.

From the research performed a few notable recommendations arise:

1. The EU should enhance transparency in the methodological framework for emission target distribution. Transparency is crucial for fostering societal trust, keeping set goals credible and achieving climate goals.
2. Decision-makers in lower emission countries could advocate for more favorable targets or increased EU funding to offset disproportionate emission reduction burdens. However, as the time passes this question is losing its relevance as both economic development and emissions per capita converge. Differences today are not as clear as they were in the beginning of the first commitment period.
3. Future research should test additional effort-sharing approaches to validate distribution patterns, develop a more sophisticated framework for net emission target adjustments considering EU funding, and analyze targets for both commitment periods.

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# SUMMARY

## ASSESSMENT OF THE DISTRIBUTION OF GREENHOUSE GAS EMISSION TARGETS IN THE EU

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**Master thesis**

***Finance and Banking Master Study Programme***

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The EU has set among the most ambitious in the world greenhouse gas emissions reduction target, yet due to lack of methodological transparency it is unclear whether the individual targets distributed to its Member States are fair and aligned with the *differentiated responsibilities and respective capabilities* principle, enshrined in the United Nations Framework Convention on Climate Change.

To evaluate whether distribution of emission reduction targets in the EU is fair, the research examines EU emission reduction targets against two prominent effort-sharing approaches: Green Development Rights (GDR) and Equality. Research also contributes to effort-sharing literature by adding additional analytical layer for climate targets assessment: the impact of EU funds towards climate change mitigation.

Performed assessment revealed that EU framework generally acts as midpoint between the two other diverging approaches applied which signals of a compromise in an arduous task to strike a balance in climate equity. However, this generalization also comes with exceptions as some countries would be better-off with alternative approaches against current EU framework targets, while other would be worse if the selected approaches were used to distribute emission reduction

targets. Another important discovery is that EU framework does not sufficiently address *responsibility* aspect of climate equity as it generally awards higher emission countries and punishes lower emission ones.

Nevertheless, EU funds play a significant role in alleviating potential discontent from countries that may perceive their targets as unfair. As the emission target adjustment demonstrates, the largest beneficiaries of EU funding often need to reduce fewer emissions using their own resources, with the remainder covered through EU funding.

# SANTRAUKA

## ŠILTNAMIO EFEKTĄ SUKELIANČIŲ DUJŲ EMISIJŲ MAŽINIMO TIKSLŲ PASISKIRSTYMO VERTINIMAS EUROPOS SĄJUNGOJE

**Matas CANCINGERIS**

**Magistro baigiamasis darbas**

**Finansai ir bankininkystė magistro studijų programa**

Vilniaus Universitetas, Ekonomikos ir Verslo Administravimo Fakultetas

Darbo vadovas – Prof. Dr. Jelena Stankevičienė

Vilnius, 2025

65 puslapiai, 7 lentelės, 16 paveikslų, 64 šaltiniai

ES nustatė vieną ambicingiausių pasaulyje šiltnamio efektą sukeliančių dujų emisijų mažinimo tikslą. Vis dėlto, dėl nepakankamos viešai prieinamos metodologininės informacijos neaišku, ar atskiroms ES valstybėms narėms nustatyti emisijų mažinimo tikslai yra sąžiningi ir atitinka Jungtinių Tautų Bendrosios klimato kaitos konvencijoje įtvirtintą *diferencijuotos atsakomybės ir atitinkamų gebėjimų* principą.

Norint įvertinti, ar dabartinis emisijų mažinimo tikslų paskirstymas ES yra sąžiningas, tyrime lyginimas ES klimato kaitos tikslų pasiskirstymas valstybių lygmeniu su dviem žinomais šiltnamio efektą sukeliančių dujų emisijų mažinimo tikslų nustatymo metodais: Green Development Rights ir Equality. Be to, tyrimas pasiūlo papildomą, mokslinėje literatūroje iki šiol netaikytą analitinę dimensiją – ES fondų poveikį valstybių emisijų mažinimo tikslams.

Atlikta analizė atskleidė, kad ES nustatyti emisijų mažinimo tikslai iš esmės pasireiškia kaip tarpinis variantas tarp dviejų taikytų skirtingų metodų. Vis dėlto tarp emisijų mažinimo skirstinių taikant skirtingus metodus pasitaikė ir išimčių – kai kurios šalys būtų palankesnėje padėtyje taikant alternatyvius, tyrime taikytus metodus, o kitos – nepalankesnėje, jei emisijų mažinimo tikslų nustatymui būti taikomi kitokie nei ES nustatyti tikslai. Kitas svarbus atradimas yra tai, kad ES nepakankamai atliepia *diferencijuotos atsakomybės* kintamąjį klimato teisingumo srityje, nes ES nustatyti tikslai dažniausiai palankesi šalims su aukštesniu šiltnamio efektą sukeliančių dujų emisijų lygiu.

Vis dėlto, ES fondai atlieka svarbų vaidmenį slopinant galimą kai kurių nepasitenkinimą nustatytais tikslais. Tyrimas atskleidė, kad didesnį ES finansavimą gaunančios neretai savo vidiniais resursais siekia tik pusę ES nustatytų emisijų mažinimo tikslų, kuomet kitą dalį padengia ES finansavimas.

# ANNEXES

Annex 1. Country abbreviation list.

| Abbreviation | Country | Abbreviation | Country |
|---|---|---|---|
| **AT** | Austria | **IT** | Italy |
| **BE** | Belgium | **LV** | Latvia |
| **BG** | Bulgaria | **LT** | Lithuania |
| **HR** | Croatia | **LU** | Luxembourg |
| **CY** | Cyprus | **MT** | Malta |
| **CZ** | Czech Republic | **NL** | Netherlands |
| **DK** | Denmark | **PL** | Poland |
| **EE** | Estonia | **PT** | Portugal |
| **FI** | Finland | **RO** | Romania |
| **FR** | France | **SK** | Slovakia |
| **DE** | Germany | **SI** | Slovenia |
| **EL** | Greece | **ES** | Spain |
| **HU** | Hungary | **SE** | Sweden |
| **IE** | Ireland | **EU 27** | Current EU 27 states |

Annex 2. National non-emission trading system emission inventories of all greenhouse gases (CO2 equivalent) in million tonnes in 2005 – 2010.

| | **AT** | **BE** | **BG** | **HR** | **CY** | **CZ** | **DK** | **EE** | **FI** | **FR** | **DE** | **EL** | **HU** | **IE** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 55,88 | 78,94 | 24,15 | 17,20 | 4,14 | 63,06 | 40,40 | 6,28 | 34,01 | 392,26 | 469,30 | 62,25 | 47,16 | 47,41 |
| 2006 | 54,47 | 77,69 | 24,85 | 17,53 | 4,22 | 63,35 | 40,37 | 6,15 | 34,05 | 387,21 | 473,45 | 59,73 | 46,82 | 47,48 |
| 2007 | 52,35 | 76,76 | 25,64 | 17,86 | 4,42 | 61,04 | 40,47 | 6,52 | 34,48 | 378,98 | 434,75 | 59,64 | 44,56 | 46,92 |
| 2008 | 51,78 | 79,20 | 25,31 | 17,88 | 4,46 | 63,51 | 39,75 | 6,50 | 33,07 | 381,99 | 460,41 | 59,24 | 44,31 | 47,33 |
| 2009 | 50,06 | 75,82 | 23,05 | 17,14 | 4,44 | 60,85 | 38,05 | 6,19 | 31,98 | 373,46 | 441,50 | 58,26 | 42,94 | 44,74 |
| 2010 | 51,27 | 78,89 | 24,25 | 17,37 | 4,42 | 62,04 | 38,36 | 6,66 | 33,47 | 375,01 | 453,56 | 55,94 | 43,02 | 44,17 |

| | **IT** | **LV** | **LT** | **LU** | **MT** | **NL** | **PL** | **PT** | **RO** | **SK** | **SI** | **ES** | **SE** | **EU 27** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 340,51 | 8,07 | 11,18 | 10,09 | 1,01 | 121,32 | 183,80 | 47,00 | 74,91 | 21,51 | 11,71 | 238,13 | 42,72 | 2454 |
| 2006 | 333,35 | 8,46 | 11,59 | 9,81 | 1,05 | 120,03 | 192,66 | 45,57 | 76,30 | 20,71 | 11,81 | 241,81 | 41,78 | 2452 |
| 2007 | 329,48 | 9,00 | 13,66 | 9,38 | 1,10 | 116,48 | 192,48 | 45,16 | 73,07 | 20,18 | 11,79 | 246,25 | 41,87 | 2394 |
| 2008 | 329,12 | 8,65 | 12,87 | 9,74 | 1,05 | 120,40 | 197,26 | 44,89 | 76,66 | 21,78 | 12,82 | 235,58 | 40,20 | 2426 |
| 2009 | 310,04 | 8,22 | 11,10 | 9,12 | 0,99 | 117,35 | 195,29 | 43,59 | 70,99 | 21,48 | 11,47 | 223,00 | 38,90 | 2330 |
| 2010 | 315,30 | 8,56 | 11,45 | 9,63 | 1,06 | 125,64 | 204,05 | 43,48 | 68,03 | 22,37 | 11,64 | 224,54 | 39,65 | 2374 |

Source: European Environment Agency[13]

[13] https://www.eea.europa.eu/en/datahub/datahubitem-view/e9ce7eb8-8439-4f2f-96f8-279a36c5fa7a

Annex 3. National per capita emission of all greenhouse gases (CO2 equivalent) in thousand tonnes in 2005 – 2010. Calculated by author based on the data in Annex 2 and population data[14].

| | AT | BE | BG | HR | CY | CZ | DK | EE | FI | FR | DE | EL | HU | IE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 6,792 | 7,534 | 3,154 | 3,989 | 5,602 | 6,176 | 7,454 | 4,638 | 6,483 | 6,226 | 5,691 | 5,666 | 4,676 | 11,396 |
| 2006 | 6,587 | 7,366 | 3,269 | 4,065 | 5,619 | 6,187 | 7,425 | 4,563 | 6,466 | 6,104 | 5,747 | 5,436 | 4,649 | 11,109 |
| 2007 | 6,311 | 7,224 | 3,399 | 4,142 | 5,757 | 5,926 | 7,411 | 4,866 | 6,520 | 5,938 | 5,285 | 5,428 | 4,431 | 10,665 |
| 2008 | 6,222 | 7,395 | 3,378 | 4,147 | 5,667 | 6,116 | 7,236 | 4,864 | 6,224 | 5,952 | 5,607 | 5,392 | 4,415 | 10,543 |
| 2009 | 6,000 | 7,023 | 3,097 | 3,979 | 5,489 | 5,827 | 6,889 | 4,638 | 5,991 | 5,790 | 5,391 | 5,303 | 4,284 | 9,865 |
| 2010 | 6,130 | 7,240 | 3,280 | 4,044 | 5,323 | 5,923 | 6,915 | 5,005 | 6,240 | 5,786 | 5,546 | 5,092 | 4,302 | 9,687 |

| | IT | LV | LT | LU | MT | NL | PL | PT | RO | SK | SI | ES | SE | EU 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | 5,874 | 3,604 | 3,365 | 21,685 | 2,495 | 7,434 | 4,816 | 4,475 | 3,514 | 4,003 | 5,852 | 5,455 | 4,732 | 5,648 |
| 2006 | 5,733 | 3,814 | 3,545 | 20,765 | 2,600 | 7,343 | 5,051 | 4,331 | 3,600 | 3,855 | 5,885 | 5,446 | 4,602 | 5,624 |
| 2007 | 5,638 | 4,090 | 4,229 | 19,548 | 2,715 | 7,110 | 5,049 | 4,283 | 3,499 | 3,754 | 5,843 | 5,445 | 4,577 | 5,473 |
| 2008 | 5,595 | 3,975 | 4,026 | 19,940 | 2,567 | 7,321 | 5,174 | 4,251 | 3,732 | 4,049 | 6,341 | 5,126 | 4,360 | 5,525 |
| 2009 | 5,246 | 3,839 | 3,511 | 18,321 | 2,396 | 7,099 | 5,119 | 4,125 | 3,486 | 3,988 | 5,624 | 4,810 | 4,183 | 5,29 |
| 2010 | 5,319 | 4,080 | 3,698 | 18,986 | 2,567 | 7,562 | 5,364 | 4,112 | 3,360 | 4,150 | 5,683 | 4,821 | 4,228 | 5,381 |

Source: European Environment Agency (emissions); Eurostat (population).

[14] https://ec.europa.eu/eurostat/databrowser/view/demo_pjan/default/table?lang=en&category=demo.demo_pop

Annex 4.1. EU 27 GDP per capita (PPS) 2005 – 2023. Source: Eurostat[15]

| | AT | BE | BG | HR | CY | CZ | DK | EE | FI | FR | DE | EL | HU | IE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2005** | 28680 | 27167 | 8339 | 12651 | 22734 | 18053 | 27966 | 13580 | 26246 | 24979 | 26397 | 20944 | 14009 | 33135 |
| **2006** | 29937 | 28024 | 8952 | 14014 | 23857 | 18963 | 29675 | 15332 | 27385 | 25811 | 27553 | 22691 | 14612 | 35187 |
| **2007** | 31132 | 29046 | 9970 | 15444 | 25961 | 20702 | 30804 | 17494 | 29874 | 26945 | 29100 | 23149 | 15075 | 36918 |
| **2008** | 32056 | 29393 | 10941 | 16316 | 27024 | 21611 | 32031 | 17675 | 31100 | 27236 | 29819 | 23941 | 16077 | 34220 |
| **2009** | 30901 | 28503 | 10508 | 15304 | 25584 | 20866 | 30451 | 15447 | 28670 | 26189 | 28287 | 22922 | 15646 | 31286 |
| **2010** | 31799 | 30148 | 11111 | 15206 | 25360 | 21014 | 32546 | 16338 | 29480 | 27176 | 30025 | 21123 | 16454 | 32702 |
| **2011** | 33133 | 30506 | 11733 | 15751 | 24890 | 21607 | 33087 | 18266 | 30486 | 27902 | 31697 | 19127 | 17159 | 33627 |
| **2012** | 34317 | 31226 | 12055 | 15892 | 23571 | 21604 | 33085 | 19158 | 30179 | 27825 | 32015 | 18393 | 17180 | 34190 |
| **2013** | 34592 | 31515 | 12015 | 16039 | 21975 | 22247 | 33731 | 19786 | 29942 | 28525 | 32468 | 18753 | 17714 | 34520 |
| **2014** | 34980 | 32197 | 12624 | 16107 | 21621 | 23293 | 34329 | 20723 | 29918 | 28768 | 33689 | 19080 | 18411 | 36760 |
| **2015** | 35902 | 33213 | 13217 | 16849 | 22948 | 24376 | 35266 | 21007 | 30545 | 29351 | 34225 | 19237 | 19265 | 49822 |
| **2016** | 36580 | 33756 | 13937 | 17670 | 24920 | 25075 | 36095 | 21747 | 31210 | 29767 | 35131 | 19109 | 19408 | 49666 |
| **2017** | 37217 | 34645 | 14738 | 18790 | 26384 | 26678 | 38020 | 23261 | 32672 | 30526 | 36450 | 19646 | 20259 | 53745 |
| **2018** | 38621 | 35620 | 15600 | 19757 | 27582 | 27908 | 38975 | 24742 | 33615 | 31420 | 37427 | 20083 | 21637 | 57660 |
| **2019** | 39399 | 36819 | 16599 | 21013 | 29058 | 29178 | 39510 | 25949 | 34184 | 33138 | 37879 | 20556 | 22858 | 59221 |
| **2020** | 37440 | 35599 | 16440 | 19607 | 27339 | 28051 | 39953 | 25593 | 34276 | 31416 | 36989 | 18581 | 22377 | 62068 |
| **2021** | 40013 | 39176 | 18544 | 23013 | 30565 | 29986 | 44087 | 28176 | 36439 | 33714 | 39060 | 20682 | 24372 | 72174 |
| **2022** | 44000 | 42398 | 22015 | 25969 | 33384 | 32043 | 48360 | 30137 | 38848 | 35490 | 41347 | 23812 | 26934 | 83264 |
| **2023** | 46242 | 44372 | 24056 | : | 35771 | 34187 | 47988 | 30666 | 40700 | 37996 | 43302 | 25333 | 28724 | 79615 |

[15] https://ec.europa.eu/eurostat/databrowser/view/nama_10_pc/default/table?lang=en&category=na10.nama10.nama_10_aux

Annex 4.2. EU 27 GDP per capita (PPS) 2005 – 2023. Source: Eurostat

| | IT | LV | LT | LU | MT | NL | PL | PT | RO | SK | SI | ES | SE | EU 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2005** | 24589 | 11394 | 11882 | 56262 | 18268 | 30810 | 11381 | 18609 | 7863 | 13589 | 19529 | 22601 | 28041 | 22006 |
| **2006** | 25681 | 12603 | 13102 | 62655 | 18538 | 32598 | 12046 | 19618 | 9185 | 14983 | 20433 | 24437 | 29988 | 23202 |
| **2007** | 26809 | 14393 | 15075 | 67097 | 19784 | 34690 | 13268 | 20317 | 10816 | 16687 | 21759 | 25630 | 32295 | 24553 |
| **2008** | 27383 | 15184 | 16077 | 70500 | 20579 | 36016 | 14205 | 20690 | 13021 | 18318 | 22962 | 25792 | 32710 | 25261 |
| **2009** | 25924 | 12851 | 13679 | 65536 | 20122 | 33642 | 14401 | 19977 | 12557 | 17325 | 20771 | 24228 | 30412 | 24051 |
| **2010** | 26365 | 13401 | 15208 | 68302 | 21738 | 34088 | 15614 | 20630 | 13134 | 19087 | 21055 | 23983 | 31953 | 24902 |
| **2011** | 26974 | 14348 | 17051 | 70245 | 21587 | 34720 | 16680 | 19945 | 14010 | 19566 | 21556 | 23747 | 33237 | 25655 |
| **2012** | 26649 | 15725 | 18240 | 71278 | 22345 | 34904 | 17204 | 19521 | 14625 | 19936 | 21448 | 23424 | 33546 | 25770 |
| **2013** | 26172 | 16336 | 19283 | 72568 | 23346 | 35535 | 17339 | 20159 | 14196 | 20221 | 21634 | 23426 | 33420 | 26014 |
| **2014** | 26139 | 17063 | 20197 | 75185 | 24648 | 35281 | 17919 | 20597 | 14780 | 20803 | 22124 | 24049 | 33813 | 26582 |
| **2015** | 26746 | 17954 | 20728 | 77565 | 26965 | 36151 | 19047 | 21322 | 15540 | 21611 | 22739 | 25121 | 35299 | 27502 |
| **2016** | 27968 | 18562 | 21480 | 78456 | 27625 | 36319 | 19331 | 21954 | 16600 | 20655 | 23576 | 25931 | 35027 | 28187 |
| **2017** | 28813 | 19705 | 23188 | 78890 | 29911 | 37837 | 20336 | 22696 | 18501 | 20706 | 25081 | 27199 | 35679 | 29324 |
| **2018** | 29447 | 20947 | 24666 | 78884 | 31123 | 39210 | 21469 | 23684 | 20039 | 21274 | 26451 | 27650 | 36292 | 30294 |
| **2019** | 30218 | 21657 | 26386 | 78751 | 32695 | 39724 | 22824 | 24609 | 21791 | 22076 | 27789 | 28460 | 37214 | 31308 |
| **2020** | 28236 | 21544 | 26298 | 77916 | 29683 | 39009 | 22927 | 22916 | 21872 | 22352 | 26850 | 24903 | 36852 | 30053 |
| **2021** | 31468 | 23211 | 29188 | 86845 | 33758 | 42688 | 25239 | 24617 | 23939 | 23860 | 29329 | 27532 | 39965 | 32683 |
| **2022** | 34658 | 25422 | 31653 | 90602 | 36741 | 46267 | 28228 | 27908 | 26669 | 25218 | 31881 | 30200 | 42261 | 35448 |
| **2023** | 36650 | 26643 | 32563 | 90183 | 39466 | 49103 | 30102 | 31079 | 29350 | 27435 | 34382 | 33314 | 43929 | 37620 |

Annex 5. EU funding support amounts and sources for climate change mitigation for 2021-2030 in M EUR.

| | ESF+[16] | Cohesion + ERDF[17] | RRF Green (RePower incl.)[18] | Just Transition Fund[19] | CAP 1st pillar[20] | CAP 2nd pillar[21] | Total | | ESF+ | Cohesion + ERDF | RRF Green (RePower incl.) | Just Transition Fund | CAP 1st pillar | CAP 2nd pillar | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AT** | 16 | 157 | 2381 | 131 | 580 | 2282 | 5547 | **IT** | 2025 | 8825 | 34734 | 1030 | 4443 | 4196 | 55253 |
| **BE** | 205 | 322 | 3491 | 176 | 605 | 357 | 5156 | **LV** | 15 | 1169 | 832 | 184 | 438 | 297 | 2935 |
| **BG** | 152 | 2632 | 3561 | 1198 | 1027 | 779 | 9349 | **LT** | 0 | 1753 | 918 | 263 | 724 | 357 | 4015 |
| **HR** | 84 | 2208 | 3408 | 189 | 468 | 468 | 6825 | **LU** | 3 | 592 | 57 | 9 | 38 | 189 | 888 |
| **CY** | 0 | 267 | 575 | 101 | 41 | 52 | 1036 | **MT** | 3 | 217 | 229 | 23 | 7 | 8 | 487 |
| **CZ** | 15 | 6095 | 5187 | 1642 | 1235 | 1478 | 15652 | **NL** | 18 | 181 | 4092 | 599 | 762 | 576 | 6228 |
| **DK** | 37 | 80 | 1038 | 89 | 820 | 152 | 2216 | **PL** | 299 | 22791 | 14388 | 3847 | 4330 | 886 | 46541 |
| **EE** | 0 | 1081 | 838 | 340 | 279 | 151 | 2689 | **PT** | 750 | 6308 | 9392 | 2140 | 874 | 484 | 19948 |
| **FI** | 64 | 305 | 1124 | 448 | 430 | 1762 | 4133 | **RO** | 118 | 6873 | 8026 | 224 | 2838 | 1706 | 19785 |
| **FR** | 388 | 2624 | 23296 | 990 | 8421 | 3037 | 38756 | **SK** | 72 | 3421 | 3519 | 459 | 559 | 642 | 8672 |
| **DE** | 354 | 3312 | 17807 | 2382 | 4935 | 5285 | 34075 | **SI** | 15 | 1017 | 1077 | 249 | 102 | 252 | 2712 |
| **EL** | 345 | 4446 | 8137 | 1375 | 2491 | 806 | 17600 | **ES** | 686 | 8850 | 41277 | 835 | 5553 | 1578 | 58779 |
| **HU** | 72 | 6848 | 4945 | 261 | 995 | 2189 | 15310 | **SE** | 9 | 270 | 2028 | 150 | 680 | 840 | 3977 |
| **IE** | 12 | 119 | 755 | 81 | 1483 | 1757 | 4207 | **EU 27** | 5757 | 92763 | 197108,278 | 19415 | 45158 | 32566 | 392767 |

Source: made by author based on data sources listed in the references.

[16] Source: Cohesion data: https://cohesiondata.ec.europa.eu/stories/s/21-27-Cohesion-policy-tracking-climate-action-and-/mdt2-qvkd
[17] Source: Cohesion data: https://cohesiondata.ec.europa.eu/stories/s/21-27-Cohesion-policy-tracking-climate-action-and-/mdt2-qvkd
[18] Source: Recovery and Resilience scoreboard: https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/country_overview.html?lang=en
[19] Source: Cohesion data: https://cohesiondata.ec.europa.eu/stories/s/21-27-Cohesion-policy-tracking-climate-action-and-/mdt2-qvkd
[20] Source: Becker et al. (2022).
[21] Source: Becker et al. (2022).

Annex 6. International Conference on Accounting, Audit and Analysis participation certificate.

ACCOUNTING AUDITING ANALYSIS

Faculty of Economics and Business Administration

Vilnius University

International Scientific Conference

THE MODERN ECONOMIC, TECHNOLOGICAL AND SOCIETAL TRENDS: NEW CHALLENGES OR OPPORTUNITIES

# CERTIFICATE

NOVEMBER 27-29, 2024

## Matas Cancingeris

has participated as presenter and made the presentation

***An Assessment of the Distribution Mechanism for Greenhouse Gas Emission Reduction Targets within the European Union***

at the International Conference on Accounting, Audit and Analysis
**The Modern Economic, Technological and Societal Trends: New Challenges or Opportunities**

The Conference was held on 27–29 of November 2024,
Vilnius, Lithuania

Aida Mačerinskienė

Dean of the Faculty of Economics and Business Administration