UNIVERSITÀ
DI TORINO

Institutions, Economics and Law PhD

XXXVI Cycle

Bridging the Green Finance Gap

Three Essays on Public and Private Roles in Ecological Transition

PhD Thesis

Michele Lemme

Alain Marciano, Supervisor
Roberto Zanola, Co-supervisor

Al caro ricordo del Prof. Giuseppe Eusepi,
che ha piantato il seme della mia crescita come ricercatore, insegnandomi che l'individuo è al contempo osservatore e soggetto osservato. A me spetta il compito di coltivare quel "cavolo" di cui spesso parlava, consapevole che la coltivazione richiede dedizione e cura, molto più del semplice piantare.
Questa tesi è il frutto di quella coltivazione.

Con eterna gratitudine e stima.

Contents

Introduction

Climate change presents a multifaceted challenge that affects multiple aspects of society, encompassing economic stability, public health, and environmental integrity. Historical analysis reveals that the genesis of our comprehension of this phenomenon dates back to 1896, credited to the seminal work of Swedish scientist Svante Arrhenius. He postulated the hypothesis that escalating carbon dioxide levels in the atmosphere could markedly influence global temperature regimes. Progressing through time, the depth of our understanding in climate science has expanded considerably. There is now a broad acknowledgment of the pronounced anthropogenic contributions to greenhouse gas emissions and their deleterious effects. The issue of climate change was firmly placed on the international political agenda in 1992 with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), a milestone that highlighted its critical global nature.

The establishment of the UNFCCC exemplifies the pivotal role of international institutions in spearheading efforts against climate change. It serves as a prime example of how institutions at all levels, from global entities like the UNFCCC to national and local governments, are indispensable in crafting, implementing, and enforcing policies aimed at combating climate change. These institutions are crucial for setting environmental standards, developing regulations, and ensuring compliance, effectively weaving climate change mitigation and adaptation strategies into both national and international plans. Their role extends beyond policy formulation to fostering global cooperation, ensuring that climate change, a challenge that knows no borders, is addressed through unified and coordinated efforts.

In economic terms, tackling climate change involves a global cooperation game, where each nation determines its approach to carbon emission cuts. In what follows, states play a pivotal role in forming and participating in international agreements, such as the Kyoto Protocol in 2005, Copenhagen Accord in 2009, or Paris Agreement in 2015, to collectively combat global warming. Through diplomatic channels, governments can encourage global cooperation, and provide support to developing countries in their climate change mitigation and adaptation strategies. However, given that mitigation implies concentrated costs and widespread benefits, it is not surprising that the UNFCCC Conference of the Parties have often established emissions reduction targets that are insufficiently ambitious.

In this context, the request for government intervention to mitigate climate change has flourished. Governments possess unique regulatory authority, essential for implementing policies that reduce greenhouse gas emissions, such as carbon pricing and setting emission reduction targets. These measures are crucial for steering both industries and consumers towards more sustainable practices, which individual or private sector efforts alone cannot achieve. From an economic perspective, government intervention is

not merely beneficial but essential. This viewpoint is supported by various economic theories and principles. First and foremost, the concept of market failure provides a fundamental rationale for government intervention. Market failures occur when the free market fails to allocate resources efficiently, leading to suboptimal outcomes from a societal perspective. In the realm of renewable energy and green technologies, positive externalities are plentiful. For instance, the environmental benefits of reduced greenhouse gas emissions benefit society as a whole, not just the entities investing in these technologies. However, because these benefits are not fully captured by the market, private sector investment in such technologies tends to be lower than socially optimal. Government intervention, in the form of subsidies, grants, or tax incentives, can help internalize these externalities, aligning private incentives with public welfare.

Furthermore, many aspects of renewable energy and green technology research can be considered public goods. Public goods are characterized by non-excludability and non-rivalry, meaning they are available to all and consumption by one individual does not diminish availability to others. Basic research, which lays the groundwork for further technological advancements, often falls into this category. Given the non-excludable nature of such research, private entities might be reluctant to invest, as they cannot easily secure exclusive benefits from their investments. This underinvestment in basic research necessitates government funding to ensure that such essential knowledge is developed and disseminated.

Especially in their initial stages, renewable energy projects can significantly benefit from economies of scale. Government investment can help achieve a critical mass, reducing costs per unit and making these technologies more competitive against traditional energy sources. This not only accelerates the adoption of renewable technologies but also fosters the development of a more efficient and sustainable energy sector. In periods of economic downturn or stagnation, these investments can serve as a fiscal stimulus, boosting economic activity and employment in emerging sectors. This aligns with Keynesian economic principles, which advocate for government spending to counteract economic recessions. In what follows, that for all the reason mentioned above the ecological transition should be produced and financed by government.

Despite the apparent advantages of government investment in renewable energy and green technologies as described, there are also significant reasons to reevaluate this approach. This thesis comprises three chapters that argue in favour of limiting government intervention, with a specific focus on curbing government public expenditure in financing the ecological transition. We achieve this by exploring how Law and Economics can contribute to this objective, examining the topic through the prism of constitutional limits. Subsequently, the thesis delves into the significant role of a financial instrument commonly employed by both governments and private entities for financing ecological transitions, namely green bonds. Finally, we shift our focus exclusively to the private sector, investigating the impact of financial development on the issuance of green loans in European countries.

The interplay between financing mechanisms for climate change mitigation and the trajectory of

sustainable financial instruments has garnered considerable scholarly attention, specifically focusing on the challenges and strategic differences between European nations. Chapter 1 delves into the fiscal conundrum posed by climate change, underscoring the urgency for social and economic transformation to curb greenhouse gas emissions predominantly originating from fossil fuels. The pivotal question it raises revolves around the choice between taxation and debt as financing tools for necessary public expenditures. With public debt already at a significant level globally, the chapter explores the potential ramifications of imprudent borrowing and ineffectual public spending. It also grapples with the issue of safeguarding future generations from the disproportionate burden of public debt, advocating for a discussion on how constitutional law can be instrumental in managing public expenditure.

In parallel, the emergence of green bonds as a financial instrument for sustainable development signifies an innovative approach to environmental challenges. Chapter 2 investigates the degree of convergence among European countries and the U.K. in green bond issuances during 2012-2022. Through a convergence log-t test on a sample comprising 24 European countries and the U.K., the findings reveal a fragmented scenario characterized by the formation of four distinct clusters of countries. This suggests a lack of a unified strategy, potentially exacerbated by the EU Green Bond Standard, which may promote market fragmentation rather than consolidation. The chapter provides an examination of the economic, environmental, and institutional factors influencing this divergence and posits that a homogenized policy may not be effective, necessitating tailored approaches to foster a cohesive green bond market.

Chapter 3 shifts the focus to green loans, an equally important financial instrument for sustainable development. It examines the convergence of green loan issuances across European countries and the U.K. from 2016 to 2022, finding variable paths influenced by market maturity, banking structures, and environmental policies, leading to disparate club memberships among nations. The study underscores the significant role of financial development in the issuance of green loans, advocating for policies that reflect the unique attributes of individual countries. The findings recommend a balance between encouraging private sector engagement and ensuring equitable bank lending, in alignment with the EU's call for amplified private investment in sustainable projects. It suggests that an overarching finance framework could facilitate easier access to green loans and mortgages for households and small and medium-sized enterprises (SMEs).

The three chapters collectively emphasize the complexity of financing climate change initiatives and the importance of a nuanced understanding of financial instruments like green bonds and loans. They reflect a need for a prudent approach to public spending, the importance of structural financial development, and the urgency for customized policies that consider the specific economic, environmental, and institutional contexts of each European nation. The thesis highlights an urgent need for strategic financial planning and regulatory alignment to guarantee that the sustainable finance market functions effectively and inclusively, thus playing a pivotal role in addressing climate change.

Chapter 1 - Should we use taxes or public debt to finance the ecological transition?

Fiscal illusion and Constitution in the climate change challenge

Abstract

This article addresses the challenge of climate change faced by human societies, primarily caused by carbon emissions from burning fossil fuels. To tackle this challenge, institutions have taken measures to control greenhouse gas emissions and require a radical social and economic transformation. The article focuses on the financing of the necessary public expenditures, specifically examining the choice between using taxes or debt as instruments. However, considering the already significant levels of public debt worldwide, this decision becomes particularly complex. It raises questions about the consequences of unwise public borrowing and wasteful public expenditure, as well as how to protect future generations from bearing the primary burden of public loans. The article further undertakes a scholarly examination of what constitutional law can contribute to the ongoing debate.

Keywords: Constitution, Ecological Transition, Public Debt, Fiscal Illusion, Taxation, Future Generations.

JEL Classification: K10, K30, H60

1.1 Introduction.

It would probably not be an exaggeration to say that climate change is immense challenge human societies have to face. And it is a problem that was caused mainly by carbon emissions due to human activity burning fossil fuels. As written in the latest IPCC report[1] - Summary for Policymakers 2021: "It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. [...] Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since [2013]." Five possible future climate scenarios have been forecasted for greenhouse gasses (GHG) and CO2 emissions over the 21st century, namely near-term (2021-2040), mid-term (2041-2060) and long-term (2081-2100). In all five possible scenarios, the global surface temperature is expected to continue to increase until at least mid-century.

To face this challenge, various institutions have decided to control greenhouse gas emission reduction. For instance, the European Union decided that net emissions should fall to 55% of their 1990 levels by 2030, and zero by 2050[2]. To reach that goal, a radical social and economic transformation has to be undertaken. Consumers have to change their habits. Producers have to modify their modes of production. New forms of energy have to be invented. In other words, an ecological transition seems to be required. To be more precise, an ecological transition that requires huge amounts of money. Indeed, even if William Nordhaus claimed that without a new policy measure, climate change would reduce world GDP by just 3% or 4% by the end of this century, others argue that the costs would be huge. For instance, economist Bjorn Lomborg predicts that doing nothing would cost about $140 trillion (expressed in terms of damages provoked by climate change) while cutting the damage to $40 trillion would require policy costs of circa $177 trillion. In any case, for political reasons, it seems impossible not to act against climate change. Thus, the common decision coming from the COP27 meeting in Sharm el-Sheikh in November 2022 and COP26 meeting in Glasgow in 2021 was to engage in large, global public expenditure programs to slow down climate change because "[...] with concern that the current provision of climate finance for adaptation remains insufficient to respond to worsening climate change impacts in developing country Parties[3]".

Then, the question is obvious: how to finance these massive public expenditures? And, more precisely, which instrument should be used—taxes or debt? We decided not to take into account the discussion about whether climate change is (or is not) an international public good and why it should (or should not) be produced. The reason is that these points do not change the fact that climate change is

[1] Intergovernmental panel on climate change 2021 - the physical science basis - summary for policymakers (p. 4)
[2] Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people (p. 2)
[3] Decision -/CP.26 - Glasgow Climate Pact https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf

financed with public debt. In other words, our main focus is not on a normative question but on a positive one, and the fact remains that climate change is produced and financed with public debt. Nevertheless, in a world in which public debts are already large, the question is particularly tricky. Who suffers if the public borrowing is unwise and the public expenditure to finance it is wasteful? How to preserve future generations from the primary burden of public loans? What Constitutional law can do to the current debate?

We suggest discussing these questions within the frame of the Virginia School of Political Economy. The arguments are developed as follows. We first make readers wonder why we can treat the question of climate change as a form of public expenditure, namely environmental debt. Indeed, financing the latter by using debt, or taxes, raises the question of who is going to pay for the ecological transition. Are these two fiscal instruments identical, equivalent or not? The equivalence between debt and taxes was put forward by David Ricardo at the beginning of the 18th century but unearthed by the Italian public finance theorists two hundred years later and then by James Buchanan (see, in particular, 1958).

After exploring the reason the equivalence does not work, we discuss the environmental debt in terms of Ricardian equivalence. Having defined what is meant by transferring the burden to future generations, we move on to discuss another major problem against Ricardian equivalence which is the fiscal illusion. This was raised by Puviani (1903) and then recalled by Buchanan (1960,1967) and it is not unlike what behavioural economists did. We discuss the subjective dimension of costs. The latter, not only is an important aspect of Virginia's political economy's approach to debt but also an important factor for behavioural economics. Both share several key features. Nevertheless, the concept of the subjective nature of choice refers to the individualised processes by which individuals comprehend their choice contexts and assess the alternatives available to them. Subjectivity is a result of an individual's psychological processes.

Having discussed the subjective dimension of costs and the presence of illusion, we address the institutional and legal way to deal with those problems by reviewing the constitutional rules suggested by Buchanan. Environmental debt has political reasons and implications. Since we, as a collective, are willing to change and (re)shape our society towards a less polluted world, the interaction between politics and the economic problem occurs. Nevertheless, the Virginia School of Political Economy is the school that studies these interactions. We explore how to implement constitutional/legal regulations to avoid fiscal illusion and how this can be used to deal with environmental debt.

This chapter is organized as follows. Section 1.2 discusses why we can treat the question of climate change as a form of public expenditure. Section 1.3 describes the Ricardian equivalence and why it does not work. Section 1.4 introduces the problem of fiscal illusion within Buchanan's works and behavioural economics main findings. Section 1.5 connects VPE to Behavioural Economics and L&E, and suggests how to deal with fiscal illusion in terms of constitutional/legal rule, therefore discussing how institutions and law can be used to address environmental debt. Section 6 presents our final considerations.

1.2 Can we treat the question of climate change as a form of public expenditure?

In this section, we show why we can treat the question of climate change as a form of public expenditure and therefore discuss it in terms of Ricardian equivalence. These two crises unfold over a comparable period (decades for both), with remarkable similarities such as uncertainty, free-rider incentives, and political disincentives to fully address the respective issue with early, farsighted policy actions.

Generally speaking, the length of time is a significant obstacle to successful political decision-making. Both human-induced climate change and the public debt issue are characterised by a time lag between society's attempts to solve the problem and the resulting benefits. The time lag between any attempts to decrease greenhouse gas emissions and the benefits emerging from those efforts, in terms of reduced climatic damages, is an evident challenge that makes it difficult for politicians to deal with climate change. If a successful policy initiative is not ensured, future generations will pay the price. Also with the public debt, there is a lag between the cost that future taxpayers will bear and the current gain obtained from public initiatives (as put forward in section 3, it is even more clear in presence of wasteful expenditure).

The next parallel between public debt and the climate crisis is that both require international collaboration. Just as no one nation can avoid climate change, no single country can prevent an increase in public spending in the case of the progressive mutualisation of debts, especially when specific projects, such as resilience or ecological transition, are financed by common instruments, namely euro-bonds or Next-Generation EU Green Bonds. Branger and Quirion (2014) reported that economists frequently use the phrase "carbon leakage" in the context of the climate challenge. This means that unilateral efforts by one country to cut greenhouse gas emissions are compromised if other nations do not follow suit, as enterprises may transfer production and local firms may lose international competitiveness. Thus, unilateral emission reduction programmes essentially move emissions from one nation to another rather than reducing emissions globally, unless additional mechanisms that expressly address leakage are utilised, such as the introduction of a border carbon adjustment system. Otherwise, carbon leakage diminishes any single country's incentives to invest in climate change mitigation in the first place. Furthermore, it reinforces the so-called "free-rider incentive," which characterises the climate problem from a game-theoretic standpoint: rather than becoming a proactive country, each country has incentives to remain inactive and let other countries go ahead, by investing limited resources to reduce domestic emissions (Barrett, 1994). This is because any unilateral attempts to cut greenhouse gas emissions would ultimately benefit all countries, whereas the costs will primarily affect the home economy and society.

Also with the public debt problem, there is a "leakage" issue that becomes more apparent when Euro-bond instruments are analysed. This is especially relevant when investigating the so-called

mutualization of public obligations in the EU. In a word, it entails the sharing of a portion of the public debt by European Union member states, or rather the choice of certain states to guarantee the issuing of debt instruments by other governments. This is accomplished through the mediation of the Commission: as stated in point A3 of the European Union Council Conclusions of 17-21 July 2021, even the states that had previously raised objections agreed to this fundamental novelty to equip the EU with the resources necessary to address the challenges posed by the COVID-19 pandemic. Therefore, the Commission authorised borrowing on the capital markets on behalf of the Union. This indicates that the EU will be the primary debtor. Ultimately, the implication is that, in the event of a country's future inability to repay its share of debt, the solvent nations will have to compensate those in need with their resources, with the only option being for the EU to implode. From an economic standpoint, such a system exposes itself to extraordinarily high risks of individual and institutional free-riding (De Caria, 2021). The economic literature has demonstrated conclusively that corruption, waste, and inefficiency increase proportionally to the distance between the recipient and the payer of a particular social service (Liu & Feng, 2015).

Uncertainty is another deterrent to a successful climate policy. This relates to both the magnitude of predicted future losses and the costs of climate change mitigation. Nobody can anticipate how expensive it will be to meet, for example, the 1.5 °C targets, or which technologies will be used to do so (Howard & Sterner, 2017). This is similar when the public project is financed by debt and the cost of the investment must be compared with the individual returns rate rather than the decrease in net worth of the taxpayer occasion by the interest payment (Buchanan J. M., 1958, 54). The productivity of the public project at the individual level is hard to predict. Taking this into account, there is every reason to expect that the interposition of bureaucrats and politicians may convert beneficial expenditures into unproductive ones, and so public debt is no longer a viable option. Moreover, the strategic use of budgeting by politicians and bureaucrats may lead them to define an "investment" as an outlay that improves the supply of future public services which is the actual result of the rent-seeking activity (Eusepi & Wagner, 2018). It should be emphasised that because actions are determined by an actor's goals, the same activity might be classified as current consumption or investment depending on how the activity is mapped into the actor's goals. In any instance, the chooser, the taxpayer, should make the distinction, not the observer, the government, as expressed by Eusepi (2020).

There is another common point between the problem of climate change and public debt, namely the existence of tipping points. In the climate system, the tipping may lead to climate change spiralling out of control. This is a possibility, but it is not a certainty (Schmidt, 2021). This also applies to the topic of public debt: studies by Caner, Grennes and Koehler-Geib (2010) addressed the questions of whether such a tipping point in public debt exists and how severe the impact of public debt on growth would be if this threshold were to be exceeded. With the use of threshold calculations based on an annual dataset of 99

developing and developed economies covering the years 1980 to 2008, they were able to determine: that the estimates create a debt-to-GDP ratio threshold of 77 per cent. If the debt exceeds this threshold, each incremental percentage point of debt reduces yearly real growth by 0.017 percentage points. The effect is considerably more significant in developing countries, where the debt-to-GDP ratio threshold is 64 per cent. In both circumstances, climate crisis and public debt, the multiple types of uncertainty around the problem make it considerably more difficult for legislators to impose strict policy actions early on.

The public perception and media coverage of the respective problem, as well as the impact of politicians, political parties, or interest groups who are attempting to influence the media coverage following their interests or (politically flawed) beliefs, are yet another aspect of the climate change problem that shares some similarities with the public debt. Because these two challenges unfold on comparable time scales, policymakers' mistakes in managing the public debt and climate change will only become evident in a few decades. Involving irrevocable tipping points that have the potential to create catastrophic climate change and uncontrollable governmental debt levels, both may have severe impacts.

The final connection between these two situations is that there is a systemic dearth of incentives for politicians to appropriately handle either problem. Climate change is a problem that, by its very nature, would have necessitated prompt policy action at a period when serious climate damage was not yet evident. As is the situation with climate change now, politics, and this is also true for democracies, typically appears to handle problems only when the damages become nearly universally apparent, i.e., when the subject becomes urgent (Schmidt, 2021). The same holds for public debt. The fundamental issue seems to be that politicians lack the proper incentives to pursue proactive, long-term policy. Such policies are initially unpopular, and as a result, politicians who implement them must fear for their political careers, as the general populace cannot fully appreciate the necessity of the actions until the repercussions become apparent.

All the considerations mentioned above raise the following question: if the issue of climate change can be treated as a form of public expenditure, should we use taxes or public debt to finance the ecological transition? In the next section, we discuss it in terms of Ricardian equivalence.

1.3 Public Debt or Taxes? It does not matter: the Ricardian Equivalence and why it does not work.

To some it does not matter, to others it does. How is it possible? Are taxes equivalent to debt to finance public expenditures? It is not sure. We explain why. Then we discuss that the Ricardian theorem does not hold.

1.3.1 Ricardo's theorem: do taxes exert the same effect as debt?

At the beginning of the 18th Century, classical political economist David Ricardo wrote "Principles of political economy and taxation" (Ricardo, 1817) and "Essay on the Funding System" (Ricardo, 1820). In these two fundamental works, Ricardo gave some of the principles upon which rest classical political economy. One of the questions he addressed was that of the financing of extraordinary expenses. The standard tax system should not be used in the face of a long-term war; instead, debt was a viable option because an extraordinary occurrence should not be compensated with an ordinary tax. Therefore, it must be paid through an extraordinary tax. The question Ricardo addressed was whether (or not) borrowing by the government would have shifted the burden of excessive government spending to future generations. In this regard, he argued that taxation and public debt have the same effect from an individual's perspective.

He also stated that, regardless of the method of financing, the weight of present government expenditures cannot be passed to future generations (Ricardo, 1817). From an individual point of view, the latter decision should not make any difference, as expressed in Ricardo's formulation: *"When, for the expenses of a year's war, twenty millions are raised by means of a loan, it is the twenty millions which are withdrawn from the productive capital of the nation[...] Government might at once have required the twenty millions in the shape of taxes; in which case it would not have been necessary to raise annual taxes to the amount of a million. This, however, would not have changed the nature of the transaction. An individual instead of being called upon to pay 100£, per annum, might have been obliged to pay 2000£, once and for all*[4]*"*. The reason is purely numerical.

Therefore, within Ricardo's framework, the nature of the transaction would not have changed whether using an extraordinary tax or public debt. Thus, his proposition implied that taxes and debt have the same effect on private consumption, at least for two reasons. First, since debt is a future repayment obligation, an increase in government debt is considered a postponement of tax increases in the future. Second, the consumer is rational and able on the one hand to write down the present value of his income streams. On the other hand, the individual can forecast an increase in taxes in the future whenever

[4] David Ricardo, "Principles of Political Economy and Taxation," *Works and Correspondence*, Vol. I (Cambridge, 1951), pp. 244-45

government runs a deficit in the short-term, adjusting his spending behaviour at the present moment. In this light, as it will be put forward more than a century later by Keynes (1936), the Ricardian formulation gave birth to literature slightly able to explain the defect of the most shared economic analysis of government debt and deficits which argued, more than a century later, stimulation of aggregate demand mainly caused by a rise of disposable income induced by a deficit-financed tax policy (Keynes, 1936).

One of the economists who (at least partially) built on Ricardo's equivalence theorem was James Buchanan. In his chapter "Public Principles of Public Debt: A Defense and Restatement" (Buchanan J. M., 1958), he demonstrates that the real primary burden of public debt is shifted to future generations. He achieved this by highlighting the following seven points: [1] when future periods are considered, the focus on the national balance sheet confuses, rather than the individual or family which is the philosophical entity in society (Buchanan 1958, 36), [2] individuals who will be obliged to give up resources in the future, acquire and pay for the public project, [3] no real economic resources are sacrificed by the bondholder since there is a voluntary alteration in the structure of his actual asset pattern, [4] because the taxpayer does not pay any tax for the useless project, he makes no sacrifice in period t0, [5] the burden must fall only on the taxpayer, in the future. To transfer money to the bondholder, the future taxpayer must now cut his real income with no productive asset, in the form of a public project, to offset his genuine sacrifice (Buchanan 1958, 39) in case the public borrowing is unwise and the public expenditure wasteful, [6] while interest payments indicate future revenue that the bondholder or his forefathers paid for via resource sacrifice during the debt creation period, future generations cannot be compelled to pay for resources that have already been used in the past, [7] the project's productivity or lack thereof is irrelevant in and of itself. In any instance, the taxpayer is the one who foots the bill and makes real-world sacrifices. The future taxpayer is the final "purchaser" of public goods and services.

The necessary conditions for the Ricardian theorem to hold are very specific and summarized as follows (Brennan & Buchanan, 1980):

1. Public expenditures in the initial period are constant between the two financing instruments;
2. Public debt issued in the early period must be repaid and/or amortized from taxes collected in the later period;
3. The capital market is perfect, and individuals can borrow at the same rate as the government;
4. Individuals have certainty about their current and future income prospects;
5. As current taxpayers and potential future taxpayers, their behaviours have unlimited planning horizons- they act "as if" they plan to live forever;
6. The individual fully anticipates tax liabilities arising from debt issuance in future periods;
7. All taxes are one-time payments.

Conditions (5) and (6) above appear to impose very strict behavioural and informational assumptions on actors in the economy. Ricardo himself seems to challenge the validity of the equivalence theorem on these grounds (O'Driscoll Jr, 1977). According to these assumptions, the generation that lives at the time of the expenditure will bear the whole cost of the public project because individuals write down the present value of their future revenue streams as a result of taking on debt. As a result, the present value of the tax liabilities caused by future service charges will directly lower the present value of assets. (Buchanan J. M., 1958). The major critique of the Ricardian proposition, using Buchanan's words *"[...] is that individuals do not fully discount future taxes"* (1958, 45). Moreover, individuals with no assets are incapable of operating complete discounting logic. The future tax burden associated with interest payments will not be completely capitalised by the individual who owns no capital assets. Only if the latter person will be a future taxpayer would he capitalise them. Due to the shortness of human life, much of the debt burden must remain uncapitalized. As a result, even if all of the other Ricardian assumptions are true, the burden must fall on "future generations" to some extent. The position of the debt burden on future taxpayers becomes increasingly clearer when the prospect of individual irrationality in discounting future tax payments is considered.

However, in 1974, Robert Barro wrote an article in which he examines whether government bonds should be considered net wealth or not. In a nutshell, if government bonds are not considered net wealth, changes in consumption of government finance do not have a real effect on consumption. Therefore, debt does not play any role in consumption, and it is said to be neutral. Since that article (Barro, 1974), Buchanan explored the tight relationship[5] between Barro's arguments and the theory proposed by Ricardo (Buchanan J. M., 1976), embracing at glance a new label: Ricardian Equivalence. The equivalence of what? The equivalence between financing through tax or debt Barro's analysis (1974) extended Ricardo's model. While the latter considers a rational individual living in two different periods, the former relates the individual of the present generation to his future generation, assuming that these intergenerational relationships are purely altruistic. Therefore, consumers have a limited life with benevolent behaviour towards their descendants, delivering them a positive bequest. In this way, the government cannot perpetually postpone the repayment of the bonds because consumers act "as if" they do have an infinite life since adopting an altruistic behaviour concerning their descendants. The reimbursement received by consumers includes capital plus interest and is equal to the sum of the principal and taxes collected to pay the obligation (Ricciuti, 2003). In this light, government bonds are not considered net wealth because a decrease in government savings is offset by an increase in private savings. As a result, national savings remain constant.

Feldstein (1976) criticized the altruistic approach to intergenerational justice by questioning the existence of a connection between households, since Barro includes in his analysis the families without

[5] Noting that Barro did not make reference to Ricardo or other early contributors (Buchanan J.M., 1976 pp. 337)

children. When the government substitutes debt for taxes, childless households lose interest in future-generation taxes and modify their behaviour (Buiter & Tobin, 1978). Stated differently, why a person without children should consider someone in the future as himself? For example, assuming that individuals live during exactly two periods in a series of overlapping generations, and their only source of utility is their consumption. The government collects funds by taxing people and running deficits. Because current issues of government debt, which cut the taxes of the current working generation, will be redeemed with taxes collected on future generations, Ricardian equivalence will not hold. The present value of the future tax burden imposed on the current working generation by the debt will be less than the current tax cut. As a result, even lump-sum taxes, such as debt-for-tax swaps, will have wealth implications if they are financed differently (Seater, 1993). In addition, from a microeconomic point of view, there is a difference between debt and tax related to the consumer age. While an elderly person will be more favourable to finance public expenditure through debt to avoid tax today, a young person (with a limited disposable income) will be more favourable to tax today to avoid taxation when her/his future wealth will be greater than the actual one. Even if Barro's hypothesis is more restrictive than Ricardo's, the occurrence of childless families has not been proven to be an acceptable basis for rejection of the Ricardian equivalence in the empirical study (Boór, 2021). Some research supports benevolence (Seater, 1993), while others contradict it (Bernheim, 1987).

1.3.2 Empirical studies. Does Ricardian Equivalence hold?

For decades, numerous economists have tried to scientifically prove or disprove Ricardian equivalence using a variety of methodologies (Boór, 2021). The aggregate consumption function, calculating the consumption Euler equation, investigating interest rates, and the trade deficit concerning deficit fluctuations have all been used to test Ricardian equivalence. The empirical evidence is contradictory. The notion of Ricardian equivalence is often rejected when investigated in a life-cycle framework but supported when empirical research is based on optimising models (Ricciuti, 2003). Academics from developing and emerging markets are currently interested in Ricardian equivalence. This section draws the recent studies and main findings.

Khalid (1996) demonstrated that increased government expenditure can boost aggregate demand in developing nations in the short run, partially validating Ricardian equivalence. Marinheiro (2001) used the Portuguese economy to show that it's impractical to meet all Ricardian equivalence assumptions, with experiments based on consumption functions using the Euler equation indicating its inapplicability in Portugal. By constructing a dynamic panel threshold model for 22 industrialised nations, Nickel and Vansteenkiste (2008) examined the empirical relationships between fiscal policy and the current account of

the balance of payments and how Ricardian equivalence modifies this relationship. The interaction between the current account and the government balance was permitted to shift based on the government debt-to-GDP ratio. According to their findings, for nations with debt-to-GDP ratios of up to 90%, the link between the government balance and the current account is positive, implying that an increase in the fiscal deficit leads to an increase in the current account deficit. This association becomes negative but minor for very high-debt countries, implying that an increase in the fiscal deficit does not increase the current account deficit. This conclusion implies that families in high-debt nations tend to become Ricardian.

Sardoni (2021) criticized the Ricardian equivalence and proposed a new method based on the concept that a well-structured government spending programme may assure a steady government debt ratio even if the government runs a primary deficit. Hameed, Ahmed, and Salman (2020) investigate the validity of Ricardian equivalence in country clustering, using SAARC countries as a representative sample of countries from 1990 to 2018. The findings of their analysis do not confirm the validity of Ricardian equivalence in SAARC because private consumption rises in line with government debt, and people do not postpone present spending despite rising government debt and the possibility of future taxes to meet debt commitments.

Agarwal and Gangal (2020) have proven, using India as an example, that fiscal deficit does not influence GDP and has no negative impact on GDP, supporting the applicability of Ricardian equivalence in this country. Ikiz (2020) proved the presence of rational families in Turkey, which respond to increases in government spending by increasing savings over time. Using an ARDL cointegration technique, Beyene and Kotosz (2020) established the partial validity of Ricardian equivalence in Ethiopia from 1990 to 2011. The findings of their research revealed that rises in the budget deficit and government consumption spending satisfy the Ricardian equivalence assumptions, but not in the case of public debt.

To summarise, several economists have attempted to demonstrate or reject Ricardian equivalence using a variety of scientific methods. However, the empirical evidence is contradictory. Following Buchanan's methodological approach, even if all of the other Ricardian assumptions are true, the burden must fall on "future generations" to some extent. The major actual cost of public debt is borne mostly by future generations, and debt production involves the transfer of burdens to those living in periods after debt issues. Not only the position of the debt burden on future taxpayers becomes clearer when the prospect of individual irrationality in discounting future tax payments is considered but also when the public expenditure is wasteful. Nevertheless, the mechanism for shifting burdens to future generations also occur in the so-called ecological crisis.

1.4 The problem of fiscal illusion.

There is also a major problem against Ricardian equivalence, which is the problem of illusion. This was raised by Puviani (1903) and recalled by Buchanan (1960, 1967) and it is not unlike what behavioural economists did.

1.4.1 Buchanan and the fiscal illusion.

One of the main aspects of the theory of fiscal illusion is that it highlights the fact that citizens do not always make an accurate comparison between the expenses of public activity (taxes) and its benefits (public services). Specifically, there is no certainty of symmetry between cost and benefit assessments. We briefly examine the types of fiscal illusion mentioned by Puviani (1903).

To facilitate our work, we should utilize Buchanan's concise classification system (1967, pp. 126-43). The first group of illusions consists of situations in which the total amount of publicly available resources is concealed from taxpayers. This is the case of a government using revenues from the public domain (whose amount is typically ignored by taxpayers), tax shifting on consumption goods (often quite uncertain), public debt (for which Puviani, following Ricardo's hypothesis, observes that taxpayers prefer to pay taxes despite the equal present value), and inflation due to monetary expansion (a taxpayer cannot determine his or her share of public service costs). Lastly, this is an instance of a government making misleading promises, for example, declaring that a particular measure will be temporary, but is destined to endure over time. The second type of illusion consists of payment methods that link a taxpayer's responsibility to pay taxes to a beneficial period or event. In this instance, individuals' opinions are influenced by the specific circumstances in which they find themselves, for example, paying inheritance tax taxes on an unexpected bequest or donation. A third group includes taxes paid for specific, primarily nominal services given by public offices, such as fishing license fees, degree fees, and so forth. The final type of illusion, arguably the most relevant from the perspective of taxation because it is also the most frequent, consists of dividing the tax burden through a complicated system of many taxes and duties.

All of these categories refer to tax levying. Those pertaining to public expenditure are less complex and refer primarily to the less-than-exact facts provided by governments to stress the significance of public expenditures and so make an increase in public expenditures more acceptable. In Puviani's analysis (1903), it appears that public expenditure illusions can be categorized primarily as the illusion of lack of information, as the required information has not been distributed by the government or other responsible entities. As it has been discussed, there is no “irrational" behaviour among taxpayers who are just "victims" (Da Empoli, 2002) of a lack of information in any of the circumstances mentioned above.

Intuitively, the illusion seems not to require irrational behaviour. The individual who behaves irrationally makes inconsistent decisions; he does not conduct in a way that would allow an external observer to predict his behaviour, even if his utility function remained constant. By contrast, the individual who behaves in the presence of an illusion will act consistently; when presented with the same choice situation on two separate occasions, he will tend to make the same decision, provided that learning from experience does not dispel the illusion and his utility function may not change in the interim. It follows that the external observer can make predictions if he is aware of the consequences of illusion on decision-making behaviour (Buchanan J. M., 2014). Since illusion results from the individual's perception of the properties of the alternatives, while irrationality is a trait of the mind, it would not be exaggerated to argue that institutions of social choice can create (or reduce) illusions, and it is worthwhile to explore this aspect of such institutions in the context of ecological transition financing system. However, to Buchanan, fiscal illusion did not explain that the burden of debt could be shifted to the next generation.

There are numerous forms of information asymmetry within the theory of fiscal illusion. One of them is the asymmetry between citizens and politicians, that on the one hand, argue that citizens have a flawed understanding of fiscal facts, rendering them unable to appropriately appraise the consequences of public finance decisions. On the other hand, argue that politicians have a clear understanding of these facts, allowing them to take advantage of this disparity by convincing citizens to choose unsuitable options. How to deal with that? In the next section, we show the arguments provided by Behavioural Economics.

1.4.2 The economic psychology of public debt.

The question of why voters and politicians so seldom dispute the excessive rise in public debt despite the ensuing financial hardship is (partially) answered by economic psychology and the findings of behavioural economics (Döring & Oehmke, 2019). We start by summarizing the psychological factors that may lead political actors to lose control over public debt, and then we turn our attention to explaining why an individual in democratic countries continues to tolerate such political behaviour rather than penalising it.

First, habits might have a detrimental impact on present decision-making behaviour as a result of previous governments. This decision-making style is termed "methodism" by Dieter Dörner (1990). It arises when individuals build a mental system and assume it can solve all future difficulties. This is especially true if the approach has a lengthy track record of success. However, it may cause individuals to overestimate the effectiveness of their strategy. Following psychological studies (Wiswede, 2012), political actors have a propensity to overestimate the macroeconomic impacts of public debt. Politicians naively overestimate their locus of power, assuming that government borrowing can address economic issues. In addition, similar to the reasons driving the over-indebtedness of individual families, the rising government debt might be

understood as a collective inability to postpone the satisfaction of needs. In a behavioural study, this process is referred described as—melioration or procrastination and is considered to be the cause of time-inconsistent preferences.

Thus, politicians and taxpayers might quickly support future constraints on debt financing, but fail to fully foresee that their strategy may be damaged by unanticipated events. Richard Thaler and Cass Sunstein (2009) refer to such behaviour as dynamically inconsistent, describing it as a combination of temptation and thoughtlessness. This cognitive effect is exacerbated by the significant discounting of predicted long-term consequences of public debt. The remaining longevity of individuals plays a significant part in this behaviour. Thus, the shorter the remaining lifetime, the greater the inclination to value the present over the future, with the result that nations with a high average population age typically have a higher amount of public debt. If we look at the reduction of public debt, the history of debt policy is marked by continuous procrastination, which can be overcome only via the use of self-discipline measures (Ariely & Wertenbroch, 2002). However, we did not provide a thorough explanation for public debt since we focused solely on the behaviour of politicians.

Therefore, we now turn our attention to explaining why an individual in democratic countries continues to tolerate such political behaviour rather than penalising it. The number of publications on taxation psychology has expanded dramatically, but publications on the psychological consequences of public debt remain uncommon. This is even more puzzling considering the vast number of psychology research that examines private debt. Private debt behaviour is a subcategory of intertemporal decision-making that differs dramatically from rational behaviour, according to economic theory (Döring & Oehmke, 2019). According to the psychological reactance theory, individuals respond to punishing stimuli via avoidance behaviour. The stronger the punitive stimulus, the greater the financial burden associated with public financing instruments that are consciously recognised by the involved actors—noticeability. By expanding the theory, the constraint of financial resources might be considered a restriction of behavioural freedom. In the event of consciously perceived taxes, reactance can result in both legal and unlawful tax avoidance. The concept of—loss aversion, as explained in Daniel Kahneman and Amos Tversky's prospect theory (1979), amplifies the consequences of the punishing stimuli. According to them, losses were twice as impactful as gains of the same magnitude. As a result, the various public financing vehicles may be categorised according to their degree of visibility and the related capacity for reactivity. Both of these features are scored higher for direct taxes than indirect taxes. In the latter case, taxes are already included in the price, and the majority of taxpayers do not view taxes as a significant factor in everyday pricing.

It would probably be safe to argue that public debt is (one of) the most misperceived method through which governments manage their budgets. Typically, it does not provoke instant opposition from individuals. This does not imply that there is no public debt opposition. As suggested by Döring & Oehmke

(2019), **i**f the "psychological borders of public debt" are crossed, resistance against public debt, akin to opposition to taxes, might develop. According to the authors**,** these psychological boundaries are breached if the public perceives that the quantity of public debt poses a threat to the orderly continuation of society. In such circumstances, the private desire to acquire further government bonds diminishes dramatically. In the event of a persistent illusion, it should be considered that the general public is unaware of the economic consequences of governmental debt. Thus, indicating a lack of learning effect (Gandenberger, 1985).

More often than not, the tax burden is experienced directly by individuals in the form of a loss of their assets. Particular information is necessary to be well educated about the effects of public debt, such as details on the magnitude of future financial pressures. In addition, acquiring enough knowledge is expensive and requires lengthy investigation and analysis. Thus causing people to select ignorance over adequate information while having the cognitive capacity to acquire it. If this is true, the illusion can be treated as the outcome of people's rational ignorance (Döring & Oehmke, 2019, 5). For this hypothesis to be valid, people's attitudes regarding public debt must remain relatively constant across time.

In addition to low reactance and the absence of learning processes, the degree of tax compliance among citizens is a significant determinant of the level of public debt. Tax compliance is the overall attitude of taxpayers about the execution or not of their tax obligations. Cowell (1992) and Robben et al. (1990) found that tax compliance is positively related to perceived tax justice and a favourable opinion toward the overall taxation system. The degree to which citizens comply with tax laws varies considerably from country to country. Perceived fairness causes taxpayers to regard taxes as more legitimate and increases their state loyalty. "Psychological tax treaty" (Feld & Frey, 2007) is used in this context to define the nature of the connection between taxpayers and their government. A review of worldwide comparative research on Europe (Zimmermann, 2015) argues that tax compliance and the amount of confidence in the political system are historically linked to public debt behaviour. Thus, countries such as Switzerland, Germany, Austria, the United Kingdom, the Netherlands, and the Scandinavian nations have very modest fiscal policies. Countries such as Spain, France, Belgium, Italy, and Greece, on the other hand, are characterised by lower tax compliance and a greater predisposition toward excessive government borrowing. However, it would probably not be correct to claim that the first set of nations is immune to the debt illusion. They employ government borrowing to finance public expenditures but on a far smaller scale.

Not surprisingly, the EU green bond and Recovery plan funding systems go in the above-mentioned direction: collective debt rather than collective taxation. As opposed to public debt, taxation's drawbacks are realised immediately, while its benefits, such as increased government services, are ambiguous. This so-called mental accounting process has been emphasised by Richard Thaler (1985) concerning the consumer behaviour of private households. Nonetheless, mental accounting may also be applied to public debt behaviour, as the term only reflects the fundamental human inclination to approach

cognitive tasks in steps, even when doing so violates rationality. This illusion can be explained psychologically by the endowment effect (and the above-mentioned loss aversion). The endowment effect reflects the human tendency to assign subjectively higher worth to owned goods. This indicates that for public debt, present increases in assets (bondholders) and future financial liabilities associated with public debt are assessed asymmetrically. The endowment effect and loss aversion create a behavioural predisposition toward debt-based public funding (Döring & Oehmke, 2019).

Moreover, the illusion is attributed to perceptual errors resulting from cognitive constraints. Thus, individuals consistently misperceive both the cost associated with public debt and the benefit derived from debt-financed public services and thus tend to consistently underestimate the net fiscal burden associated with public debt. The disparity between the actual and perceived burden of public debt indicates an issue with perception (different to taxation where such a discrepancy does not exist). According to the Weber-Fechner law (Sinn, 2003), it is not fair to assume that the true (statistically measured) amount of public debt and the experienced (subjectively perceived) level of public debt, inclusive of future payments, coincide. In reality, they tend to be rather distinct from one another. If the real quantity of public debt is essentially ignored, a psychological illusion would occur. So, how do deal with that?

1.5 How to deal with that? Buchanan suggested constitutional rules.

The constitutional approach to debt, taxes and expenditures allows for a comparison of their costs and benefits before their implementation and, thus, before the consolidation process begins. Several public debates argued that a fiscal constitution would play an important role in terms of taxpayers' access to additional information and the reduction of fiscal illusions. This section is composed by three subsections. First, we summarize the similarities and synergies between VPE and Behavioural Economics, and then we draw a connection between VPE and L&E through the Constitutional lens. Last, we discuss how to use constitutional/legal rules to avoid fiscal illusion and how this can be used to deal with environmental debt.

1.5.1 The similarities and synergies between VPE and Behavioural Economics.

It would not be overstating things to suggest that there are similarities between the Virginia School of Political Economy and Behavioural Economics, although they are easy to overlook due to variations in terminology and technique. Most behavioural economists emphasise the psychological aspects of a decision, which they view as a combination of rational and irrational information processing systems (Kahneman, 2011). An essential aspect of Virginia's political economy is the subjective nature of choice, which refers to the highly individualised processes by which individuals comprehend their choice contexts and assess the alternatives available to them. Subjectivity is a result of each individual's psychological processes. A significant commonality between behavioural economics and public choice is their rejection of mainstream neoclassical research's super-rationality theories.

What is important in VPE's approach to debt is the subjective dimension of costs. Buchanan states within his definition of cost (1969, 43): [1] costs must be borne alone by the decision-maker; shifting or imposing costs on others is not possible; [2] cost is subjective; it exists solely in the mind of the decision maker; [3] cost is dependent on expectations; it is always a prospective or ex ante concept, [4] cost is never acknowledged due to the nature of choice: what is sacrificed cannot be enjoyed; [5] cost cannot be measured by anybody other than the decision-maker because subjective experience cannot be examined directly; [6] cost might be dated at the time of choosing or decision.

The same holds for behavioural economics. Congleton (2001) demonstrated that natural ignorance (the state of individual knowledge at birth) implies subjectivism due to humans having genetically transmitted data-collecting abilities associated with their sense organs and genetically transmitted information-processing systems by which they make sense of the data. Nevertheless, the majority of human processing systems are derived through direct observations, teachings from others, and each individual's efforts to make sense of an issue faced. As a result, humans are all somewhat distinct people while having

many similarities. It is the latter that enables the existence of social science. The fact that each individual must construct his or her mind, as highlighted by Buchanan (1978/1999), suggests that humans are self-constructed or, more precisely, self-programmed. Such disparities are evident in both life experiences and empirical and statistical studies, although such studies frequently seek "average" behaviour rather than exceptional behaviour.

The subjectivist approach is important to the public choice method, which, when combined with what Congleton has dubbed rule-bound choice (1999), has implications which are compatible with the majority of the experimental results published by behavioural economics. Indeed, these results are consistent with the subjectivist line of questioning at the Virginia school. Empirical research typically utilises government data sources, whereas behavioural economists develop their data through small-scale studies. Congleton (2019) asserts that the subjectivist approach of the VPE school is complementary to behavioural economics, even though its results were obtained by different techniques and for quite different goals.

1.5.2 The Virginia School of Political Economy and the connection with L&E

Buchanan not only traces the origins of public choice back to the Thomas Jefferson Center, cofounded in 1957 with Nutter at the University of Virginia (UVA) but also to property-rights economics and law and economics. The Thomas Jefferson Center for Studies in Political Economy produced relevant academic works (Boettke P. J., 2015). The 1960s not only was a particular high watermark for research with the publication of "The Calculus of Consent" by Buchanan and Tullock but also with the publication of "The Problem of Social Cost by Coase" in 1960 while at the University of Virginia. Nevertheless, the latter publication has been recognized as the founding paper of Law and Economics.

Even though exists various important methodological approaches among law and economics practitioners, there is a significant common ground: the pursuit of new legal insights through the application of economic concepts and theories (MacKaay, 2000). A large portion of law and economics is driven by the need of comparing various regulations. To this point, one major methodological challenge is the identification of criteria for conducting comparative analyses (Parisi, 2004). While law and economics mostly reveal insight in terms of the efficiency of alternative legal rules and the study of the effects of alternative rules on the distribution of wealth and income, VPE adopted a constitutional perspective that focuses on analyzing "the rules of the game" and how the modification of institutions could generate positive-sum forms of interaction (Boettke & Candela, 2020). Below we connect VPE to L&E.

Given the sophisticated mathematical tools of economic analysis, judges and policymakers lack the knowledge and procedures to evaluate the effectiveness of alternative legal systems in many instances. Rather than just seeking to analyze the costs and advantages of specific laws, such an examination requires

them to first investigate the incentives underpinning the legal or social structure that established the legal rule. In this way, the VPE approach extends the domain of L&E by including the study of the influence of market and non-market institutions on legal regimes, as well as the study of the comparative advantages of alternative sources of centralized or decentralized law making in supplying efficient rulemaking (Parisi, 2004). Nevertheless, both constitute complemental facets by focusing on the legal and political restrictions under which economic and political agents operate (Van den Hauwe, 1999).

Constitutional economics is intended to offer normative guidance in constitutional matters and provide a normative framework for comparative institutional research. Of course, some differences exist among them. While law and economics attempt to explain the choices of economic agents, their interactions with each other, and the outcomes of these interactions within the existing legal institutional-constitutional structure of the polity, constitutional economic analysis try to describe the working properties of alternative sets of legal-institutional-constitutional rules that constrain the choices and activities of economic and political agents. The emphasis is on the norms that establish the framework within which the ordinary decisions of economic and political actors are made.

Consequently, the latter involves a "higher" level of analysis by investigating the choice of constraints rather than the choice within constraints (Van den Hauwe, 1999). Moreover, the connection between VPE and L&E is even clear for some authors (Boettke & Candela, 2020). To Candela[6], Coase and the Virginia School understood the conditions of Pareto optimality to be the result of individuals devising institutional arrangements not only to reduce transaction costs but also to exhaust the gains from trade, whereas their contemporaries of the post-WWII Chicago School assumed that Pareto-optimality characterizes actual market outcomes. This implies the discussion is not about what some levy needs to be to internalize the market failure, but rather what set of institutions will encourage such internalization. If climate crises would be treated as market failure, the discussion of optimal tariffs, and Pigouvian taxes might be misguided. In a world of subjectivity, Pareto relevance is important in a discussion on market failure, but policy relevance might be the crux (Dahlman, 1979).

Buchanan warned that any theory that considers the state and individuals in society as a single organic entity would mislead the observer by promoting the exchange model of politics involved in tax and spending decisions in a democratic polity. Individualist theory views the state as the sum of the individual members of a given society acting in their collective capacity. Not surprisingly, Buchanan regularly made fun of his class with the following question: it is said that a fly that grew nine times its size could no longer fly; what does that say about fiscal dimensionality? What would be the consequences of a government growing ninefold in size? It is a matter of scale. All the considerations mentioned above raise questions: in

[6] ECONLOG POST, R. Candela: https://www.econlib.org/ronald-h-coase-chicago-school-or-virginia-school-economist/

a world in which public debts are already large, how do analyse and control the ecological transition? Are constitutional rules needed? If so, what they can do to avoid fiscal illusion and how this can be used to deal with the environmental debt?

1.5.3 How to use constitutional/legal rules to avoid fiscal illusion and how this can be used to deal with the environmental debt.

In this last subsection, after recalling a distinction between a protective state and a productive state, we define constitutional and post-constitutional rules. We then address how to use the constitution to avoid fiscal illusion. Lastly, we use these arguments to deal with the environmental debt.

Buchanan separates government functions into a protective state that safeguards citizens' rights and a productive state that provides communal goods that individuals cannot produce independently or via market processes. The title of his book, "The Limits of Liberty: Between Anarchy and Leviathan", effectively encapsulates the central dilemma of his constitutional quest (Buchanan J. M., 1975). To some authors (Holcombe, 2020), Buchanan felt that a protective state is required to safeguard liberty, but feared that a government powerful enough to defend individual rights may use its authority to violate those principles. In other words, constitutional standards allow the government to defend rights and generate communal goods for the benefit of its citizens while preventing it from acting against the interests of the individuals it ruled. At this point, we recall the distinction between the constitutional stage, in which policymakers determine the rules of the game, and the post-constitutional, or implementation stage, in which policymakers act under the rules of the game. As will be elaborated upon below, interests may vary depending on the stage the argument is currently in.

There may exist vested interests in rules, especially when those rules are more complex. Not only does the same reasoning apply to these regulations, but also the underlying statistics and evaluation techniques. The more complicated the data and evaluation processes, the more the relevant parties will attempt to exploit this complexity for their benefit (Schuknecht, 2004). Politicians may embrace complexity when it allows for interpretation and discretion and makes strict execution more difficult. Commonly shared in the public economics literature, the assumption of government as a welfare-maximizing almost by definition results in "optimal rules" that conflict with very simple ones. This may hold also for the various institutions that have decided to control greenhouse gas emission reduction. The EU Commission could have more influence on the process and get larger budgetary allocations through the use of complex rules as opposed to financial markets and the public concerns that, due to transaction/monitoring costs, have an interest in very simple and clear regulations.

Individuals should be effectively educated on the long-term economic consequences of public debt

to have a better understanding of the present and future effects. This obligation ought to be obligatory and possibly incorporated as a constitutional principle. This information might be given consistently and clearly. The issue must be portrayed negatively by emphasizing the scale of government debt-related losses. For example, it may be more beneficial to display the level of public debt per capita on people's annual tax bills, as politicians may be obligated to inform voters about the amount of debt required to finance a certain public service if they utilize it. This might result in a reduction of fiscal illusion. Voters possibly would understand the inter-temporal budget constraint because they would have low information costs. If this would be the case, politicians would not be able to raise spending more than taxes. This could lead to symmetric (or at least partially less asymmetric) information.

Political institutions such as political and tax systems, voting rules, and budget regulations can minimize (or exacerbate) the deficit, the illusion bias, and the time inconsistency issue mentioned above. From a normative standpoint, budgetary principles are welcome to restrict governmental behaviour. Assumptions regarding the long-term viability of policy can be anchored by fiscal regulations, mitigating deficit bias and time inconsistency. There is widespread agreement (Schuknecht, 2004) that Europe needs stricter budgetary laws. Political markets may fail due to high transaction costs and a lack of time consistency, but constitutional rules could help. So, an obvious question follows: what form of rules can be implemented and enforced? Ex-post compliance and performance monitoring may be the first step. The second step may be a way to punish unsuitable compliance and performance. Therefore, rule complexity and enforceability may be crucial, but it would not be an error to examine the dependency and possible conflict between these two criteria. On the one hand, fiscal rules should be economically feasible; if not, they will lose the support of the public and policymakers, and hence their enforceability. On the other hand, rules must also be clear and straightforward; otherwise, the public's monitoring costs will be too high, and policymakers' discretion and disagreement will undermine their enforceability and legitimacy. This possible trade-off depends on several economic factors and the legal-institutional environment in which rules are embedded. These difficulties and their repercussions are examined below.

Identifying incentives for enforcement is not easy. Nevertheless, post-constitutional politicians are interested in a "soft" implementation of the rules, where the concept of “soft law” describes non-binding agreements, principles, and declarations (Abbott & Snidal, 2000). At the constitutional stage, politicians may desire norms that ensure good public finances and generally efficient governments, but they may prefer that these constraints bind the subsequent government rather than the current one (Schuknecht, 2004). They will not enhance budgetary regulations until they obtain significant signals from the public and financial markets. In other words, constitutional thinking may emerge and greater enforcement provisions may be required only if there is a sense of urgency. Likewise, this may be the case with the ecological transition, where picking the right moment to introduce rule changes could be a challenge.

In this direction, Article 9 of the Italian Constitution was recently amended to read as follows: "The Republic promotes the development of culture and scientific/technical research, protects environment, biodiversity and ecosystems, also in the interest of future generations; the laws of the State will regulate the forms of animals protection". This amendment was approved by the Italian Parliament on February 8th, 2022. Article 9 of the original Constitution was rewritten in this way, expanding protections for landscape more broadly. Furthermore, the essential Article 41 was revised to reflect that: "Private economic initiative is free. It cannot take place in conflict with social utility or when damaging safety, freedom, human dignity, health and the environment. The law provides appropriate programs and controls so that public and private economic activities can be directed and coordinated for social and environmental purposes". This Constitutional amendment clarifies the conditions for the applicability of environmental crimes removing the ambiguous formulation of the punishment for environmental damage caused "abusively," thus suggesting that there may also be non-abusive environmental crimes (Piscitelli, 2022).

The respect for solidarity principle between generations and future generations seems not to be fully undertaken by the Court of the European Justice. The comparative analysis of the latter court with the Italian Constitutional Court (De Caria, 2021) draws our attention to his conclusion[7] (2021, 131) "[…] even if the Italian Constitutional Court did not give precedence to the interests of future generations (see the following cases 70/2015, 178/2015 and 275/2016[8]), it has nonetheless demonstrated a willingness to assume responsibility for them and to base its decisions on the need to protect future generations, thereby fulfilling the principle of intergenerational solidarity". The same cannot be said about the Court of Justice of the European Union. Then, we propose the expansion of the idea of intergenerational solidarity at the European level to include constitutional protections against public debt. It would not be inappropriate to leave on to future generations, not only a healthy environment but also robust and stable public finances.

[7] Translated by the author.
[8] Respectively, C. Cost., 20 April 2015 n. 70; 23 July 2015, n. 178; and 16 December 2016, n. 276.

1.6 Discussion, and concluding comments.

By using the above-mentioned sections, one might make certain conclusions. First, individuals should be adequately informed about the long-term economic implications of public debt to have a better comprehension of the present and future consequences. This requirement should be mandatory and perhaps added as a constitutional principle. This information should be presented regularly and be understandable. The issue must be framed negatively by emphasising the magnitude of losses connected with governmental debt. For instance, it may be more effective to display the level of public debt per capita on people's annual tax bills since politicians might be compelled to tell voters about the amount of debt used to support a particular public service if they utilise it. The situation may be more complicated when the ecological transition progresses are taken into account. Indicators for a sustainable fiscal strategy might be devised to illustrate the anticipated costs of public debt to present and future generations. Thus, the indicators should be shared frequently so that the public may acquire and provide sufficient feedback to stimulate the learning processes.

In the context of public debt, further measures should address melioration and procrastination from an economic psychology perspective. To assist politicians (and voters) avoid the attraction of public debt and overcoming their lack of self-control when it comes to debt financing, the political decision-making architecture should be altered through the use of a constitutional constraint. By using Buchanan's Constitutional project, an example of a rather strong constraint is a constitutionally guaranteed balanced-budget norm that fosters positive fiscal policy decision-making. This institutional system aids political actors in overcoming the cognitive loss of control. In addition, compliance with debt constraints requires consolidation of the budget. According to research in economic psychology, expenditure cuts and tax hikes are functionally identical weapons for budget consolidation that differ in terms of the levels of reactance and loss aversion they elicit (Schmölders, 1970). According to prospect theory, individuals perceive forgoing a benefit (reducing public costs) as less painful than losing their assets (tax increase). Certainly, the taxpayers' support of budget cuts is also contingent on the amount of their visibility and their participation. To have a balanced budget, however, it is preferable to reduce government spending rather than raise taxes. To achieve the ecological transition, tax increases should be favoured above (or combined with) increases in public debt. Especially given the absence of an EU fiscal constitution and the accountability of EU political parties. So, what is the next step?

The climatic challenges are constantly emphasised, but the consequences of a carbon dioxide reduction programme are equally serious. As stated by Lomborg (2020), a climate strategy should not eradicate almost all carbon dioxide emissions within a few short years to prevent costs from escalating uncontrollably. All nations, but especially those that are highly exposed, will need to make investments in

climate adaptation, such as strengthening physical infrastructure and buildings to withstand natural disasters, constructing dams and other barriers to protect against storm surges, adapting farms and the food supply, and so on. Unfortunately, many nations will find it expensive to adapt to the effects of climate change. Green finance plays a crucial role in providing support for such adaptation, and this topic is examined in the second chapter. Specifically, we will explore the economics of green bonds and focus on the central question of whether there is uniformity in their issuance among European countries and the UK. Our aim is to test for convergence patterns and identify potential clustering clubs across nations. This will shed light on the different stages of development that such clubs are going through in the green bond market.

References

Abbott, K. W., & Snidal, D. (2000). Hard and soft law in international governance. *International organization, 54(3)*, 421-456.

Agarwal, K. &. (2020). Fiscal Deficit and GDP in Reference to Ricardian Theory: An Evidence from India. *Pramana Research Journal.*

Ariely, D., & Wertenbroch, K. (2002). Procrastination, deadlines, and performance. *Psychological Science, Vol. 13, No. 13*, 219-224.

Barrett, S. (1994). Self-enforcing international environmental agreements . *Oxford economic papers*, 878-894.

Barro, R. J. (1974). Are government bonds net wealth? *Journal of political economy 82(6)*, 1095-1117.

Bernheim, B. D. (1987). Ricardian equivalence: An evaluation of theory and evidence. *NBER macroeconomics annual*, 2, 263-304.

Beyene, S. D. (2020). Testing the Ricardian equivalence hypothesis in the case of Ethiopia: An autoregressive-distributed lag approach . *Hungarian Statistical Review*, 3(2), 26-49.

Boettke, P. J. (2015). The past, present and future of Virginia political economy. *Public Choice, 163(1)*, 53-65.

Boettke, P. J., & Candela, R. A. (2020). Where Chicago meets London: James M. Buchanan, Virginia political economy, and cost theory. *Public Choice, 183(3)*, 287-302.

Boór, M. (2021). Ricardians in the European Union: The Role of Fiscal Rules. *Finance a Uver: Czech Journal of Economics & Finance*, 71(3).

Branger, F., & Quirion, P. (2014). Climate policy and the 'carbon haven'effect. *Wiley Interdisciplinary Reviews: Climate Change*, 5(1), 53-71.

Brennan, G., & Buchanan, J. M. (1980). The logic of the Ricardian equivalence theorem. *FinanzArchiv/Public Finance Analysis*, (H. 1), 4-16.

Brennan, G., & Buchanan, J. M. (1985). The reason of rules: Constitutional political economy. *Cambridge: Cambridge University Press.*

Buchanan, J. M. (1949). The pure theory of government finance: A suggested approach. *Journal of Political Economy, 57(6)*, 496–505.

Buchanan, J. M. (1958). Public principles of public debt: a defense and restatement. Vol. 2. In J. M. Buchanan, *The Collected Works of James M. Buchanan.* Indianapolis: Liberty Fund, 1999.

Buchanan, J. M. (1960). *Fiscal theory and political economy.* Chapel Hill: University of North Carolina Press.

Buchanan, J. M. (1962a). Politics, policy, and the Pigouvian margins. *Economica, 29(113)*, 17–28.

Buchanan, J. M. (1962b). The relevance of Pareto optimality. *Journal of Conflict Resolution, 6*, 341–354.

Buchanan, J. M. (1964). What should economists do? *Southern Economic Journal*, 213-222.

Buchanan, J. M. (1967). *Public finance in democratic process.* Chapel Hill: University of North Carolina Press.

Buchanan, J. M. (1969). *Cost and choice.* Chicago: Markham.

Buchanan, J. M. (1975). The limits of liberty: Between anarchy and leviathan. *Chicago: University of Chicago.*

Buchanan, J. M. (1976). Barro on the Ricardian equivalence theorem. *Journal of political economy 84(2)*, 337-342.

Buchanan, J. M. (1978). *Cost and choice: An inquiry in economic theory.* University of Chicago Press.

Buchanan, J. M. (1978/1999). Natural and artifactual man. In *The collected works of James M. Buchanan, Vol 1 The logical foundations of constitutional liberty* . Indianapolis, IN: Liberty Fund.

Buchanan, J. M. (2014). *Public finance in democratic process: Fiscal institutions and individual choice.* UNC Press Books.

Buchanan, J. M., & Tullock, G. (1962). *The calculus of consent: Logical foundations of constitutional democracy.* Ann Arbor: University of Michigan press.

Buchanan, J. M., & Wagner, R. E. (1977). *Democracy in deficit: The political legacy of Lord Keynes.* New York: Academic Press, Volume 8.

Buiter, W. H., & Tobin, J. (1978). Fiscal and monetary policies, capital formation, and economic activity.

Caner, M. Grennes, T. J., & Köhler-Geib, F. F. N (2010). Finding the tipping point-when sovereign debt turns bad. *Available at SSRN 1612407*.

Congleton, R. D. (1999). Buchanan and the Virginia School. In H. K. Geoffrey Brennan, *Method and Morals in Constitutional Economics* (pp. 23-38). Berlin, Heidelberg: Springer.

Congleton, R. D. (2001). Rational ignorance, rational voter expectations, and public policy: A discrete informational foundation for fiscal illusion. *Public Choice*, 107(1), 35-64.

Congleton, R. D. (2019). Behavioral economics and the Virginia school of political economy: Overlaps and complementarities. *Public Choice*, 1-18.

Congleton, R. D. (2019). Toward a rule-based model of human choice: On the nature of homo constitutionalus. In R. E. Wagner, *James M. Buchanan: A theorist of political economy and social philosophy.* New York: Palgrave Macmillan.

Cowell, F. A. (1992). Tax evasion and inequity. *Journal of economic Psychology*, 13(4), 521-543.

Da Empoli, D. (2002). The theory of fiscal illusion in a constitutional perspective. *Public Finance Review, 30(5)*, 377-384.

Dahlman, C. J. (1979). The problem of externality. *The journal of law and economics, 22(1)*, 141-162.

De Caria, R. (2021, 06 28). Il principio della solidarietà tra generazioni tra mutualizzazione dei debiti e divieto di finanziamento monetario. *Rivista Associazione Italiana dei Costituzionalisti N°(3)*, pp. 120-140.

Döring, T. (2015). *Zur Psychologie der budgetwirksamen Staatstätigkeit.* Springer-Verlag.

Döring, T., & Oehmke, R. D. (2019). About the Economic Psychology of Public Debt. *Intereconomics*, 54(5), 297-303.

Dörner, D. (1990). The logic of failure. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*, 327(1241), 463-473.

Eusepi, G. (2020). From subjectivism to constitutionalism: the intellectual journey of James M. Buchanan through his Italian heroes. *Public Choice, 183(3)*, 273-285.

Eusepi, G., & Wagner, R. E. (2018). De Viti de Marco vs. Ricardo on public debt: self-extinction or default?. In Debt default and democracy. *Edward Elgar Publishing.*

Feld, L. P., & Frey, B. S. (2007). Tax compliance as the result of a psychological tax contract: The role of incentives and responsive regulation. *Law & Policy*, 29(1), 102-120.

Feldstein, M. (1976). Perceived wealth in bonds and social security: A comment. *Journal of Political Economy*, 84(2), 331-336.

Gandenberger, O. (1985). On government borrowing and false political feedback. *Volkswirtschaftl. Fak. d. Ludwig-Maximilians-Univ.*

Goetz, C. J. (1991). Uncommon common-sense vs. conventional wisdom: the Virginia school of economics. *Center for Studies of Public Choice.*

Gwartney, J. D., & Holcombe, R. G. (2014). Politics as exchange: The classical liberal economics and politics of James M. Buchanan. *Constitutional Political Economy, 25(3)*, 265–279.

Hameed, M. R. (2020). Does the Ricardian Equivalence Proposition Hold in SAARC Countries? *Pakistan Journal of Social Sciences (PJSS)*, 40(4).

Holcombe, R. G. (2020). James M. Buchanan's constitutional project: past and future. *Public Choice, 183(3)*, 371-387.

Howard, P. H., & Sterner, T. (2017). Few and not so far between: a meta-analysis of climate damage estimates. *Environmental and Resource Economics*, 68(1), 197-225.

İkiz, A. S. (2020). Testing the Ricardian equivalence theorem: Time series evidence from Turkey. *Economies*, 8(3), 69.

Kahneman, D. (2011). *Thinking Fast and Slow*. New York: Macmillan.

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decisions Under Risk. 263-291.

Keynes, J. M. (1936). *The General Theory of Employment, Interest, and Money*. London : MacMillan.

Khalid, A. M. (1996). Ricardian equivalence: empirical evidence from developing economies. *Journal of Development Economics*, 51(2), 413-432.

Kurz, H. D. (2016). David Ricardo (1772–1823). In *Handbook on the History of Economic Analysis Volume I*. Edward Elgar Publishing.

Levy, D. M., & Peart, S. J. (2019). *TOWARDS AN ECONOMICS OF NATURAL EQUALS: A Documentary History of the Early Virginia School*. Cambridge University Press.

Liu, Y., & Feng, H. (2015). Tax structure and corruption: cross-country evidence. *Public Choice 162(1-2)*, 57-78.

Lomborg, B. (2020). *False Alarm: How climate change panic costs us trillions, hurts the poor, and fails to fix the planet*. Hachette UK.

MacKaay, E. (2000). History of Law and Economics. In *Encyclopedia of Law and Economics, vol. 1* (pp. Encyclopedia of Law and Economics, vol. 1,). Cheltenham, UK: Edward Elgar Publishing.

Marinheiro, C. F. (2001). Ricardian equivalence: an empirical application to the Portuguese economy. *Catholic University of Leuven, CES Discussion Paper Series* , (01.12).

Nickel, C. &. (2008). Fiscal policies, the current account and Ricardian equivalence. *ECB Working Paper Series*, NO 935.

O'Driscoll Jr, G. P. (1977). The Ricardian nonequivalence theorem. *Journal of Political Economy 85(1)*, 207-210.

Olson M., &. C. (1971). Dissent in economics: The convergence of extremes. *Social Research*, 751-776.

Parisi, F. (2004). Positive, normative and functional schools in law and economics. *European journal of law and economics, 18(3)*, 259-272.

Pearce, D. W. (2004). Does European Union Environmental Policy Pass a Cost-Benefit Test? *World Economics*, 5(3), 115-137.

Piscitelli, P. e. (2022). Italian Constitution amended to include environmental and health protection: A model for Europe. *The Lancet Regional Health–Europe, Vol 16*.

Puviani, A. (1903). *Teoria della illusione finanziaria*. Palermo: Sandron.

Ricardo, D. (1817). *On the principles of political economy*. London: J. Murray.

Ricardo, D. (1820). Funding system. In P. Sraffa, *The Works and Correspondence of David Ricardo (1951)*. Cambridge: Cambridge University Press.

Ricciuti, R. (2003). Assessing ricardian equivalence. *Journal of Economic Surveys*, 17(1), 55-78.

Robben, H. S. (1990). Decision frames, opportunity and tax evasion: An experimental approach. *Journal of*

Economic Behavior & Organization, 14(3), 353-361.

Salsman, R. M. (2017). *The political economy of public debt: three centuries of theory and evidence* . Edward Elgar Publishing.

Sardoni, C. (2021). The public debt and the Ricardian equivalence: Some critical remarks. *Structural Change and Economic Dynamics*, 58, 153-160.

Schmidt, R. C. (2021). Are there similarities between the Corona and the climate crisis? *Journal of environmental studies and sciences, 11(2)*, 159-163.

Schmölders, G. (1970). *Finanz- und Steuerpsychologie.* Hamburg.

Schuknecht, L. (2004). EU fiscal rules: issues and lessons from political economy. Available at SSRN 631661.

Seater, J. J. (1993). Ricardian equivalence. *Journal of economic literature*, 31(1), 142-190.

Sinn, H. W. (2003). Weber's Law and the Biological Evolution of Risk Preferences: The Selective Dominance of the Logarithmic Utility Function, 2002 Geneva Risk Lecture. *The Geneva Papers on Risk and Insurance Theory*, 28(2), 87-100.

Thaler, R. (1985). Mental accounting and consumer choice. *Marketing science*, 4(3), 199-214.

Thaler, R., & Sunstein, C. (2009). *Nudge: How to Initiate Smart Decisions.* Ullstein eBooks.

Tol, R. S. (2012). A cost–benefit analysis of the EU 20/20/2020 package. *Energy Policy*, 49(C), 288-295.

Tol, R. S. (2021). Europe's Climate Target for 2050: An Assessment. *Intereconomics*, 56(6), 330-335.

Toso, S. (1992). The Italian School of public Finance at the turn of the twentieth Century and the Ricardian Equivalence Theorem. *History of Political Economy*, 24(4), 819-841.

Van den Hauwe, L. (1999). Public Choice, Constitutional Political Economy and Law and Economics. In B. B. Geest, *NCYCLOPEDIA OF LAW AND ECONOMICS* (pp. Vol. 1, p. 603). Edward Elgar Publishing.

Wicksell, K. (1986). Finanztheorie Untersuchungen. *Jena: Gustav Fischer.*

Wiswede, G. (2012). *Einführung in die Wirtschaftspsychologie.* München: Reinhardt.

Zimmermann, H. (2015). The deep roots of the government debt crisis. *Journal of Financial Perspectives, 3(1).*

Chapter 2 - Green Debt: Do European countries' green bond issuances converge?

Abstract

Green bonds have emerged as a powerful financial instrument in fostering sustainable development and addressing environmental challenges. Did European countries' green bond issuances converge? The primary goal of this chapter is to investigate whether any convergence occurred among European countries and the U.K. in the euro amount of green bonds issued during 2012-2022. To this aim, a convergence log-t test has been performed on a panel of 24 European countries and the U.K. Results do not support the existence of a common path, but rather the presence of four separate clubs of countries suggesting the absence of a common strategy. Additionally, we provide an in-depth analysis of the economic, environmental, and institutional factors that may influence convergence in the green bond market among countries. From this analysis, we offer insights into the related policy implications. Our findings suggest that a 'one size fits all' approach, as seen in the EU Green Bond Standard, may actually intensify market fragmentation.

JEL Classification: K20, K32, G20

Keywords: Climate Finance, Ecological Footprint, Green Bonds, Financial Markets, Club Convergence

2.1 Introduction

The actions of humans are continuously releasing greenhouse gases into Earth's atmosphere, causing an ongoing and progressive transformation of its climate, alongside naturally occurring gases. According to the latest IPCC Press Release (2023) it states: "There are multiple feasible and effective options to reduce greenhouse gas emissions and adapt to human-caused climate change, and they are available now […]". The need to change the modes of production and consumption, along with the imperative of ecological transition, is widely acknowledged and longstanding (Adger, 2010; Nordhaus, 2013).

However, effectively addressing the challenges posed by the shift towards safer and more sustainable production requires substantial financial investments (Tol, 2018, 2021; Nordhaus, 2019). It is commonly recognized that neither states nor enterprises possess the necessary capital to invest in the innovative technologies required for this transition (Petrov et al., 2023). Consequently, the field of green finance has emerged, facilitating the allocation of investments towards sustainable and environmentally-friendly projects aimed at transitioning to a low-carbon, climate-resilient economy (Falcone, 2020).

The presence of a cohesive approach in green financing among European nations has the potential to lead to harmonized standards, frameworks, and guidelines. These can facilitate cross-border investments, improve market efficiency, and enhance transparency and comparability when evaluating green projects and their environmental impacts (Hafner et al., 2020). However, the absence of such a cohesive approach at the EU level, especially concerning the advancement of green financing initiatives at the subnational level due to political factors (Gómez & Basterra, 2021) highlights the importance of focusing on economic, environmental, and institutional roles in promoting green finance, specifically green bonds.

This chapter explores the economic, environmental, and institutional dimensions of fostering green finance, with a particular emphasis on green bonds. The arguments are developed as follows. First, we introduce readers to the institutional and legal framework of green bonds, also known as Climate bonds. These are fixed-income securities exclusively used to finance or refinance environmentally friendly 'green' projects, assets, or business activities (OECD, 2015). In 2007, the European Investment Bank issued the first green bond, known as the 'Climate Awareness Bond,' to fund renewable and energy-efficient projects.

Next, we delve into the scale of green bond issuance among EU countries and the U.K.

from 2007 to 2022. Since then, the green bond market has experienced three stages of development: creation, structuring, and expansion (Bussani, 2023). As a result, there has been a growing interest in the use and impact of green bonds among academics, policymakers, and investors alike (Debrah et al., 2023). The growing literature reflects this interest, exploring a wide range of topics such as the challenges of regulating the green bond markets (Weber & Saravade, 2019; Chen & Zhao, 2021; Chan, 2021), the legal and policy issues (Park, 2018; Freeburn & Ramsay, 2020), the effectiveness of this financial tool in mitigating climate change (Flammer, 2020; Mok et al., 2020), the impact of green bonds on issuer performance (Cox et al., 2004; Kim et al., 2014; Saeidi et al., 2015) and on investor behaviour (Agliardi, 2019; Chung et al., 2019).

Then we conduct an empirical analysis to cover significant gaps in the green bond's literature. Existing studies have provided valuable insights into the evolution of the need for green bonds, focusing on several significant factors (Bhutta et al., 2022). Firstly, the role of information quality in the development of green bonds has been extensively discussed. According to Martin and Moser's (2016) findings, investors respond positively to investment opportunities when managers provide detailed information about the intended use of funds, especially for long-term environmentally friendly projects. This provides investors with confidence in the sustainable use of their funds. According to Biddle et al. (2009), building stakeholder trust is crucial, and one effective approach is to offer high-quality information.

Secondly, regulatory support for financing sustainable projects is necessary. Drawing on previous research into the drivers of capital market growth, Chinn and Ito (2006) identify key factors for the development of green bonds. Their study proposes measures to minimize the impact of legal barriers to sustainable projects. In their (2012) paper, Mathew and Kidney recommend the use of development banks and green financing to provide capital for sustainable projects. Tolliver et al. (2019) highlight a challenge with using green bond funds for ongoing projects rather than new investments in green initiatives. Hafner et al. (2020) identify several factors that impede the development of green investments, including unclear policies, high costs of green financing, and misinformation. Moreover, in Tolliver et al.'s (2020) paper, a study exploring the drivers of green and brown (conventional) bonds suggest that macroeconomic factors, rather than institutional factors, play a more significant role in green bond emissions. However, significant gaps persist in our understanding regarding whether an observable pattern of convergence in the issuance of green bonds emerges, in identifying potential clusters among European countries and the United Kingdom, and in analyzing the potential role that economic, environmental and

institutional factors play in promoting (or not) the adoption of this financial instrument. Clustering refers to the identification of groups within a dataset, based on similarities or patterns among the data points. In this study, clustering is used to determine if any specific convergence patterns emerge among European nations, helping to identify potential groups of countries that share similar behaviour in terms of the amount of green bond issues in both the private and public fields. The presence of leadership at the national level (Doh & Guay, 2006), along with shared structural and cultural characteristics, suggests that debt issuers in the green bond market may exhibit comparable behaviour, which can be detected by forming clubs (Krahnen, et al., 2023). Thus, the emergence of these clubs could provide insights into the different stages of development that the clubs are experiencing in the green bond market. To this end, we use a convergence log-t test on a panel of 24 European countries and the U.K. from 2012 to 2022. Results do not support the existence of a common path, but rather the existence of four separate groups of countries converging on their path.

To further explore the potential influences on club memberships, we conducted additional tests using ordered probit and logit models to investigate whether green bond market convergence across countries is affected by economic, environmental, and institutional variables. Finally, we discuss the main policy implication derived from the analysis, providing arguments that do not support the 'one size fits all' approach.

The novelty of this chapter lies in the fact that it represents the first known instance in which this particular type of analysis has been conducted. Our study reveals the presence of clubs of countries at different stages of green market development, shedding light on the complex relationships between institutional, economic, and environmental factors in fostering green finance. The existence of a common path of green bond issuance across European countries can pave the way for unified norms, systems, and principles that support transnational investments, boost market functionality, and offer clearer assessment criteria for green initiatives and their ecological repercussions. Furthermore, such unification can promote a more robust and fluid green bond marketplace, drawing in more participants and financial investors. As a result, it would elevate the global standing of European organizations and exchanges, bolstering the shift towards a carbon-conscious economy.

The rest of the chapter is organized as follows: Section 2.2 analyzes green bond instruments' institutional and legal framework. Section 2.3 presents the data pertaining to the green bond market in the EU and the U.K. Section 2.4 presents the primary findings, examines structural

breaks, and investigates the likelihood of belonging to the convergence clubs through an ordered logit and probit regression. Finally, Section 2.5 concludes and highlights its policy implications.

2.2 Institutional and Legal framework

The market for sustainable debt instruments refers to the financial markets where debt instruments are issued and traded. These instruments are explicitly labelled as sustainable, or labelled in a way that refers to sustainable development, for environmental and social purposes (Schmittmann & Chua, 2021; G20 Sustainable Finance Working Group, 2021; Climate Bonds Initiative 2021). Green bonds represent a significant portion of the sustainable debt market, as they are designed to finance environmentally low-impact projects. Since the creation and adoption of international green bond standards, the green market has grown on a global scale.

At the international level, green bonds are regulated by the Green Bond Principles (GBP) of the International Capital Market Association (ICMA), the Climate Bonds Standard (CBS) of the Climate Bonds Initiative (CBI) and the ASEAN Green Bond Standard (GBS) of the ASEAN Capital Markets Forum (ACMF). According to the ICMA definition (2022, p.3) green bonds are "any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible green projects and which are aligned with the four core components of the GBP". A similar definition is provided in the CBS, clause D1.1 (2019) and ASEAN art. 1.2 (2018) explanation[9]. The green bond definition can be divided into two essential parts: the first part specifies the qualification of the debt instrument as a bond instrument, while the second part focuses on its eligibility as green.

The term 'bond' is widely employed within the financial realm but lacks a precise technical-legal definition (Bamford, 2011). Essentially, a bond represents a loan made by an investor to an entity in exchange for a promise to repay the borrowed capital along with interest at regular intervals. They are typically issued by governments, corporations, and other organizations as a means to finance their operations or projects. The unique characteristic of bond instruments is their fixed-income nature, which means that the interest payments are determined in advance and are typically

[9] Art. 1.2 clarifies that "the ASEAN GBS are aligned with the GBP. Any guidance issued by ICMA on the GBP should also be considered, where relevant".

paid at regular intervals, according to the contract terms (Collin, 2015). Therefore, it is a security representative of a long-term debt financing operation, traded through the public offering mechanism on financial markets.

The designation of a bond as 'green' is a formal identification element directly attributed by the issuer, indicating the specific environmental objectives that the instrument aims to achieve (OECD, 2015; Park, 2018)[10]. To qualify as green, a bond must be broken down into four core constituents. These constituents include the process of allocating proceeds, the eligible green projects, the four core components of the GBP, and the green bond framework.

Firstly, the earmarking process is the distinctive feature of use-of-proceeds bonds, where proceeds are allocated to finance or refinance sustainable projects. It is a process established by the issuer, and its legal effectiveness varies depending on the jurisdiction and contractual scheme adopted (Bussani, 2023). The GBP (2022) specifies that the raised capital must be entirely dedicated to sustainable projects, which can be either new or existing and may be financed or refinanced.

Secondly, only eligible green projects can be financed through green bonds. The GBP (2022) does not provide a precise definition of what is meant exactly by this denomination[11]. The same level of ambiguity applies to varying extents to the ASEAN standards and the political agreement reached on the EU Green Bond Standard[12] (EU GBS) on February 2023. The GBP (2022, p. 4) defines that these projects must be green, meaning that they should "provide clear environmental benefits [...] by explicitly recognise several broad categories of eligibility for green projects, which contribute to environmental objectives such as climate change mitigation, climate change adaptation, natural resource conservation, biodiversity conservation, and pollution prevention and control". These five objectives represent the main form of classification of green projects adopted by ICMA.

Thirdly, the four core components are essential elements of the green bonds definition, and are composed of (a) Use of proceeds; (b) Process for project evaluation and selection; (c)

---

[10] OECD 2015, p. 2 "A green bond is differentiated from a regular bond by this label"; Park 2018., p. 12 "A standard green bond is distinguished from a standard bond by being labelled as green by the issuer".

[11] Green Bond Principles 2022, p. 5: "[…] the GBP's purpose is not to take a position on which green technologies, standards, claims and declarations are optimal for environmentally sustainable benefits", **because** p.1 "[…] principles are a collection of voluntary frameworks with the stated mission and vision of promoting the role that global debt capital markets can play in financing progress towards environmental and social sustainability." Bold added by the author.

[12] While ASEAN standards do not define "eligible green projects," referring to ICMA standards instead, EU GBS establishes, in Article 4.1, the specific categories of expenditures for which the proceeds of the European green bond can be allocated. See p. 25 at the following link, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0391

Management of proceeds; and (d) Reporting and the key recommendations relate to the framework and external review[13]. Regarding the (a) Use of proceeds, ICMA principles (2022), similar to CBS, ASEAN standards, and EU GBS, require the issuer to specify in the legal documentation of the instrument the manner in which it intends to use the capital raised to finance eligible green projects. As for the (b) Process for project evaluation and selection, the principle requires the issuer to provide investors with adequate communication regarding the environmental objectives pursued, the process, and the criteria for selecting projects within each category of eligible green projects. The provisions related to (c) the Management of proceeds require tracking of various financial flows to demonstrate the correct use of the borrowed capital. Finally, regarding the (d) reporting activity, the principle provides that each issuer must annually report on the allocation of proceeds until the full amount is used up. These annual allocation reports refer to each funded project and contain a brief description of the project, the financing provided, and the expected impact. Nevertheless, it must be made public[14].

Lastly, despite the general lack of regulation in most jurisdictions regarding sustainable debt, the act of self-labelling a bond as green is not purely self-referential for the issuer. It is based on a specific document known as a framework[15]. This framework is crucial for legitimizing the qualification of the instrument as green to investors and third parties because it explains the alignment of the financial tool with the four core components mentioned above[16].

To summarize, the green bond market operates primarily through self-regulation (Chan, 2021). Private governance bodies, such as ICMA and CBI, play a key role in filling the void of public regulation (Banahan, 2018). These private bodies establish their own validation and certification frameworks, which contribute to the legitimacy and growth of the market (Pyka, 2023). The magnitude of this growth is substantial, as demonstrated by the market data we present for EU countries and the U.K. in the following section.

[13] For further information, see ICMA, Guidance Handbook 2022.
[14] In addition to reporting on the use of proceeds, the Green Bond Principles, p. 6: also recommend the publication of specific "impact reports" to evaluate and quantify the environmental impact of the various financed projects.
[15] The Green framework, also called a factsheet, is a document in which the green peculiarities of the instrument are indicated.
[16] Green Bond Principles 2022, p.7: […] "Such Green Bond Framework and/or legal documentation should be available in a readily accessible format to investors. It is recommended that issuers summarize in their Green Bond Framework relevant information within the context of the issuer's overarching sustainability strategy".

2.3 The green bond market in EU countries and the U.K.

The bond data are obtained from Refinitiv Advanced Search – Government and Corporate Bonds database. Since the green bond market started in 2007, we extract all the green fixed income with the country of issue related to EU24[17] and the U.K., between January 1, 2007, and December 31, 2022. To distinguish between green and ordinary bonds, we use Refinitiv green bond indicator, which reports whether a bond is labelled green[18]. We select the universe of issuer types: "Government", "Corporate", "Agency", "Non-US Municipal Bonds", and "Other Gov/Supra" both with active and inactive status[19]. This yields a total of 3,158 green bonds.

In the following, we first describe the green bond market over time. Then, we provide a separate characterization across countries and the economic sector. Table 1 provides statistics on the issuance of green bonds on a year-by-year basis. The first column reports the issuance of green bonds in billions of euros (all foreign currencies are converted into euros), whereas the second column reports the number of green bonds.

Table 1

Green Bonds over time (2007-2022)

Year	Issuance of Green Bonds (billion EUR)	Number of Green Bonds
2007	0.60	1
2008	0.10	1
2009	0.26	2
2010	0.47	10
2011	0.06	5
2012	1.15	7
2013	6.36	27
2014	20.29	86
2015	26.79	87
2016	36.17	111
2017	85.39	168

[17] EU24 includes Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. No green bonds were issued by Croatia, Bulgaria and Malta in the chosen period.

[18] We selected Refinitiv categories: CBI Aligned Green Bond, CBI Certified Green Bond, and Self-Labeled Green Bond

[19] Refinitiv includes a series of other fixed-income securities, such as certificates of deposit and commercial paper that can also be marked as green. Because these are not bonds per se, we do not include them in the analysis.

Year	Issuance of Green Bonds (billion EUR)	Number of Green Bonds
2018	74.68	207
2019	135.14	357
2020	151.49	557
2021	331.56	844
2022	281.46	688
Total	1151.98	3,158

Note: This table reports the amount in billion EUR, and the number of green bonds issued on an annual basis. The data set includes green issues in Refinitiv issued for the above-mentioned countries (supra §. 17) between January 1, 2007, and December 31, 2022.

The pattern is consistent with the "green bond boom" often mentioned in the literature (Flammer, 2020; Ribeiro, 2023). Over 16 years, the issuance of green bonds soared from 0.6 €B in 2007 to 281.46 €B in 2022[20].

Table 2 provides summary statistics separately for each country[21]. Notably, the three main issuers are Germany (240.83 €B), France (200.98 €B), and the Netherlands (145.01 €B), consistent with the view that Europe tends to be greener thanks to the ecological leadership of those countries (Doh & Guay, 2006).

Table 2

Green Bonds across Countries (2007-2022)

Country	Issuance of Green Bonds (billion EUR)	Number of Green Bonds
Austria	16.04	60
Belgium	65.86	30
Cyprus	0.65	2
Czech Republic	1.36	3
Denmark	38.31	62
Estonia	0.06	1
Finland	23.56	71
France	200.98	478
Germany	240.83	698
Greece	2.31	7

[20] The green bond boom is even bigger if considering other leading issuers such as the United States and China.

[21] The countries used to characterize issuers are the countries of domicile (as opposed to the countries of incorporation) in Refinitiv, defined as the location from which the instrument was issued.

Country	Issuance of Green Bonds (billion EUR)	Number of Green Bonds
Hungary	6.00	26
Ireland	24.00	32
Italy	59.06	78
Latvia	0.39	6
Lithuania	0.73	5
Luxembourg	92.49	230
Netherlands	145.01	209
Poland	5.73	12
Portugal	5.68	12
Romania	0.67	5
Slovakia	1.26	7
Slovenia	0.08	1
Spain	62.15	140
Sweden	72.07	765
United Kingdom	86.70	218
Total	1151.98	3,158

Note: This table reports the amount in billion EUR, and the number of green bonds issued by the country. The data set includes green issues in Refinitiv issued for the above-mentioned countries (supra §. 17) between January 1, 2007, and December 31, 2022

Figure 1 provides a visualization of the data from Table 2 (panel A refers to the billion EUR, whereas panel B refers to the number of green bonds). The areas with darker shades indicate greater amounts of issuance and correspondingly higher numbers of green bonds. The general pattern is in line with the above characterization: Germany, France, and the Netherlands are the main issuers, followed by a fragmented set of other European countries.

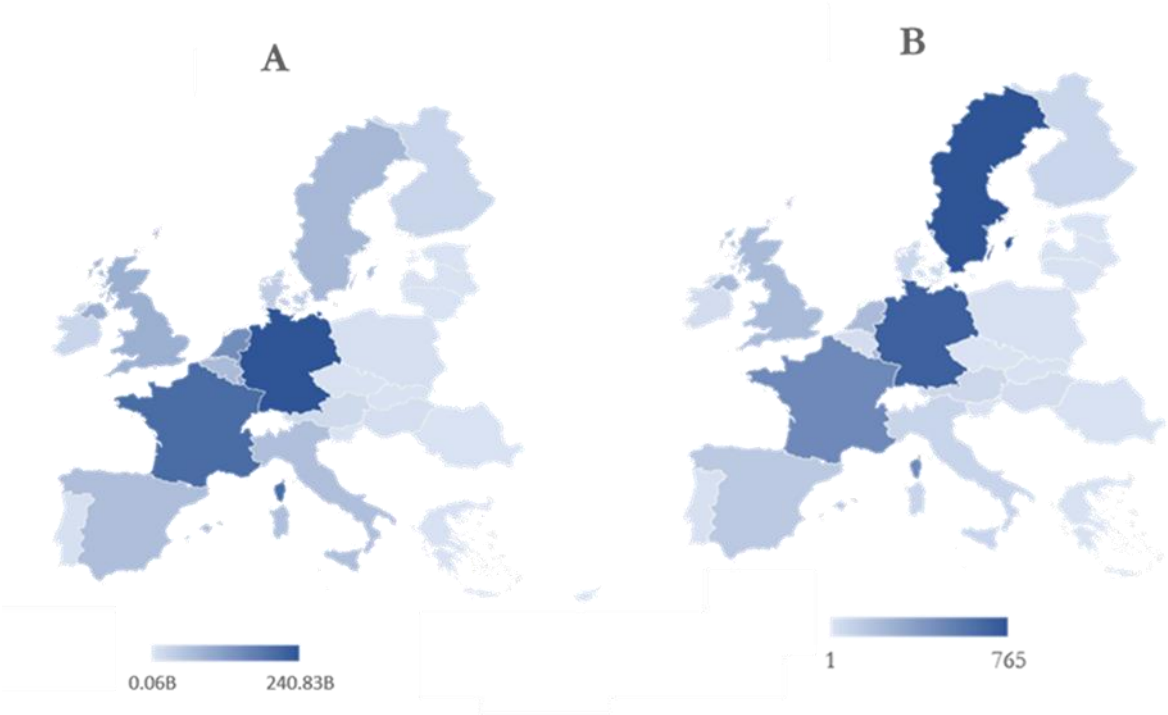

Fig. 1. Green bonds across countries. **Panel A,** Green bond issuance in billion EUR. **Panel B**, Number of green bonds.
Notes: This figure reports the prevalence of green bonds across countries. Darker-shaded areas represent higher issuance amounts (A) and a higher number of green bonds (B), respectively. The underlying statistics are provided in Table 2.

Table 3 provides a characterization of green bond issuance across Economic Sectors defined according to Refinitiv Business Classification codes (TRBC)[22]. As is shown, Financials are the main issuers (514.97€B), followed by Governments Activity (283.67€B), Utilities (155.31€B), Industrials (72.83€B), and Real Estate (63.46€B). The latter three are emission-intensive sectors (Ritchie, Roser, & Rosado, 2020). The general pattern confirms the prevalence of green bonds among a set of key sectors, with the government sector being an earlier adopter of green finance. Drawing from the data on green bond issuance, it's evident that different sectors show differing levels of commitment to green finance. This dynamic plays a crucial role in understanding the broader landscape of sustainable investments across Europe. As we transition into our next analysis, we delve deeper into the adoption patterns of European nations.

[22] TRBC Classifies companies with increasing granularity by Economic Sector, Business Sector, Industry Group, Industry and Activity. For further information, see, https://www.refinitiv.com/content/dam/marketing/en_us/documents/quick-reference-guides/trbc-business-classification-quick-guide.pdf

Table 3

Green Bonds Across Economic Sector

TRBC Sector	Issuance of Green Bonds (billion EUR)	Number of Green Bonds
Financial	514.97	1767
Government Activity	283.67	186
Utilities	155.31	358
Industrials	72.83	141
Real Estate	63.46	529
Basic Materials	20.43	59
Consumer Cyclicals	14.15	44
Technology	12.37	21
Energy	6.82	30
Consumer Non-Cyclicals	5.74	17
Healthcare	2.20	5
Academic & Educational Services	0.02	1
Total	1151.98	3,158

Note: This table reports the amount in billion EUR, and the number of green bonds issued by the Economic sector. Sectors are defined according to Refinitiv Business Classification codes (TRBC) The data set includes green issues in Refinitiv issued for the above-mentioned countries (supra §. 17) between January 1, 2007, and December 31, 2022.

2.4 Empirical investigation

This section aims to test whether any convergence pattern emerges and to detect potential clustering clubs across European nations. We initially present our methodology and then provide a detailed discussion of the principal findings and structural breaks. Lastly, we aim to provide insights into the possible determinants of club membership.

2.4.1 Methodology

To investigate the club convergence across European countries and the U.K. in adopting a green finance emissions strategy, we apply the log t-test as developed by Phillips and Sul (2007). This method can identify club convergence groups that progress towards separate equilibria or stable states without making any assumptions about trend stationarity or stochastic process non-stationarity (Okazaki & Sakai, 2020).

Let y_{it} denote the amount (billion EUR) green bonds issued of country $i=1,..., N$ at time $t=1,..., T$. Adhering closely to the methodology outlined by Phillips and Sul, we make the assumption that y_{it} can be modelled as a nonlinear common-factor model that varies over time, such that:

$y_{it} = \delta_{it}\mu_t$

where μ_t is a single common component and δ_{it} is a time-varying idiosyncratic element, which captures the deviation of country i from the common path δ defined by μ_t.

Given that the number of parameters exceeds that of observations, Phillips and Sul eliminate the common component μ_t through rescaling by panel average:

$$h_{it} = \frac{y_{it}}{1/N \sum_{i=1}^{N} y_{it}} = \frac{\delta_{it}}{1/N \sum_{i=1}^{N} \delta_{it}}$$

where the panel average $N^{-1} \sum_{i=1}^{N} \delta_{it}$ and its limit as $N \to \infty$ both exist and differ from 0.

To test for convergence, Phillips and Sul (2007) assume that δ_{it} has the following transition form:

$$\delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}$$

where δ_i is fixed, $\sigma_i > 0$ is an idiosyncratic scale parameter, ξ_{it} is iid $(0, 1)$ with finite fourth moment over i, $L(t)$ is a slowly varying function and α is the decay rate. Since all countries will converge to the same steady state if $\delta_{i,t+k} = \delta \; for \; all \; i$, which holds if and only if $\delta_i = \delta$ for all i and $\alpha \geq 0$,

the null hypothesis of convergence is as follows:

$$H_0: \delta_i = \delta \; for \; all \; i \; and \; \alpha \geq 0$$

and the alternative:

$$H_A: \delta_i = \delta \; for \; all \; i \; and \; \alpha < 0$$

These hypotheses are tested using the following "log t" regression model (Phillips & Sul, 2007)

$$log(H_1/H_t) - 2logL(y) = \hat{c} + \hat{b}\, log\, t + u_t$$

where $log(H1/Ht)$ is the cross-sectional mean square transition differential and measures the distance of the panel from the common limit; and $t = [rT], [rT] + 1, \ldots, T, with\ r > 0$.

2.4.2 Club convergence

In response to climate change, European countries implemented several strategies to mitigate and manage adaptation risks (Biesbroek et al., 2010; Porrini & Schwarze, 2014; Bukowska et al., 2023). Those strategies required action plans financed by substantial funding from the public and private sectors. The green bond instrument aimed to achieve the above-mentioned need. We use a sample of 24 European countries and the U.K., covering the period from 2012 to 2022[23]. Croatia, Bulgaria and Malta have been excluded from our analysis due to the absence of green bond issuance during the selected period. We apply the Refinitiv filter to convert all currencies to euros. Hence, our panel consists of the total amount of green bonds in euros for each country and each year[24], including government, corporate, agency, non-US municipal bonds, and other government or supranational entity issuances. We choose not to rescale the issued amount for the GDP data, as the latter will subsequently serve as a covariate.

Table 4 displays results from the convergence log-t-test applied to the amount issued. The series was subjected to the Hodrick-Prescott filter in order to eliminate any seasonal or cyclical factors[25]. When the log t-test is employed on the annual issuance figures across 24 European

[23] We selected November 23, 2011, as the starting point for our analysis because it was the year when the Climate Bonds Initiative (supra §. 2) published the first standard on green bonds (https://www.climatebonds.net/standard/about/history). However, since no green bonds were issued during the period from November 23rd to December 31st, 2011, we believe it is more consistent to begin our analysis from 2012. We conducted a robustness check for the periods 2011-2022 and found that the results for the first three groups did not substantially change, confirming the validity of our choice.

[24] supra §. 17

[25] We strictly follow the literature, for yearly data λ=100. See (Larsson & Gabrielle, 2012, p. 7).

countries and the U.K., the hypothesis of overall convergence is rejected at the 5% significance level if T-stat < -1.65. In the full sample analysis, the T-stat is -17.231 well below -1.65, concluding that the test rejects the hypothesis of overall convergence at 1% statistical significance (Brosio et al., 2022). This leads us to infer that there's no shared steady-state equilibrium among European countries in terms of amount issued.

Subsequently, we investigate the testing procedure for clustering mechanisms, which reveals the identification of 4 convergence groups. The outcomes of the log t-test are laid out in Table 4, where we detail the coefficient and the corresponding t-statistic, accompanied by a list of each group's members. Furthermore, a visual representation of group membership is provided in Figure 2.

Table 4

Convergence Club Classification

Club	Coefficient	T-stat	Club members
Full sample	-0.797	-17.231	
Club 1	-2.321	-0.898	France, Germany
Club 2	-0.032	-0.305	Austria, Belgium, Denmark, Ireland, Italy, Luxembourg, Netherlands, Spain, Sweden, United Kingdom
Club 3	0.117	1.555	Finland, Hungary, Portugal, Slovakia
Club 4	0.002	0.083	Cyprus, Czech Republic, Estonia, Greece, Latvia, Lithuania, Poland, Romania, Slovenia

Note: Log (t) results for convergence in green bond amount issued for the above-mentioned countries (supra §. 17) between January 1, 2012, and December 31, 2022. The null hypothesis of convergence is rejected at the 5% level if T-stat < -1.65. In our case, the null hypothesis of convergence is rejected at the 1% level because T-stat = - 17.231

Despite the fact that most of coefficients are negative, the t-statistic is the primary criterion for assessing club convergence. The null hypothesis of convergence can be rejected if this value is smaller than 1.65 (Mendez, 2020). Therefore, since -17.231 is less than 1.65, we reject the hypothesis of overall convergence for the full sample. Subsequently, we proceed to examine whether there exists local convergence. Four clubs are identified: the first group contains 2 countries; 10 countries comprise the second group; the third includes 4 countries; and the fourth is composed of 9 countries. The result of the log t-test for club 1 is -2.321 with a statistical value t of -0.898 so the null hypothesis of convergence is not rejected and France and Germany converge according to the log t-test. Analogously, the log t-tests provide evidence of convergence of the other clubs. Club 2,

whose t-test is -0.032 with a statistical value t of -0.305 is composed of Austria, Belgium, Denmark, Ireland, Italy, Luxembourg, Netherlands, Spain, Sweden, and the United Kingdom. Club 3 leads to a similar outcome, whose value of the log t-test is 0.117 with a statistical value of t of 1.555. This is the reason why the null hypothesis of convergence of Finland, Hungary, Portugal, and Slovakia is also not rejected.

Finally, club 4 results in a value of 0.002 for the log t-test and a statistical value t of 0.083, so the null hypothesis of convergence is not rejected and Cyprus, Czech Republic, Estonia, Greece, Latvia, Lithuania, Poland, Romania, and Slovenia converge.

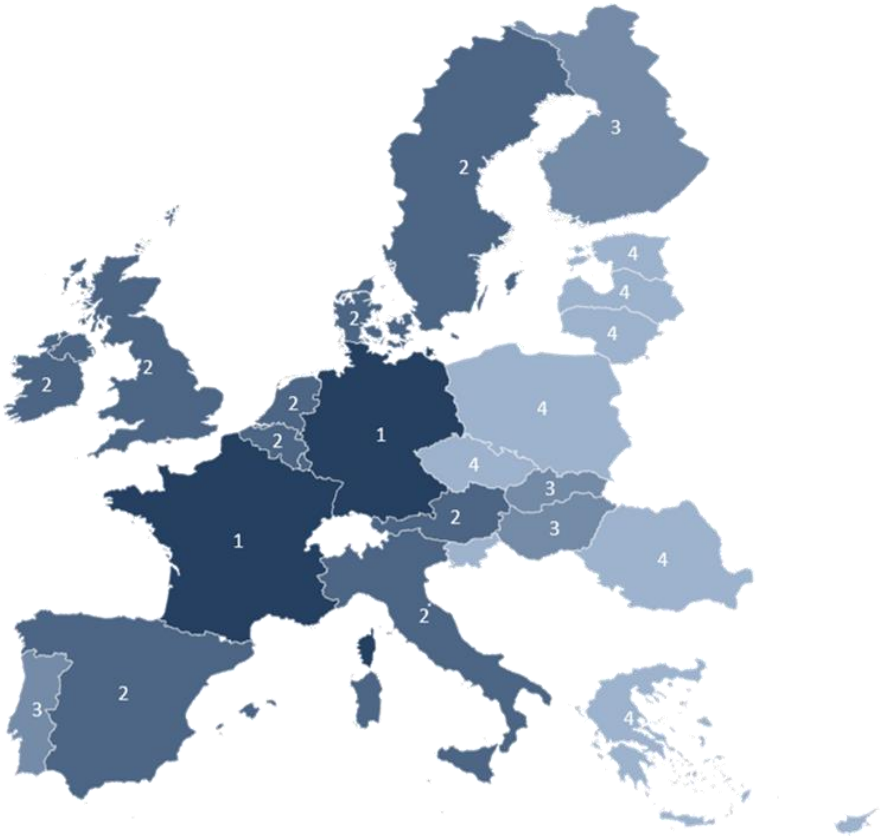

Fig. 2. Club Convergence.

However, since the convergence club algorithm developed by Phillips and Sul (2007) may overestimate the number of clubs, we performed a merging test to correct this issue following the methods outlined in Phillips and Sul (2009) and Lyncker and Thoennessen (2017). A sequential

merging test was performed to correct this issue. The results rule out the possibility of a club merger, concluding that the convergence analysis is robust with the finding of Table 4.

Figure 3 shows the four convergence behaviours. From visual inspection, it is possible to gain insights into the various stages of development that clubs are experiencing in the green bond market. Countries in groups 1 and 2 are currently in the stage of market expansion, while clubs 3 and 4 are in the stage of market creation. Club 3 exhibits a significant and consistent structural increase in green issuance since 2018. Conversely, countries in club 4 are at different speeds in the stage of market creation since 2020. The identification of two structural breaks in distinct clubs, observed in the United Kingdom and Poland (dashed lines), necessitates further explanation.

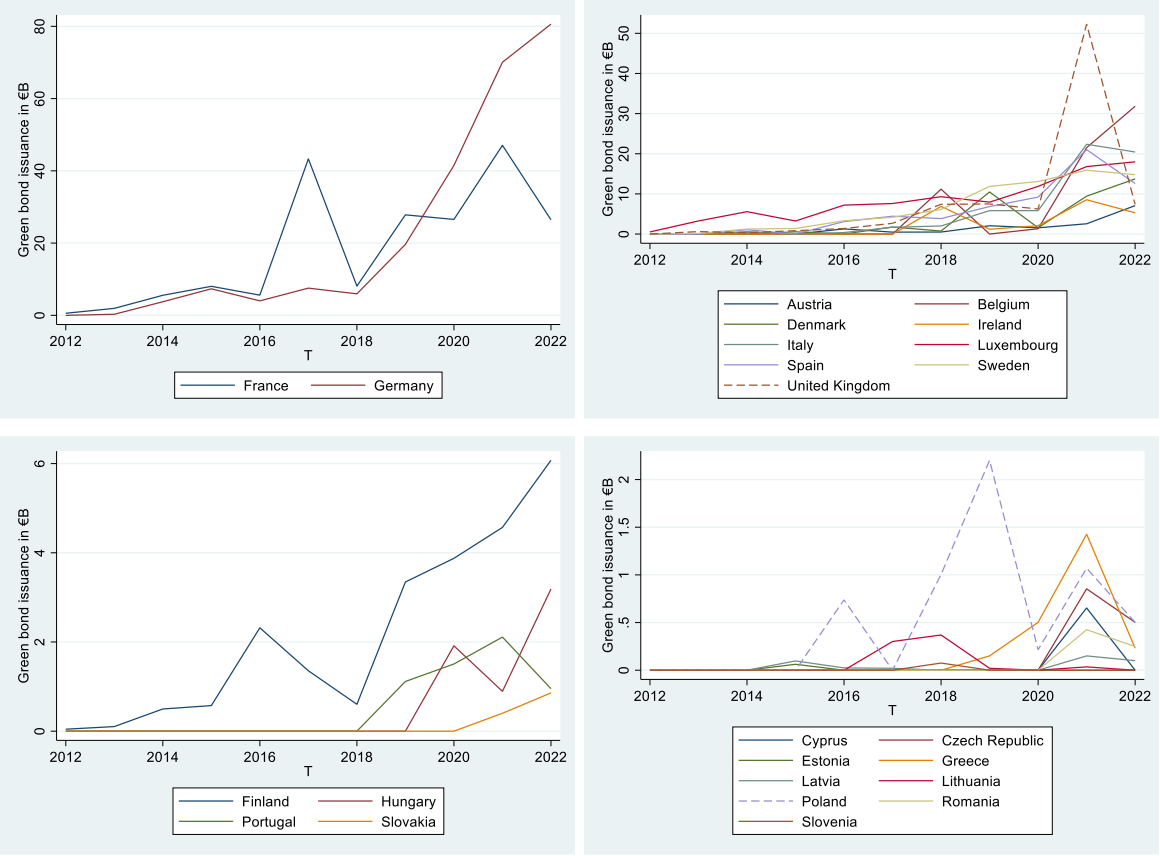

Fig. 3. European Green Bond emission Clubs Convergence (absolute value in billion EUR).

The observed structural discontinuity in U.K. green bond issuance occurred during the same period as Brexit, which refers to the U.K.'s withdrawal from the European Union in January 2020, and the subsequent conclusion of the EU annual budget cycle for the period 2014-2020, in which the U.K. was involved. Since then, the U.K. Government, as stated by HM Treasury in 2021, announced plans to increase its provision of international climate finance from 2021 to

2025[26], alongside legal reform. These plans include the introduction of the UK Government Green Financing Framework[27] in June 2021, which led to the government's issuance of approximately 21 billion euros of green bonds in September and 15 billion euros in October, and the enactment of the Environmental Act in November 2021[28].

The reason for the structural break in Poland is indeed unique. On December 20, 2016, the Polish government issued the world's first sovereign green bond (Whiley, 2016), thereby pioneering green bond issuance at the sovereign level. The green instrument had a value of 0.75 billion euros, which was utilized to finance a range of climate-related projects. This pioneering role in the sovereign green bond market enabled Poland to effectively reduce the cost of fundraising for environmental initiatives[29]. Building upon this accomplishment, in March 2019, the Republic further capitalized on the green market by issuing 2 billion euros worth of bonds. Rather than choosing the local currency (zloty), the decision was made to denominate the bonds in euros to attract a diverse array of green investors. However, at the corporate level, green issuance did not follow the governmental stimulus at the same speed. This explains why the country's emissions dropped to 0.2 billion euros in 2020 and rose to 1 billion euros in 2021.

Although there is no definitive reason why countries differ in their approaches to financing ecological strategies, the choice to issue green bonds may reflect the specific development and consequences of mitigation and adaptation actions within those countries. While the motivations for issuing green bonds might vary across countries, it is crucial to understand the factors influencing these choices. To further explore this, we delve into the determinants of club membership in the following section.

---

[26] For further information, please refer to the UK Government, December 2020: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943566/UK_Biennial_Finance_Communication_2020.pdf

[27] See the UK Government Green Financing Framework published in June 2021. The document is available at the following link: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1002578/20210630_UK_Government_Green_Financing_Framework.pdf.

[28] Environmental Act, November 2021 https://www.legislation.gov.uk/ukpga/2021/30/introduction/enacted

[29] See https://wholesale.banking.societegenerale.com/en/news-insights/clients-successes/clients-successes-details/news/pioneering-poland-pumps-environmental-credentials-and-considers-local-green-bonds/

2.4.3 Club membership

In this section, we attempt to shed some light on the potential drivers of club membership. As suggested by Bartkowska and Riedl (2012), we perform an ordered logit with the robust standard error, to explain club membership of the four convergence clubs, denoted by the ordinal variable *c* (McKelvey & Zavoina, 1975). Following Bartkowska and Riedl (2012), we can model the dependent variable as an ordinal variable since convergent clubs could be ranked according to the amount (billion EUR) of green bond emissions of countries in the respective club. We assume that there exists a continuous latent variable that is associated with club membership, given that we do not have knowledge of the variations in steady-state levels between different clubs, y*, such that:

$$y_i^* = X_i\beta + \varepsilon_i$$

where X are the explanatory variables in the initial period, and ε are the errors with a mean of zero and a variance of $\pi^2/3$.

Due to the few observations, it is not possible to include a large set of covariates. Hence, in what follows we adopt a parsimonious specification of the regression model to maintain enough degrees of freedom (Brosio et al., 2022). Table 5 presents the key descriptive statistics for the data used in the determinants of club convergence, and Appendix A (2.1) provides the correlation matrix. To assess the connection between income and environmental quality across countries, we use national Gross Domestic Product (GDP) adjusted for Purchasing Parity Power (constant 2017 international $) normalized by population[30] at t_0=2012. The World Bank supplies data on GDP PPP per capita[31]. This connection, known as the Environmental Kuznets Curve (EKC), provides an empirical pattern which suggests that environmental harm first rises with country wealth but then falls as countries dedicate more resources toward environmental protection. Since the EKC's conception, policymakers and researchers have heavily debated its existence (Grossman & Krueger, 1991; Stern, 2018).

To capture the importance of environmental consumption in the decision of green issuing, we use the Ecological Footprint (EF) following Ulucak et al. (2020), and Arogundade et al. (2023). The EF quantifies the amount of land and water needed to sustain the resources consumed by an

[30] We decided to use GDP adjusted for PPP as a more accurate way to compare the economic productivity and living standards of different countries. A robustness check was performed using GDP per capita. Results substantially do not change, confirming the validity of the choice.

[31] For more details, see https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD

individual, population, or activity, along with the urban infrastructure it occupies and the waste it produces, given the current technology and resource management practices. The EF is an exhaustive framework for evaluating the consumption of natural resources by a population, as well as the effect of anthropogenic activities on nature. The dataset is produced by the Ecological Footprint Initiative of York University in collaboration with Global Footprint Network[32]. The EF accounts for six important components of the environment – built-up land, carbon footprint, cropland, fishing grounds, forest products, and grazing land. We employ data on EF consumption global hectares per person in the year 2012[33].

To further explore the role that environmental disasters have played in the decision to issue green bonds, we employ an average index of weather-related loss events. We expect to find a correlation between the scores of countries most affected by extreme weather events and their increased issuance of green bonds as a response to climate events, and vice versa. We employ the Climate Risk Index (CRI) by Eckstein et al. (2014), which identifies the extent to which countries have been affected by extreme weather events in 180 countries from 2000 to 2012. These events can be meteorological, such as tropical storms or tornadoes; hydrological, such as storm surges or flash floods; or climatological, such as wildfires or droughts. The index score is derived from the following indicators and averaged according to their weighting: death toll, 1/6; deaths per 100,000 inhabitants, 1/3; absolute losses in purchasing power parity (PPP), 1/6; losses per unit of Gross Domestic Product (GDP), 1/3. A lower score indicates countries with higher climate risk, while a higher score highlights countries with lower climate risk.

Moreover, we link the well-established theoretical connections between institutions and financial investment. The data underlying this analysis come from the World Bank's Worldwide Governance Indicators (Kaufmann, Kraay, & Mastruzzi, 2010). The field of law enforcement holds appeal for investors and contributes to the growth of the bond market, whereas corruption is a barrier to law enforcement and, as a result, should exhibit a negative correlation with bond market development. The Rule of law (RL) acts as a proxy for assessing the effectiveness of contract enforcement, property rights, law enforcement agencies, and judicial systems, all of which facilitate the advancement of private sector development (Eichengreen & Luengnaruemitchai, 2004).

[32] https://www.footprintnetwork.org/resources/data/
[33] For more details, see https://data.footprintnetwork.org/#/countryTrends?type=BCpc,EFCpc&cn=11

Finally, to assess the market's role in promoting green financing, we use as an approximation the Financial Market Depth Index (FMD) developed by the International Monetary Fund (IMF). The latter takes into account the size of the stock market (capitalization, or the value of listed shares), the volume of traded stocks, the number of sovereigns with outstanding foreign debt securities, and the number of domestic and foreign financial and nonfinancial corporations with outstanding debt securities[34] (Svirydzenka, 2016). We expect to find a positive correlation between the index scores of countries most advanced in market development and their increased issuance of green bonds as a response to climate financing.

Table 5

Covariate-level descriptive statistics

	Mean	**StD**	**Min**	**Max**
GDP PPP ($ per capita)	40657.24	18215.35	21953.23 (Romania)	112137.1 (Luxembourg)
Ecological Footprint (gha per capita)	5.506	2.152	2.670 (Romania)	13.842 (Luxembourg)
Climate Risk Index	79.641	27.372	29.67 (Romania)	126.17 (Luxembourg)
Rule of Law	1.202	0.561	0.093 (Romania)	1.944 (Finland)
Financial Market Depth	0.478	0.316	0.032 (Lithuania)	0.989 (United Kingdom)

Since y_i^* is not observable, we compute the probabilities of belonging to a specific club, c, given the set of covariates X by performing a maximum likelihood technique. To prevent possible cases of heteroscedasticity we use the ordered logit model with the robust standard error. As a robustness check of our empirical estimation, we followed Johnston et al. (2020) by employing the ordered probit model with robust standard errors, which addresses misspecification. We acknowledge that additional potential covariates could be employed to capture the complexity of

[34] Financial Market Depth index is an aggregate of the size of the stock market **(stock market capitalization to GDP)**, how active the market is **(stocks traded)**, the outstanding volume of international debt securities of sovereigns **(international debt securities of government to GDP)**, and the international and domestic debt securities of financial and nonfinancial corporations. See, https://data.imf.org/?sk=F8032E80-B36C-43B1-AC26-493C5B1CD33B&sId=1485894037365&ref=mondato-insight

economic, environmental, and institutional factors and their impact on the decision to issue green bonds. Such covariates may include the Environmental Performance Score, Voice and Accountability, Government Effectiveness, Control of Corruption, Population, and Market Capitalization to GDP. However, we are constrained to adopt a parsimonious specification due to the limited sample size. Nevertheless, we have tested the aforementioned additional covariates, and the results remain statistically significant.

Table 6 provides a comprehensive overview of the marginal effects, expressed as the changes in the predicted probabilities, that each variable exhibits in the context of predicting club membership, thereby offering a detailed and quantitative understanding of the individual contributions of these variables to the likelihood of being a member of the club. Marginal effects provide a straightforward and intuitive interpretation of the model's results, enabling a clear understanding of how changes in independent variables impact the likelihood of an event occurring (Norton et al., 2019).

Additionally, these effects facilitate the comparison of different predictors, allowing for the identification of variables that exert a more substantial influence on the outcome, which is crucial for prioritizing factors in decision-making and policy development. The marginal effects assess how the probability of belonging to a club change when one of the independent variables is changed by one per cent (since GDP PPP $ per capita is in logarithm form) or by one unit (for the other four covariates), while all other variables are held constant at their sample averages.

In other words, the coefficients serve as indicators of the extent to which the likelihood of an individual belonging to a specific club would change in response to a slight variation in the covariates, providing valuable insights into the relationship between the predictors and club.

Table 6

What determines membership in the Green Debt Club? Marginal effects on probabilities with robust SE.

		Ordered logit model		Ordered probit model	
Variables	**Club**	**dy/dx**	**Std. Err.**	**dy/dx**	**Std. Err.**
(log) GDP PPP per capita	1	0.688***	0.182	0.682***	0.193
	2	-0.188	0.181	-0.207	0.195
	3	0.281*	0.152	0.240**	0.120
	4	-0.781***	0.229	-0.715***	0.166
Ecological Footprint	1	-0.043***	0.017	-0.042***	0.016

		Ordered logit model		Ordered probit model	
Variables	**Club**	**dy/dx**	**Std. Err.**	**dy/dx**	**Std. Err.**
	2	0.012	0.012	0.013	0.012
	3	-0.018*	0.010	-0.015*	0.008
	4	0.049**	0.020	0.044***	0.015
Climate Risk Index	1	-0.006**	0.002	-0.006**	0.002
	2	0.002	0.002	0.002	0.002
	3	-0.002*	0.001	-0.002*	0.001
	4	0.007***	0.002	0.007***	0.001
Rule of Law	1	0.140*	0.079	0.159**	0.079
	2	-0.038	0.048	-0.048	0.056
	3	0.057*	0.033	0.056*	0.034
	4	-0.159**	0.064	-0.167***	0.058
Financial Market Depth	1	0.244	0.162	0.284*	0.164
	2	-0.067	0.089	-0.087	0.108
	3	0.100*	0.060	0.100	0.069
	4	-0.277**	0.133	-0.298**	0.125

*** Significance at 1%, **Significance at 5%, *Significance at 10%, rounded.

In Table 6 the coefficients show the change in the probability of belonging to a specific club given a small change in the covariates. One of the assumptions underlying ordered logistic (and ordered probit) regression is that the relationship between each pair of outcome groups is the same. In other words, ordered logistic regression assumes that the slope of the logistic function is the same for all clubs. Therefore, we tested the proportional odds assumption by performing the approximate likelihood-ratio test using the Stata command *omodel*. The null hypothesis is that there is no difference in the coefficients between groups, and the assumption is considered valid if we obtain a non-significant result. The results chi2(10) = 5.54; Prob > chi2 = 0.853 suggest that the proportional odds approach is reasonable since the chi-square test is not significant (Wolfe, 1997). Similar results hold true for the probit robustness check.

The GDP PPP per capita level plays a role in explaining the probability of club membership 1, 3 and 4, which accounts for 15 countries, while it is not statistically significant in the case of group 2 (p-value of 0.300). Specifically, a percentage increase in GDP per capita increases the probability of belonging to the higher green bond issuers of clubs 1 (p-value of 0.000) and 3 (p-value of 0.064), the opposite occurs in the case of club 4 (p-value of 0.001). Given the existence

of a trade-off between the negative short-term environmental degradation and economic level, and the long-term environmental protection in wealthy countries (Grossman & Krueger, 1995; Stern, 2018), our results seem to show the importance of economic effects on the decision to issue a green bond, signalling their environmental preferences.

The Global Footprint Network (2022) asked the basic question: how much do people demand from biologically productive surfaces? Hence, they come up with a proxy answer by computing the Ecological Footprint indicator at the country level. We try to extend this question as follows: is there any connection between EF and green bond club membership? Our findings seem to suggest the importance of biological resource consumption advocates on green bond leadership to signal environmental commitment, confirming the idea that the request for a less polluted world comes from those with a lower EF. The higher the level of EF consumption (hectares per person), the lower the probability of belonging to clubs 1 (p-value of 0.010) and 3 (p-value of 0.087). The opposite holds for Club 4 (p-value of 0.013). The coefficient associated with group 2 is not statistically significant (p-value of 0.315).

The Climate Risk Index assesses the degree to which nations have experienced the impacts of severe climatic occurrences across 180 countries during the period spanning from 2000 to 2012. The index score is calculated based on several factors, including the death toll, deaths per 100,000 inhabitants, absolute losses in purchasing power parity (PPP), and losses per unit of gross domestic product (GDP). A lower number indicates countries with a higher degree of climate risk, whilst a higher score signifies countries with a lower level of climate risk. Our findings seem to suggest a CRI plays a role in green bond issuance but in a counter-intuitive relationship for clubs 1, 3, and 4 not confirming our expectation to find a positive correlation (p-value of 0.001, 0.063, and 0.000 respectively) between the scores of countries most affected by extreme weather events and their increased issuance of green bonds as a response to climate events, and vice versa.

At the institutional level, our results show that a higher Rule of Law Index score increases the probability of belonging to clubs 1 (p-value of 0.073) and 3 (p-value of 0.081), but the opposite holds true in the case of group 4 (p-value of 0.013). This finding is consistent with the concept that institutions matter (Allen, 2001). This underscores the crucial role that institutional factors play in shaping the dynamics of club categorization and aligns with the insights put forth by North Douglass (1971) regarding the significance of institutional influence. However, the coefficient of club 3 is not statistically significant.

Finally, our results show that a stronger Financial Market Depth increases the probability

of belonging to clubs 3 (p-value of 0.099) but the opposite holds true in the case of group 4 (p-value of 0.038). This aligns with the theory that stock market capitalization to GDP, stocks traded to GDP, international government debt securities to GDP, and total debt securities of nonfinancial corporations to GDP are significant factors for countries with low levels of Financial Market Depth. The coefficient of club 1 (p-value of 0.132) and 3 (p-value of 0.455) is not statistically significant.

2.5 Discussion, and concluding comments

This chapter aims to study the market for green bonds among European countries and the U.K. and examine whether there has been any convergence in terms of the euro amount issued within the period spanning from 2012 to 2022. To achieve this objective, a convergence log-t test has been conducted using a panel dataset comprising 24 European countries and the U.K. The findings reveal that four distinct clusters exhibit a significant level of convergence. However, it is important to note that solely relying on visual inspection provides insights into the developmental stages experienced by these clusters within the green bond market, without enabling us to draw conclusions regarding the potential determinants of the spatial distribution of these clusters across Europe. Consequently, we employ an ordered regression model to identify potential drivers of club membership. Factors such as the economic, environmental, institutional, and market emerge as influential determinants in determining the likelihood of a country belonging to a specific club.

By definition, the presence of clubs within the green bond market indicates the absence of a unified European financial strategy for issuing such bonds. Our research findings indicate that clusters of countries have embraced a collective approach to the issuance of green debt. The emergence of these clusters sheds light on the diverse developmental stages that these clubs are currently undergoing within the green bond market. While countries belonging to groups 1 and 2 are positioned in the phase of market expansion, club 3 is firmly situated in the stage of market structuring, characterized by a substantial and consistent increase in green bond issuance since 2018. In contrast, countries within club 4 are experiencing the stage of market creation, albeit at varying rates of progress.

In an attempt to provide a comprehensive understanding of the fragmentation within the

EU green bond market, our research delves into the examination of various economic, environmental and institutional and market factors that contribute to this phenomenon. Consequently, our study directly addresses this issue through an inferential lens, enabling us to draw meaningful insights. Taking into account the well-known trade-off between economic growth and environmental preservation as established by Grossman and Krueger (1991), our findings seem to suggest the significance of economic effects on the decision to issue green bonds, serving as a signaling mechanism for the environmental preferences of both affluent and less-wealthy nations. Furthermore, our key findings indicate the importance of advocates for biological resource consumption within green bond leadership, as it signifies a strong commitment to environmental preservation, thus affirming the notion that the demand for a less polluted world predominantly arises from those with a lower Ecological Footprint. Additionally, the Climate Risk Index, counterintuitively, also plays a role. Lastly, our results highlight that better Rule of Law and Financial Market Depth not only increases the probability of countries issuing green bonds but also reflects the establishment of robust frameworks and governance structures that promote sustainable financial practices. This suggests that countries with stronger financial institutions and markets may be more equipped to effectively implement and monitor the environmental standards associated with green bond issuance, thereby fostering greater confidence in investors and the credibility of the green bond market as a whole.

Taking into account the heterogeneous nature of the nations within the outlined clubs discussed in section 4, it becomes evident that the policy implications resulting from our empirical research do not support the 'one size fits all' approach. More precisely, our research does not endorse the adoption of a standardized legal framework for the issuance of green bonds, particularly in the case of the EU Green Bond Standard. As discussed by Pyka (2023), rather than achieving its intended objective, the EU Green Bond Standard may be inclined to further intensify market fragmentation.

However, it is crucial to exercise caution when interpreting our findings in terms of causal relationships, as there may be underlying factors that require further exploration. We strongly emphasize the significance of delving deeper into the phenomenon of the burgeoning green finance sector, as it remains a topic of scholarly debate. Our hope is that future research will not only build upon our findings but also enhance the empirical analysis to establish a clearer understanding of the causality that exists between economic, environmental, and institutional factors and countries' commitment to green finance. Given the escalating levels of environmental fragmentation

observed in the current period, it is highly probable that club decisions to issue green debt for ecological transition or adaptation are likely to persist and will play a significant role in shaping the future.

References

Adger, W. N. (2010). Social capital, collective action, and adaptation to climate change. *Der Klimawandel: Sozialwissenschaftliche Perspektiven*, 327-345.

Agliardi, E., & Agliardi, R. (2019). Financing environmentally-sustainable projects with green bonds. *Environment and development economics, 24(6)*, 608-623.

Allen, F. (2001). Do financial institutions matter? *The Journal of Finance, 56(4)*, 1165-1175.

Arogundade, S., & et al. (2023). Closer together or farther apart: are there club convergence in ecological footprint? *Environmental Science and Pollution Research, 30(6)*, 15293-15310.

ASEAN Capital Markets Forum. (2018). ASEAN Green Bond Standards.

Baker, M., Bergstresser, D., Serafeim, G., & Wurgler, J. (2018). Financing the response to climate change: The pricing and ownership of US green bonds. *National Bureau of Economic Research*, No. w25194.

Bamford, C. (2011). *Principles of international financial law*. Oxford University Press.

Banahan, C. M. (2018). The bond villains of green investment: why an unregulated securities market needs government to lay down the law. *Vt. L. Rev., 43*, 841.

Bartkowska, M., & Riedl, A. (2012). Regional convergence clubs in Europe: Identification and conditioning factors. *Economic Modelling*, 29(1), 22-31.

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, 175, 121378.

Biddle, G. C., Hilary, G., & Verdi, R. S. (2009). How does financial reporting quality relate to investment efficiency? *ournal of accounting and economics, 48(2-3)*, 112-131.

Biesbroek, G. R., Swart, R. J., Carter, T. R., Cowan, C., Henrichs, T., Mela, H., & Rey, D. (2010). Europe adapts to climate change: comparing national adaptation strategies. *Global environmental change, 20(3)*, 440-450.

Brosio, G., Pelosi, R., & Zanola, R. (2022). Short-term exit from pandemic restrictions: did

European countries' speed converge? *The European Journal of Comparative Economics, 19(2)*, 145-159.

Bukowska, J., Godlewska, J., & Sidorczuk-Pietraszko, E. (2023). Differences and Similarities in Climate Change Adaptation Policy Instrument Mixes in Selected European Countries. *Energies, 16(6)*, 2541.

Bussani, T. (2023). *Il Mercato del Debito Sostenibile nel Diritto internazionale.*

Chan, R. (2021). Ensuring impactful performance in green bonds and sustainability-linked loans. *Adel Law Review*, 221-258.

Chen, Y., & Zhao, Z. J. (2021). The rise of green bonds for sustainable finance: Global standards and issues with the expanding Chinese market. *Current Opinion in Environmental Sustainability, 52*, 54-57.

Chinn, M. D., & Ito, H. (2006). What matters for financial development? Capital controls, institutions, and interactions. *Journal of development economics, 81(1)*, 163-192.

Chung, K. H., Wang, J., & Wu, C. (2019). Volatility and the cross-section of corporate bond returns. *Journal of Financial Economics, 133(2)*, 397-417.

Climate Bonds Initiative. (2019). Climate Bonds Standard Version 3.0. *International Best Practice for Labelling Green Investments.*

Climate Bonds Initiative. (2021). Sustainable debt global state of the market 2020. *London: Climate Bond Initiative.*

Climate Bonds Initiative. (2021). Sustainable debt. Global state of the market 2021. *London: Climate Bond Initiative.*

Collin, P. H. (2015). *Dictionary of Banking and Finance, III. ed.* Bloomsbury Publishing.

Cox, P., Brammer, S., & Millington, A. (2004). An empirical examination of institutional investor preferences for corporate social performance. *Journal of business ethics, 52*, 27-43.

Debrah, C., Darko, A., & Chan, A. P. (2023). A bibliometric-qualitative literature review of green finance gap and future research directions. *Climate and Development*, 15(5), 432-455.

Doh, J. P., & Guay, T. R. (2006). Corporate social responsibility, public policy, and NGO activism

in Europe and the United States: An institutional-stakeholder perspective. *Journal of Management studies*, 43(1), 47-73.

Eichengreen, B., & Luengnaruemitchai, P. (2004). Why doesn't Asia have bigger bond markets?

Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. *International Journal of Green Economics, 14(2)*, 159-173.

Flammer, C. (2020). Green bonds: effectiveness and implications for public policy. *Environmental and Energy Policy and the Economy*, 1(1), 95-128.

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics, 142(2)*, 499-516.

Freeburn, L., & Ramsay, I. (2020). Green bonds: legal and policy issues. *Capital Markets Law Journal, 15(4)*, 418-442.

G20 Sustainable Finance Working Group . (2021). *Synthesis Report.*

Gómez, J. F., & Basterra, M. L. (2021). Fostering green financing at the subnational level. The case of the Basque Country. *EKONOMIAZ. Revista vasca de Economía, 99(01)*, 151-181.

Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement.*

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The quarterly journal of economics, 110(2)*, 353-377.

Hafner, S., Jones, A., Anger-Kraavi, A., & Pohl, J. (2020). Closing the green finance gap–A systems perspective. *Environmental Innovation and Societal Transitions, 34*, 26-60.

HM Treasury. (2021, June 30). UK Government Green Financing Framework.

International Capital Market Association. (2022). *Guidance Handbook.*

IPCC. (2023). Climate Change 2023: Synthesis Report. IPCC, Geneva, Switzerland, pp. 184.

Johnston, C., McDonald, J., & Quist, K. (2020). A generalized ordered Probit model. *Communications in Statistics-Theory and Methods, 49(7)*, 1712-1729.

Kahlenborn, W., Cochu, A., Georgiev, I., Eisinger, F., & Hogg, D. (2017). *Defining "Green" in the Context of Green Finance.* Belgium: Report, Final; European Commission: Brussels.

Karpf, A., & Mandel, A. (2018). The changing value of the 'green'label on the US municipal bond market. *Nature Climate Change, 8(2)*, 161-165.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). Response to 'What do the worldwide governance indicators measure?'. *The European Journal of Development Research, 22*, 55-58.

Kim, Y., Li, H., & Li, S. (2014). Corporate social responsibility and stock price crash risk. *Journal of Banking & Finance, 43*, 1-13.

Krahnen, J., Rocholl, J., & Thum, M. (2023). A primer on green finance: From wishful thinking to marginal impact. *Review of Economics*, 74(1), 1-19.

Kreft, S., & Eckstein, D. (2014). Global Climate Risk Index 2014. *Bonn: Germanwatch.*

Larsson, V., & Gabrielle, T. (2012). Comparison of Dettrending Methods.

Martin, P. R., & Moser, D. V. (2016). Managers' green investment disclosures and investors' reaction. *Journal of Accounting and Economics*, 61(1), 239-254.

Mathews, J. A., & Kidney, S. (2012). Financing climate-friendly energy development through bonds. *Development Southern Africa, 29(2)*, 337-349.

McKelvey, R. D., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *Journal of mathematical sociology*, 4(1), 103-120.

Mendez, C. (2020). *Convergence Clubs in Labor Productivity and its Proximate Sources. Evidence from Developed and Developing Countries.* SpringerBriefs in Economics.

Mok, L., Tripathy, A., & Lunven, G. (2020). A Multidisciplinary Literature Review of Academic Research on the Green Bond Market. *Journal of Environmental Investing.*

Nordhaus, W. (2013). *The climate casino: Risk, uncertainty, and economics for a warming world.* Yale University Press.

Nordhaus, W. (2019). Climate change: The ultimate challenge for economics. *American Economic Review, 109(6)*, 1991-2014.

North, D. C. (1971). Institutional change and economic growth. *The Journal of Economic History*, 31(1), 118-125.

Norton, E. C., Dowd, B. E., & Maciejewski, M. L. (2019). Marginal effects—quantifying the effect

of changes in risk factors in logistic regression models. *Jama 321.13*, 1304-1305.

OECD. (2015). Green bonds. Mobilising the dept capital markets for a low-carbon transition. *Policy Perspectives*.

Okazaki, T., & Sakai, K. (2020). Capital Market Integration with Multiple Convergence Clubs: The Case of Prewar Japan. *The Canon Institute for Global Studies.*, No. 20-004E.

Park, S. K. (2018). Investors as regulators: Green bonds and the governance challenges of the sustainable finance revolution. *Stan. J. Int'l L*, 54, 1.

Petrov, M. V., Tkachev, V. N., & Turuev, I. B. (2023). Development of National Systems of Green Finance in the Context of Industry 4.0. In *Current Problems of the Global Environmental Economy Under the Conditions of Climate Change and the Perspectives of Sustainable Development* (pp. 131-141). Cham: Springer International Publishing.

Phillips P, S. D. (2009). Economic transition and growth. *Journal of Applied Econometrics*, 24(7),1153–1185.

Phillips, P. C., & Sul, D. (2007). Transition modeling and econometric convergence tests. *Econometrica*, 75(6), 1771-1855.

Porrini, D., & Schwarze, R. (2014). Insurance models and European climate change policies: an assessment. *European Journal of Law and Economics, 38*, 7-28.

Pyka, M. (2023). The EU Green Bond Standard: A Plausible Response to the Deficiencies of the EU Green Bond Market? *European Business Organization Law Review, 1-21*.

Ribeiro, V. M. (2023). Green bond market boom: did environmental, social and governance criteria play a role in reducing health-related uncertainty? *Green Finance*, 5(1), 18-67.

Ritchie, H., Roser, M., & Rosado, P. (2020, August). *CO2 and greenhouse gas emissions*.

Saeidi, S. P. (2015). How does corporate social responsibility contribute to firm financial performance? The mediating role of competitive advantage, reputation, and customer satisfaction. *Journal of business research 68(2)*, 341-350.

Schmittmann, J., & Chua, H. T. (2021). How green are green debt issuers? *International Monetary Fund*.

Senn, M. (2011). On Regulation. *Non-State Regulatory Regimes: Understanding Institutional Transformation, 5-47*.

Stern, M. J. (2018). *Social science theory for environmental sustainability: A practical guide*. Oxford University Press.

Svirydzenka, K. (2016). Introducing a new broad-based index of financial development. *International Monetary Fund*.

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance, 61*, 101427.

Tol, R. S. (2018). The economic impacts of climate change. *Review of Environmental Economics and Policy*.

Tol, R. S. (2021). Europe's Climate Target for 2050: An Assessment. *Intereconomics, 56(6)*, 330-335.

Tolliver, C., Keeley, A. R., & Managi, S. (2019). Green bonds for the Paris agreement and sustainable development goals. *Environmental Research Letters, 14(6)*, 064009.

Tolliver, C., Keeley, A. R., & Managi, S. (2020). Drivers of green bond market growth: The importance of Nationally Determined Contributions to the Paris Agreement and implications for sustainability. *Journal of cleaner production, 244*, 118643.

Ulucak, R., & et al. (2020). Does convergence contribute to reshaping sustainable development policies? Insights from Sub-Saharan Africa. *Ecological Indicators*, 112, 106140.

Von Lyncker, K., & Thoennessen, R. (2017). Regional club convergence in the EU: evidence from a panel data analysis. *Empirical Economics*, 52, 525-553.

Weber, O., & Saravade, V. (2019). Green bonds: current development and their future.

Whiley, A. (2016). Poland wins race to issue first green sovereign bond. A new era for Polish climate policy? *Climate Bonds Initiative*.

Wolfe, R. (1997). Omodel: Stata modules to perform tests on ordered probit and ordered logit models.

York University Ecological Footprint Initiative & Global Footprint Network. (2022). National Footprint and Biocapacity Accounts.

Chapter 3 - Green loans and Financial Development: New Evidence?

Abstract

Green loans have emerged as a financial instrument for promoting sustainable development and addressing environmental challenges. But what role does financial development play in the issuance of green loans? We begin by analysing whether any convergence occurred among European countries and the U.K. in the amount issued during 2016-2022, providing evidence of the influences exerted by market maturity, banking structure, and environmental variables in influencing different paths toward club memberships. Next, we investigate the potential impact of financial development on green loans. Our analyses highlight two key policy insights: the need for customized policies based on distinct country characteristics and the imperative of achieving dual objectives, boosting private sector involvement and ensuring balanced bank lending. These recommendations echo the EU's call for increased private investment in sustainable ventures. A broader finance framework should ease access to green loans and mortgages for households and SMEs.

JEL Classification: K20, M20, G20

Keywords: Climate Finance, Financial Development, Banking regulation, European Banking Authority

3.1 Introduction

In response to the demand for ecological transition, a new form of finance emerged, focused on allocating investments toward sustainable and environmentally-friendly projects, with the aim of facilitating the transition to a low-carbon and climate-resilient economy: green finance (Scholtens, 2017; Falcone, 2020).

Within the realm of green finance, green loans have carved out a significant niche. Green loans refer to lending for projects and activities that have a positive environmental impact, such as renewable energy ventures, sustainable agriculture, or pollution control initiatives (Loan Market Association, 2018). The inception of green lending can be traced back to as early as 2005 when major U.S. banks began allocating resources to support sustainable entrepreneurship (Gilchrist et al., 2021). These financial instruments are exclusively designated for financing or refinancing eligible green projects, regardless of whether they are new or existing. The ambiguity surrounding the use of proceeds from green funds has, in part, stimulated international commitment.

In response to this growing international commitment and the need for greater transparency, the Loan Market Association (LMA) introduced the Green Loan Principles (GLP) in December 2018[35]. These principles aim to enhance transparency and establish standardized practices, providing a framework for categorizing loans as green based on factors like the use of proceeds, project evaluation, management of funds, and reporting.

Since the introduction of the GLP, there has been a noticeable surge in the adoption and popularity of green loans within the financial sector. This uptick in activity has not only piqued the interest of industry professionals but also prompted researchers to investigate the details of these financial instruments. As a result, a growing body of academic literature has emerged, delving into various facets of green loans (Akomea-Frimpong et al., 2022; Gilchrist et al., 2021; Vanishvili & Katsadze, 2022). These existing studies have indeed provided insights into the evolution of the need for green loans, with a particular focus on several key determinants (Zahedi, 2010; D'Orazio & Popoyan, 2019; Gilchrist et al., 2021; Debrah et al., 2022; Rahman et al., 2022; Vanishvili & Katsadze, 2022; Akomea-Frimpong et al., 2022; Debrah et al., 2023).

This surge of academic interest has not only gained attention among financial actors, resulting in a more rigorous evaluation and underwriting process for green loans based on the latest

[35] LMA, 2018: https://www.lma.eu.com/application/files/9115/4452/5458/741_LM_Green_Loan_Principles_Booklet_V8.pdf

research findings, but has also sparked the interest of policymakers. The issuance of green loans in Europe and the United Kingdom is a topic that remains fraught with unanswered questions. Notably: Is there a standardized approach among European green loan issuers? If disparities exist, what drives these differences? And significantly, does financial development influence green loan issuance, and if so, how?

Recently, the European Banking Authority (EBA) received a Call for Advice[36] from the European Commission, set to be delivered by 29 December 2023. This call is centered around devising and recommending tools to support green loans and mortgages, especially for retail and SME borrowers. It encompasses areas such as the loan origination process, pre-contractual information, advice to borrowers, information required by the credit institution, advertising, product governance, and consumer protection. This call from the European Commission emphasizes the importance of establishing clear guidelines and protective measures for green loans, ensuring transparency, and bolstering consumer trust. As the realm of green finance grows, it is paramount to understand the nuances of its application across different European nations and ascertain if financial development plays a decisive role in the landscape.

With these considerations in mind, our research aims to shed light on potential fragmentation in green loan issuance among European countries and the United Kingdom. We endeavor to uncover the intricacies of this domain and offer insights that might guide future policy and industry practices. We propose to address this gap by examining whether a pattern of convergence emerges and by identifying potential clustering groups among European nations. The arguments are developed as follows. We first make the readers wonder why it is important to make a distinction between green loans and green bonds. Indeed, we offer a comparative analysis of those instruments, highlighting their unique characteristics and their pivotal roles in advancing sustainability within the financial sector.

After exploring the scale of green loans market among the EU countries and the U.K, we investigate the formation of clubs among issuers in the green lending by applying a convergence log-t-test to a panel dataset spanning from 2016 to 2022. Having defined four distinct groups that are converging along their own individual paths, with one group diverging from the others, we

[36] EBA (2022, p.4). Call for advice to the European Banking Authority on green loans and mortgages. Available at: https://www.eba.europa.eu/sites/default/documents/files/document_library/About%20Us/Missions%20and%20tasks/Call%20for%20Advice/2022/CfA%20on%20green%20loans%20and%20mortgages/1043881/EBA%20Call%20for%20Advice%20Green%20Loans%20and%20Mortgages_Clean.pdf

offer insights into the levels of green commitment experienced by countries.

We use ordered probit and logit models to assess green loan issuance patterns, considering market maturity, environmental aspects, and banking structures. Our panel data analysis includes the Pooled OLS and Population-averaged estimators, both with fixed and random effects. We also discuss potential regulatory measures, in line with the European Commission's recommendations (EBA, 2022), to boost private investment in sustainable ventures.

This study makes a contribution to the existing literature by introducing potential drivers for the convergence of the green loan market among European countries and the U.K. It represents the first known attempt to conduct such an analysis, adding to its novelty. The findings provide evidence of the complex relationships between market maturity, environmental considerations, and banking structures in promoting green finance. Furthermore, it marks the first known attempt to explore the potential impact of financial development on green loan issuance.

The remaining sections of the chapter are structured as follows: Section 3.2 discusses the institutional and legal differences between green loans and green bonds. Section 3.3 presents the data concerning the green loan market in the EU and the U.K. Section 3.4 presents the main findings, which include the results of the club convergence analysis, the ordered probit and logit models, and the OLS method. Lastly, Section 3.5 concludes highlighting its policy implications.

3.2 Institutional and Legal differences between green loans and green bond

In recent years, the field of sustainable finance has experienced significant expansion, marked by a growing emphasis on environmentally responsible investments (Migliorelli, 2021). Within this landscape, two prominent financial instruments, namely green loans and green bonds, have emerged as pivotal channels for directing capital towards environmentally friendly projects. Despite sharing the common objective of advancing sustainable development, these instruments exhibit notable distinctions concerning their market prominence, financial attributes, regulatory frameworks, liability mechanisms, and accessibility to diverse borrower profiles (McGarry et al., 2018). This section conducts a comprehensive comparative analysis of green loans and green bonds, highlighting their unique characteristics and their pivotal roles in advancing sustainability within the financial sector.

Green bonds have commanded substantial attention in capital markets for an extended period, capturing the interest of investors, issuers, and regulators alike (Alamgir & Cheng, 2023). These fixed-income securities have established a robust market presence, driven by substantial issuance volumes and diverse applications in project financing[37]. In contrast, green loans have remained relatively understated within the realm of sustainable finance. Despite their potential to address sustainability initiatives, green loans have not garnered the same level of recognition as green bonds (McGarry et al., 2018). Highlighting this disparity in market popularity is essential, as it reflects varying degrees of awareness and adoption among participants in financial markets.

A fundamental differentiation between green loans and green bonds pertains to their financial attributes. Just as in the broader financial market, where bonds are typically associated with larger denominations, longer tenors, and cater mostly to established entities (Zerbib, 2019), green bonds follow a similar trend. The latter, often issued in larger denominations and featuring extended tenors, predominantly cater to well-established entities and sizable projects. Furthermore, bonds, including green bonds, are often endowed with public credit ratings, which increases their visibility and appeal to institutional investors (Bhutta et al., 2022). On the other hand, loans (whether traditional or green) generally encompass smaller amounts and shorter tenors, targeting a different segment of borrowers. Green loans, in particular, exhibit these distinct financial dynamics, emphasizing the bespoke needs of borrowers. This divergence in financial characteristics between green loans and green bonds, mirroring the broader differentiation between traditional loans and bonds, underscores the significance of comprehending the specific requirements and contexts of prospective borrowers or issuers when navigating the choice between these two tools.

Another distinguishing factor between these instruments concerns their purpose and the utilization of proceeds. Green bonds are noted for their ring-fenced proceeds, wherein funds raised are explicitly earmarked for financing environmentally responsible projects. This earmarking of proceeds fosters transparency and accountability, guaranteeing that capital is directed towards predefined green initiatives (Flammer, 2021; Park, 2018). In contrast, green loans exhibit a higher degree of flexibility concerning their purpose. While certain green loans may involve funds disbursed contingent upon the borrower fulfilling specific environmental commitments, others may be allocated for general purposes. Borrowers are incentivized with reduced funding costs,

[37] ICMA (January 2022). The GBP Guidance Handbook. Available at: https://www.icmagroup.org/assets/GreenSocialSustainabilityDb/The-GBP-Guidance-Handbook-January-2022.pdf.

contingent on the extent to which their business aligns with environmental criteria as assessed by lenders over a specified timeframe (Chan, 2021; Gilchrist et al., 2021; McGarry et al., 2018). This uncertainty in the utilization of green loan proceeds accommodates a broader spectrum of projects and borrowers, rendering green loans a versatile option within the domain of sustainable finance.

Furthermore, green bonds have benefited from the establishment of recognized and standardized principles, exemplified by the Green Bond Principles (GBP), which function as benchmarks for issuers when structuring green bonds. These principles foster consistency, streamline tracking processes, and promote mutual recognition across markets, playing a pivotal role in the global expansion of the green bond market and instilling confidence among both investors and issuers. In contrast, green loans lack universally recognized principles, resulting in a more diverse array of structures (McGarry et al., 2018). The Green Loan Principles (GLP), introduced by the Loan Market Association (2018) serve as a framework to facilitate and support environmentally sustainable economic activities (LSTA University, 2023). These principles, built upon the foundation of the GBP, aim to create consistency within financial markets. The GLP provides voluntary guidelines applicable on a case-by-case basis to categorize a loan as green, encompassing four essential components: use of proceeds, process of project evaluation and selection, management of proceeds, and reporting. While applying use of proceeds rules akin to green bonds may be feasible for some green loans, it becomes more complex for multiple-use revolving credit facilities. Consequently, specific guidelines tailored to these instruments need to be developed, reflecting the evolving nature of the green loans market (McGarry et al., 2018).

The matter of liability concerning non-compliance with environmental commitments and sustainability targets holds significant importance within the realm of green finance. Green loans and green bonds employ distinct mechanisms to address this issue. In the case of former, borrowers may face explicit consequences for non-compliance. For instance, failing to allocate loan proceeds for green purposes can trigger an event of default or lead to built-in penalties until the breach is rectified (Chan, 2021; Lupo-Pasini, 2022; Ozili, 2022). In cases of non-compliance, green bonds typically rely on legal actions, such as misrepresentation claims. Bondholders may pursue legal remedies if issuers fail to uphold their commitments (McGarry et al., 2018). This divergence in liability mechanisms reflects the contrasting nature of green loans, often involving bilateral contracts, and green bonds, which are widely held instruments characterized by complex legal structures.

Additionally, both instruments differ significantly in terms of accessibility and suitability

for various borrowers and projects. Green bonds, with their larger denominations and longer tenors, are well-suited for established entities and large-scale projects, attracting institutional investors seeking stable, long-term investments with dedicated green proceeds (Flammer, 2020). In contrast, green loans adopt a more inclusive approach, catering to a broader spectrum of borrowers, including SMEs and individuals (Li et al., 2018). Their smaller loan amounts and shorter tenors enhance accessibility for entities with diverse financing requirements (McGarry et al., 2018). Furthermore, the inherent flexibility of green loans enables them to adapt to the unique circumstances of borrowers, reflecting a more personalized approach to sustainable financing.

Notably, a distinctive feature of green loans is the potential for interest rates to be directly linked to a borrower's overall sustainability performance as a company (Lupo-Pasini, 2022). This innovative approach contrasts with green bonds, where investment returns are not directly influenced by environmental factors. For example, certain green loans may tie interest margins to key performance indicators (KPIs) related to sustainability. Meeting these KPIs may result in a decrease in the loan's interest rate (Lupo-Pasini, 2022), incentivizing borrowers to invest in sustainability initiatives to reduce their interest expenses. These mechanisms encourage companies to adopt greener practices throughout their operations, aligning financial incentives with environmental commitments.

Despite the exponential growth in the utilization of green loans over the years, the absence of regulatory mandates for banks to disclose green lending makes it challenging to ascertain the precise size of the green loan market (Gilchrist et al., 2021). In the following section, we attempt to quantify the scale of this market within the EU countries and the U.K.

3.3 The green loans market in EU countries and the U.K.

To understand the basic features and trends in the issuance of green loans within the EU20[38] and the U.K., we began our analysis with some descriptive statistics. We sourced our loan data from Refinitiv Advanced Search – Government and Corporate loans database. Since the green loan market started in 2016, we extract all the green lending with the country of issue, between January 1, 2016, and December 31, 2022. For precise differentiation between green loans and conventional ones, we employed Refinitiv filter "Market Segment: Green Loans". This yields a total of 903 green loans.

In the following, we initially outline the progression of the green loan market over the years. Table 1 presents data on the issuance of green loans on an annual basis. The first column indicates the amount of green loans issued in billions of euros (with foreign currencies converted to euros), while the second column represents the number of green issued.

Table 1

Green Loans over time

Year	Issuance of Green Loans (€B)	Number of Green Loans
2016	0.90	10
2017	1.75	14
2018	12.83	67
2019	18.87	108
2020	25.09	154
2021	29.25	212
2022	61.06	338
Total	149.76	903

Note: This table reports the amount in billion EUR, and the number of green loans issued on an annual basis. The data set includes green issues in Refinitiv issued for the above-mentioned countries between January 1, 2016, and December 31, 2022.

Over the course of 7 years, the issuance of green loans has experienced a remarkable surge,

[38] EU20 includes Austria, Belgium, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, Sweden. No green loans were issued by Czech Republic, Bulgaria, Estonia, Latvia, Malta, Slovakia, and Slovenia in the chosen period.

increasing from 0.9 €B in 2016 to 61.06 €B in 2022.

Table 2 presents summary statistics for each individual country with a granular perspective on the issuance of green loans from 2016 to 2022. At a glance, the dominance of certain countries in the green lending arena is evident. The United Kingdom emerges as the paramount leader with €43.23 billion in green loans, a value that is notably higher than any other country in the list. Moreover, while Spain leads in terms of the sheer number of green loans at 231, its aggregate loan amount (€27.64 billion) is significantly lesser than the U.K., suggesting larger individual loan values in the U.K. France and Germany present comparable figures in terms of loan amount, with Germany having a more concentrated portfolio, given its 57 green loans compared to France's 103. This hints at Germany's preference or ability to fund more sizable projects on average. On the other end of the spectrum, countries like Cyprus, Lithuania, and Romania have the least green loan issuances, both in terms of number and value. These countries could potentially represent emerging markets for green lending, or they might have alternative financing mechanisms outside the purview of green loans. Italy is also noteworthy. While it ranks third in terms of volume with 135 green loans, its total value (€10.50 billion) does not match the scale of the top leaders, indicating smaller average loan values.

Overall, the variance in numbers underscores the heterogeneity in green lending practices, preferences, and opportunities across European nations. These patterns might be influenced by factors such as the country's overall economic health, policy landscape, investor appetite, and environmental consciousness.

Table 2

Green Loans across Countries

Country	Issuance of Green Loans (€B)	Number of Green Loans
Austria	1.45	9
Belgium	2.57	14
Croatia	0.13	4
Cyprus	0.50	1
Denmark	1.21	7
Finland	1.67	8
France	18.30	103
Germany	18.49	57
Greece	0.25	6
Hungary	2.30	5

Country	Issuance of Green Loans (€B)	Number of Green Loans
Ireland	0.88	6
Italy	10.50	135
Lithuania	0.17	4
Luxembourg	3.74	26
Netherlands	4.25	35
Poland	0.65	14
Portugal	4.17	18
Romania	0.14	3
Spain	27.64	231
Sweden	7.53	39
United Kingdom	43.23	178
Total	149.76	903

Note: This table reports the amount in billion EUR, and the number of green loans issued by the country. The data set includes green issues in Refinitiv issued for the above-mentioned countries between January 1, 2016, and December 31, 2022

Figure 2 displays a visual representation of the data presented in Table 2. Panel A represents the euro amount of green loan issuance, while panel B represents the number of green loans issued. Darker shades in the visualization indicate higher levels of issuance and a larger number of green lending. The overall pattern highlights United Kingdom, Spain, Germany and France as the primary issuers. The remaining European countries exhibit a more fragmented distribution of green loan issuance. In the following section, we explore possible reasons behind this fragmentation and the impact of financial development on green loans.

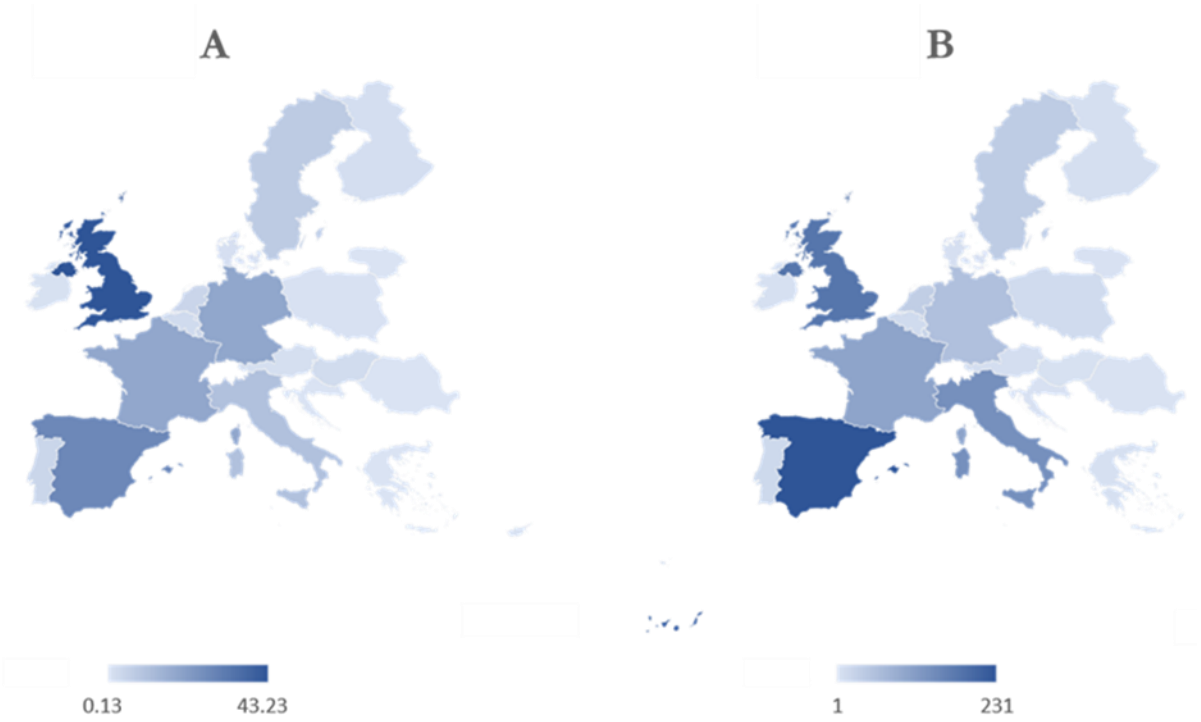

Fig. 2. Green loans across countries. **Panel A**, Green loans issuance in billion EUR. **Panel B**, Number of Green loans.

Notes: This figure reports the prevalence of green loans across countries. Darker-shaded areas represent higher issuance amounts in billion EUR (A) and a higher number of green loans (B), respectively. The underlying statistics are provided in Table 2.

3.4 Empirical investigation

This section of the study aims to address this gap by examining whether a convergence pattern can be observed and identifying potential clustering clubs among European nations. We begin by presenting our methodology (4.1) and then provide a comprehensive discussion of the main findings regarding club convergence (4.2). Subsequently, we aim to offer insights into the potential factors influencing club membership (4.3). Finally, we explore the potential impact of financial development on green loans (4.4).

3.4.1 Methodology

To investigate the club convergence across European countries and the U.K. in adopting a green finance emissions strategy, we apply the log t-test as developed by Phillips and Sul (Phillips & Sul, 2007). The approach identifies club convergence groups that move towards distinct equilibria or steady states, without making any specific assumptions about the stationarity of trends or the non-stationarity of stochastic processes (Okazaki & Sakai, 2020).

Let y_{it} denote the amount green loans issued of country $i=1,..., N$ at time $t=1,..., T$.

Adhering closely to the methodology outlined by Phillips and Sul, we make the assumption that y_{it} can be modeled as a nonlinear common-factor model that varies over time, such that:

$y_{it} = \delta_{it}\mu_t$

where μ_t is a single common component and δ_{it} is a time-varying idiosyncratic element, which captures the deviation of country i from the common path δ defined by μ_t.

Given that the number of parameters exceeds that of observations, Phillips and Sul eliminate the common component μ_t through rescaling by panel average:

$$h_{it} = \frac{y_{it}}{1/N \sum_{i=1}^{N} y_{it}} = \frac{\delta_{it}}{1/N \sum_{i=1}^{N} \delta_{it}}$$

where the panel average $N^{-1} \sum_{i=1}^{N} \delta_{it}$ and its limit as $N \to \infty$ both exist and differ from 0.

To test for convergence, Phillips and Sul (2007) assume that δ_{it} has the following transition form:

$$\delta_{it} = \delta_i + \sigma_i \xi_{it} L(t)^{-1} t^{-\alpha}$$

where δ_i is fixed, $\sigma_i > 0$ is an idiosyncratic scale parameter, ξ_{it} is iid $(0, 1)$ with finite fourth moment

over i, L(t) is a slowly varying function and α is the decay rate. Since all countries will converge to the same steady state if $\delta_{i,t+k} = \delta \; for \; all \; i$, which holds if and only if $\delta_i = \delta$ for all i and $\alpha \geq 0$, the null hypothesis of convergence is as follows:

$$H_0: \delta_i = \delta \; for \; all \; i \; and \; \alpha \geq 0$$

and the alternative:

$$H_A: \delta_i = \delta \; for \; all \; i \; and \; \alpha < 0$$

These hypotheses are tested using the following "log t" regression model (Phillips & Sul, 2007)

$$log(H_1/H_t) - 2logL(y) = \hat{c} + \hat{b} \, log t + u_t$$

where $log(H1/Ht)$ is the cross-sectional mean square transition differential and measures the distance of the panel from the common limit; and $t = [rT], [rT] + 1, \ldots, T, with \; r > 0$.

3.4.2 Club convergence

One of the most important questions to answer when analysing economic patterns among European nations is whether there is any convergence or clustering tendencies. Understanding these tendencies is crucial as it sheds light on economic integration, policy alignment, and the potential for shared green loans trajectories. To investigate this, this subsection examines potential convergence patterns and identifies potential clustering clubs among European nations. Our analysis utilizes a sample comprising 20 European countries and the U.K., covering the period from 2016 to 2022. Notably, Czech Republic, Bulgaria, Estonia, Latvia, Malta, Slovakia, and Slovenia are excluded from our analysis due to the absence of green loan issuance during the selected period. To ensure comparability, we convert all currencies to euros using the Refinitiv filter. Our panel dataset consists of the total value of green loans (GL) issued in euros, for each country and each year.

Table 4 presents the results of the convergence log-t-test applied to the amount of GL. The time series data undergo the Hodrick-Prescott filter to remove any seasonal or cyclical factors. The test rejects the hypothesis of overall convergence at a statistically significant level of 1%.

Table 4

Convergence Club Classification

Club	Coefficient	T-stat	Club members
Full sample	-1.0424	-74.570	
Club 1	0.168	3.989	France, Germany, Spain, United Kingdom
Club 2	0.115	0.827	Hungary, Italy, Sweden
Club 3	0.323	8.162	Austria, Denmark, Finland, Luxembourg, Poland, Portugal
Club 4	0.538	27.984	Croatia, Cyprus, Greece, Ireland, Lithuania, Romania
Not convergent	-7.709	-5.422	Belgium, Netherlands

Note: Log (t) results for convergence in green loans amount for the above-mentioned countries between January 1, 2016, and December 31, 2022. The null hypothesis of convergence is rejected at the 5% level if T-stat < -1.65. In our case, the null hypothesis of convergence is rejected at the 1% level because T-stat = - 74.570

Four distinct clubs have been identified based on the analysis: the first group consists of four countries, the second group comprises three countries, the third group includes six countries, and the fourth group is composed of six countries. However, it is important to note that there are two countries that do not belong to any specific group and diverge from the identified clubs.

As observed by Phillips and Sul (Phillips & Sul, 2009) as well as Lyncker and Thoennessen (2017) and Mendez (2020), it is possible for the convergence club algorithm proposed by Phillips and Sul in 2007 to overestimate the number of clubs. To tackle this problem, it is suggested to conduct a sequential merging test among the clubs. The outcome of this test is displayed in Table 4.1. Even though all the coefficients exhibit negative values, the primary parameter for assessing club convergence is the t-statistic. If this statistic falls below -1.65, the null hypothesis of convergence can be rejected. The null hypothesis of convergence can be rejected between the merge between Club 1 and 2 (-22.010 < -1.65), Club 2 and 3 (-13.287 < -1.65) and Club 3+4 (-11.501 < -1.65).

Table 4.1

Club merge test

Statistic	Club 1+2	Club 2+3	Club 3+4
Coeff	-0.608	-0.794	-0.474
T-stat	-22.010	-13.287	-11.501

Following these criteria, the results highlight that no clubs can be merged. This underscores the robustness of the four clubs identified in the analysis, as presented in Table 4. The final composition of each group, as well as the separate countries, is illustrated in Figure 3.

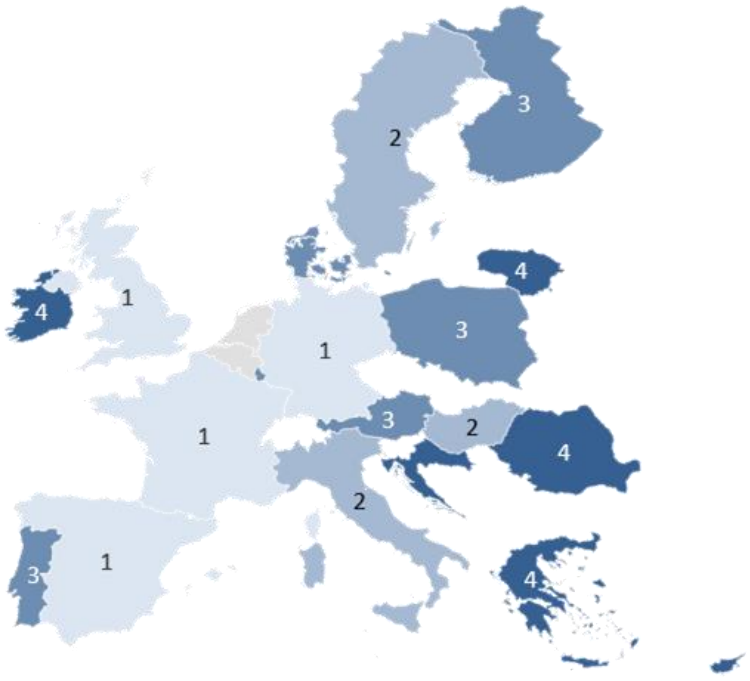

Fig. 3. Club Convergence.

The result of the log t-test for club 1 is 0.168 with a statistical value t of 3.989 so the null hypothesis of convergence is not rejected and France, Germany, Spain, and United Kingdom converge according to the log t-test. Analogously, the log t-tests provide evidence of convergence of the other clubs. Club 2, whose t-test is 0.115 with a statistical value t of 0.827 is composed of Hungary, Italy, and Sweden. Club 3 leads to a similar outcome, whose value of the log t-test is 0.323 with a statistical value of t of 8.162. This is the reason why the null hypothesis of convergence of Austria, Denmark, Finland, Luxembourg, Poland, and Portugal is also not rejected. Club 4 results in a value of 0.538 for the log t-test and a statistical value t of 27.984, so the null hypothesis of convergence is not rejected and Croatia, Cyprus, Greece, Ireland, Lithuania, and Romania converge.

3.4.3 Club membership

In this subsection, we attempt to shed some light on the potential drivers of club membership. The main goal is to test whether green loan issuance patterns across clubs are influenced by market maturity, environmental considerations, and banking structures. As suggested by Bartkowska and Riedl (Bartkowska & Riedl, 2012), we perform an ordered logit with the standard error that is robust, to explain club membership of the four convergence clubs, denoted by the ordinal variable c (McKelvey & Zavoina, 1975). Following Bartkowska and Riedl (Bartkowska & Riedl, 2012), We can model the dependent variable as an ordinal variable since convergent clubs can be ranked according to the amount of green loans each country in the respective club has issued. We assume that there exists a continuous latent variable that is associated with club membership, given that we do not have knowledge of the variations in steady-state levels between different clubs, y*, such that:

$$y_i^* = X_i\beta + \varepsilon_i$$

where X are the explanatory variables in the initial period, and ε are the errors with a mean of zero and a variance of $\pi^2/3$. Due to the few observations, it is not possible to include a large set of variables. Hence, in what follows we adopt a parsimonious specification of the regression model to maintain enough degrees of freedom (Brosio et al., 2022). Belgium and the Netherlands are assigned to Club 4 and Club 2, respectively, based on an evaluation method considering the clubs that would have formed from 2017 to 2022. To ensure the robustness of the analysis, the regressions are tested with and without these two countries[39]. The results show consistency, with no significant changes.

Table 5 presents the descriptive statistics for the data employed. Previous studies demonstrate that the size of the domestic currency bond markets tends to be larger in economies with higher stock market capitalization (Claessens et al., 2000; Tolliver et al., 2021). Does a similar relation hold for the green loans market as a club determinant? Therefore, we assess the positive relationship between green loans and the financial market structure using as a proxy Market Capitalization. Data are obtained from the World Bank's World Development Indicators (2019) and represents the value of stocks traded as a percentage of GDP for each country in 2016.

To assess the significance of environmental impact in the decision-making process for

[39] Please refer to the Stata Do-file for the version without these two countries

green issuance, we use the Ecological Footprint (EF) following Ulucak et al. (2020), and Arogundade et al. (2023). The EF quantifies the amount of land and water needed to sustain the resources consumed by an individual, population, or activity, along with the urban infrastructure it occupies and the waste it produces, given the current technology and resource management practices. The EF is an exhaustive framework for evaluating the consumption of natural resources by a population, as well as the effect of anthropogenic activities on nature. The dataset is produced by the Ecological Footprint Initiative of York University in collaboration with the Global Footprint Network[40], which provides data on EF Consumption expressed as global hectares per person for 2016.

To examine the role of bank structure in promoting (or potentially hindering) green financing, we have chosen to use bank concentration as a proxy. Bank concentration, defined here as the share of total assets held by the five largest banks at the country level in 2016, serves as a useful indicator for several reasons. First, higher bank concentration could imply that a small number of large banks have a dominant influence over the banking sector, potentially leading to more standardized practices across the industry. These large banks, due to their size and resources, might be more capable of investing in and promoting green financing initiatives. Second, in markets with lower bank concentration, where smaller and potentially more numerous banks operate, there might be greater diversity in banking practices. This could lead to either more innovation and adoption of green financing, as smaller banks seek competitive advantages, or less adoption, if these banks lack the resources to invest in new initiatives.

By choosing 2016 as our reference year, we aim to capture the bank structure at a specific point in time to analyze its potential impact on green financing trends in the subsequent years. This approach helps us to establish a baseline for our analysis and ensures consistency across the countries included in our study. This data is provided by the Global Financial Development Indicator archived in the World Bank database. Following the literature (Karadima & Louri, 2021), as a robustness check, we assess the reliability of our regression results by employing a stricter alternative measure, which involves examining the assets of the three largest commercial banks as a share of total commercial banking assets. The findings are consistent, with no variations.

Furthermore, we delve into the relationship between bank efficiency and the issuance of green loans. Previous research has consistently highlighted that efficient banks exhibit superior performance across various metrics, not just in terms of profitability but also in areas like

[40] https://www.footprintnetwork.org/resources/data/

innovation, risk management, and product diversification (Abd Karim et al., 2010; Lin & Zhang, 2009; Louzis et al., 2012; Ozili, 2019). Given this foundation, it is plausible to hypothesize that bank efficiency, which is indicative of a bank's adeptness in managing resources and adapting to market needs, might also influence its inclination towards issuing green loans

To measure bank efficiency, we use the bank cost-to-income ratio expressed as a percentage. For a robustness check on the financial stability of the bank structure, we consider two alternative measures provided by the WB database in place of bank efficiency: deposit money bank assets to GDP, serving as an indicator of the size and significance of the banking sector relative to the overall economic activity of a country in 2016, and bank regulatory capital to risk-weighted assets. The latter ratio evaluates a bank's financial strength and its capacity to absorb losses, representing the relationship between a bank's regulatory capital and its risk-weighted assets. However, for this measure, due to variances in national accounting, taxation, and supervisory regimes, the data might not be directly comparable across countries. Appendix A (3.1) presents the robustness check.

Table 5

Covariate-level descriptive statistics

	Mean	**StD**	**Min**	**Max**
Market capitalization (% of GDP)	56.868	40.213	8.989 (Lithuania)	139.104 (Sweden)
Ecological Footprint (gha per capita)	5.135	2.231	1.492 (Spain)	12.783 (Luxembourg)
Bank concentration (%)	68.612	15.662	33.525 (Luxembourg)	98.184 (Greece)
Bank cost to income ratio (%)	60.026	10.663	46.435 (Lithuania)	84.022 (Germany)
Deposit money banks' assets to GDP (%)	97.830	39.180	17.174 (Cyprus)	176.251 (Denmark)
Bank regulatory capital to risk-weighted assets	19.572	3.905	12.273 (Portugal)	26.941 (Ireland)

Since y_i^* is not observable, we compute the probabilities of belonging to a specific club, c, given the set of covariates X by performing a maximum likelihood technique. To prevent

possible cases of heteroscedasticity we use the ordered logit model with the standard error that is robust to misspecification. As a robustness check of our empirical estimation, we followed Johnston et al. (Johnston et al., 2020)and used the ordered probit model with the robust standard error.

Table 6 displays the marginal effects of the predicted probabilities of variables in predicting club membership[41]. The marginal effects assess how the probability of belonging to a club change when one of the independent variables is changed by one per cent (Market capitalization, Bank concentration, Bank cost to income ration) or by one unit (Ecological footprint), while all other variables are held constant at their sample averages. In other words, the coefficients indicate how much the probability of being a member of a particular club would alter with a slight variation in the covariates.

Table 6

What determines membership in the Green Loan Club? Marginal effects on probabilities with robust SE.

		Ordered logit model		Ordered probit model	
Variables	**Club**	**dy/dx**	**Std. Err.**	**dy/dx**	**Std. Err.**
Market capitalization	1	0.006***	0.001	0.006***	0.001
	2	0.002	0.001	0.002	0.002
	3	0.004**	0.001	0.003*	0.002
	4	-0.012***	0.002	-0.012***	0.002
Ecological Footprint	1	-0.058***	0.009	-0.056***	0.009
	2	-0.020	0.016	-0.023	0.017
	3	-0.033*	0.016	-0.028	0.017
	4	0.111***	0.027	0.108***	0.027
Bank concentration	1	-0.006***	0.002	-0.006***	0.002
	2	-0.002	0.002	-0.002	0.002
	3	-0.003*	0.002	-0.003	0.002
	4	0.012***	0.004	0.011***	0.004
Bank cost to income ratio	1	0.015***	0.002	0.015***	0.002
	2	0.005	0.004	0.006	0.004
	3	0.008**	0.004	0.008**	0.004
	4	-0.029***	0.003	-0.029***	0.003

*** Significance at 1%, **Significance at 5%, *Significance at 10%.
Appendix A (3.1) displays the table with the alternative measure used in substitution for the Bank cost-to-income ratio

[41] We acknowledge that additional potential covariates could be used to capture the complexity of the green loan issuing decision, but we are forced to adopt a parsimonious specification due to the small dimension of the sample.

One of the foundational assumptions in ordered logistic (and ordered probit) regression is that the relationship between each pair of outcome groups remains consistent. This means that ordered logistic regression operates on the premise that the slope of the logistic function is uniform across all categories. We evaluate the assumption of proportional odds by conducting an approximate likelihood-ratio test using the Stata command *omodel*. Under the null hypothesis, we test for disparities in coefficients between groups, and we deem the assumption valid if we obtain a non-significant result. The results chi2(8) = 11.08; Prob >chi2= 0.1974 suggest that the proportional odds approach is reasonable since the chi-square test is not significant (Wolfe, 1997). The robustness check for probit regression yields similar findings.

Analysing the factors influencing green loan issuance across various country clubs reveals intricate relationships. A one percentage increase in stock market capitalization relative to GDP corresponds to 0.006 points increase in the probability that a country belongs to Club 1, the highest green loan issuer (p-value of 0.000). This suggests that nations with larger and more mature stock markets have a more proactive approach to issuing green loans, underlining the importance of a developed financial system in sustainable finance integration. For Club 2 the effect is positive but not statistically significant, with a p-value of 0.159, indicating that the observed relationship could be due to random chance. For Club 3, a positive effect is observed, and it's statistically significant at the 5% level with a p-value of 0.043, indicating moderate evidence against the null hypothesis. For Club 4, the effect is negative and highly statistically significant with a p-value of 0.000. The negative relationship suggests that as stock market capitalization increases, the likelihood of a country belonging to Club 4 decreases, the lowest green loan issuer.

In contrast, the ecological footprint per capita presents an anomaly[42]. With each increase, there is a marked decrease in the likelihood of high green loan issuance in Club 1, p-value of 0.000, hinting at a potential gap between environmental concerns or impact and green loan financing. For Club 2, the effect is negative but not statistically significant, with a p-value of 0.208. For Club 3, the effect is negative with a p-value of 0.051, meaning it is just above the conventional significance level of 0.05, which may suggest a borderline significance. For Club 4, the positive relationship indicates that as the ecological footprint per capita increases, the likelihood of a country being in Club 4 also increases. This relationship is highly statistically significant, with a p-value of 0.000.

[42] The word 'anomaly' is used when comparing the main finding of the Ecological Footprint presented in second paper of my dissertation, titled: Green Debt: Do European countries' green bond issuances converge?

The higher the ecological footprint consumed per person, the greater the likelihood that a country belongs to the group with the lowest green loan issuance.

The banking sector's structure also plays a role. For every percentage increase in bank concentration, there is a decrease in the probability of high green loan issuance for Club 1, p-value of 0.000, indicating that countries with a few dominant banks might face challenges in diversifying their loan portfolios to integrate green loans. For Club 2, the effect is negative but not statistically significant, with a p-value of 0.234. For Club 3, the negative relationship has a p-value of 0.080, suggesting it is nearly significant at the 10% level. For Club 4, the implication of the positive effect is that as the concentration in the banking sector increases, a country is more likely to belong to Club 4, the club with the lowest green issuance. This effect is significant, with a p-value of 0.003.

Yet, the bank cost-to-income ratio offers a peculiar insight. An increase in this percentage ratio, which might indicate inefficiency, interestingly correlates with a heightened probability of green loan issuance in Club 1 and a p-value of 0.000. It hints at the idea that some banks or regions might prioritize green financing, even if it is operationally costlier. For Club 2, the effect is positive but not statistically significant, with a p-value of 0.171. For Club 3, the positive relationship is statistically significant with a p-value of 0.016. For Club 4, the negative relationship suggests that as the bank cost-to-income ratio increases, the probability of a country being in Club 4 decreases. This is confirmed as highly significant with a p-value of 0.000.

However, some words of caution are needed. Green loan issuance patterns across countries paint a detailed picture, influenced by market maturity, environmental considerations, and banking structures. While these observations offer insights, identifying clear cause-and-effect relationships demands a closer look, especially considering the unique financial and environmental aspects of each country. In the following subsection, we investigate the impact of financial development on green loans starting from the green loan sample used in subsection 4.2.

3.4.4 Financial Development impact

Previous studies confirmed that financial development is particularly relevant for bank profitability and efficiency (Demirgüç-Kunt & Huizinga, 1998; O'Connell, 2023), and its importance has been highlighted by Claessens et al. (2000), Naceur and Omran (Naceur & Omran, 2011) and Ozili (2015). The level of financial development within a country is crucial because it can influence the domestic mobilization of resources necessary to address various crises, including those related to climate change (Naudé, 2009; Ozili, 2019). For instance, developed countries recovered more swiftly from the 2008 global financial crisis than less financially developed nations (Naudé, 2009). Despite the establishment of green principles and various national policy frameworks aimed at promoting green loan issuance the relative slow growth of green loans compared to green bonds remains a significant concern. This raises questions about the effectiveness of existing policy measures in encouraging green finance. We contend that assessing the level of financial development can provide valuable insights to enhance our understanding of the relatively growth of green loans.

We are interested in the cross-country impact of financial development on aggregate green loans. To explore this, we use a panel dataset that includes 19 European countries from 2016 to 2021. We have excluded the year 2022 and countries such as Cyprus and the United Kingdom due to data availability constraints. Data was obtained from the global financial development indicator in the World Bank database. While Appendix A (3.2) provides a full description of the variables, Table 7 displays a summary of the descriptive statistics.

Table 7

Descriptive statistics

	Obs.	**Mean**	**StD**	**Min**	**Max**
Financial Development	126	0.620	0.173	0.196 (Lithuania)	0.901 (Spain)
Bank credit to bank deposits	114	101.532	53.025	22.705 (Luxembourg)	297.096 (Denmark)
Bank non-performing loans to gross loans	104	6.501	9.2555	0.495 (Sweden)	45.572 (Greece)
Private credit by deposit money	120	84.362	35.955	24.735 (Romania)	166.561 (Denmark)
Bank Z score	124	17.559	11.632	5.122	57.441

	Obs.	Mean	StD	Min	Max
Government Effectiveness	126	1.135	0.579	(Lithuania) -0.257 (Romania)	(Luxembourg) 2.047 (Finland)

To investigate the impact of financial development on green loans, we aim to expand the existing literature on non-performing loans (NPL) to encompass green issuance. In doing so, we adopt a simplified version of the models used by Ozili (Ozili, 2015, 2019), Beck et al. (R. Beck et al., 2015), Louzis et al. (2012), and Dimitrios et al. (2016). Our hypothesis is that financial development and banking factors influencing non-performing loans may also have an impact on green loan issuance.

Several reasons explain why these factors may be interconnected. When the banking sector lacks adequate risk assessment mechanisms, it can lead to higher NPLs. Conversely, robust risk assessment practices can reduce NPLs. This risk assessment process can also influence the issuance of green loans. If banks improve their ability to assess the creditworthiness of green projects and borrowers, it can lead to more green loan issuance. Moreover, financial development affects interest rates and lending conditions. Lower interest rates and favorable lending terms can stimulate borrowing activity and reduce the likelihood of NPLs. These conditions can also encourage businesses to seek green loans for environmentally friendly projects, as the cost of borrowing becomes more attractive. Additionally, a well-developed financial sector tends to inspire greater investor and borrower confidence. When borrowers have confidence in the banking system, they are more likely to repay their loans promptly, reducing NPLs. This trust can also extend to green loans, as borrowers may have more faith in the financing of environmentally sustainable projects through established banks.

Developed financial markets often offer a broader range of risk mitigation tools, such as credit derivatives and insurance. These tools can help banks manage their exposure to NPLs and reduce losses. Similarly, banks can use these instruments to manage risks associated with green loans, making it more attractive for them to issue such loans. Moreover, a well-developed financial sector provides banks with access to several funding sources. This access can reduce their reliance on short-term and volatile funding, making them more resilient to economic shocks. Finally, the reputation of banks and their commitment to environmental, social, and governance (ESG)

principles can influence their NPLs and green loan issuance (Bătae et al., 2020). Banks that are perceived as responsible and sustainable may attract more green borrowers and investors, reducing NPLs and increasing the demand for green loans.

Green loan (GL) is estimated as a function of internal and external determinants while controlling for financial development which is the variable of interest. The model is expressed as:

$$Green\ Loan = \beta 0 + \beta 1\ Financial\ Development + \beta 2\ Bank\ credit\ to\ bank\ deposits + \beta 3\ Bank\ non\text{-}performing\ loans\ to\ gross\ loans + \beta 4\ Private\ credit\ by\ deposit\ money + \beta 5\ Bank\ Z\ score + \beta 6\ Government\ Effectiveness + e$$

The analysis estimates the impact of financial development on GL after controlling for some bank-level determinants and the financial structure of the banking sector across countries.

We control for two determinants that potentially influence the level of green loans at the bank level: Bank credit to bank deposits ratio (BCBD), which measures banking sector liquidity, and Bank non-performing loans to gross loans (NPL), which reflects the credit quality of banks' loan portfolios. We select BCBD because banking sector liquidity can influence a bank's ability and willingness to extend credit (Demirgüç-Kunt & Huizinga, 1998; European Commission. Directorate General for Energy. et al., 2022; Ozili, 2019). While liquidity can certainly influence a bank's lending decisions, it is not the only factor at play. High profitability might encourage banks to explore a variety of lending opportunities, green loans included. That said, a higher liquidity level can provide banks with the financial flexibility to explore and invest in newer, potentially riskier areas of lending, like green loans, which might be seen as less established compared to traditional loans. Our hypothesis posits that banks with higher liquidity might be more inclined to diversify their loan portfolio, and green loans could be one avenue of this diversification. As a result, we expect a positive relationship between BCBD and GL.

NPL serves as an indicator of a bank's asset quality. Furthermore, asset quality is a pivotal indicator of the performance of a country's banking sector, among other performance indicators (ECB, 2007; Laeven & Majnoni, 2003). We highlight the importance of NPL. This is because, as Nkusu (2011) points out, a high NPL ratio can impact a bank's capital buffers negatively and diminish its profitability. Banks with limited capital might be less inclined to issue new types of loans, such as green loans. Consequently, we expect a negative relationship between these variables.

Next, we incorporate a financial sector development indicator into the model, Private

credit by deposit money banks to GDP (PCDM), which represents the extent of financial intermediation. This indicator is measured as the private credit by domestic banks to GDP ratio (Čihák et al., 2012; Claessens et al., 2000). PCDM serves as a barometer of the depth of the financial sector in a particular country (Laeven & Levine, 2009). It signals the extent to which the private sector accesses bank credit, fundamental for economic activities, including green projects. A higher PCDM ratio might suggest a more mature financial sector where banks play a crucial role in channeling savings towards investments (Rajan & Zingales, 1998). In such an environment, the likelihood of green loans being part of the bank's portfolio might be higher due to a more diverse lending portfolio (Scholtens & Dam, 2007).

Next, we integrate a financial structure indicator into the model that represents bank stability in each country. The z-score index (Z-score) is commonly used in the literature to measure banking stability, as it captures the probability of default of a country's commercial banking system (Demirgüç-Kunt & Huizinga, 2010; Foos et al., 2010; Laeven & Levine, 2009; Ozili, 2018, 2019). Higher z-score values indicate increased banking stability, which often translates to a degree of risk aversion (Anginer & Demirguc-Kunt, 2014; Berger et al., 1995). When considering green loans, perceived as novel or unfamiliar, a stable bank might exhibit greater caution (Jeucken, 2001; Scholtens, 2006). This can lead to a potential inverse relationship between stability and the volume loans (Jeucken, 2001), green issuance included.

Finally, we introduce an institutional development indicator into our model: Government Effectiveness (GE). GE comprehensively assesses the quality of public services, the civil service's independence from political influences, the effectiveness of policy formulation and implementation, and the government's commitment to these policies. The quality and effectiveness of governmental institutions often shape the broader socio-economic and regulatory environment in which banks operate (Acemoglu et al., 2005; La Porta et al., 2002). This environment can subsequently influence a bank's willingness or ability to engage in certain types of lending, including green loans (Boot et al., 1993). An effective government, characterized by clear policy direction and commitment, can provide a more predictable regulatory landscape (Djankov et al., 2006). Such predictability is vital for banks when considering longer-term and potentially riskier investments, such as green projects (Scholtens & Dam, 2007). Therefore, we expect a positive relationship between government effectiveness and the lending decision (T. Beck et al., 2003).

The correlation matrix in Appendix A (3.3) shows that multicollinearity may be an issue in our analyses. Therefore, we run Variance Inflation Factor (VIF), which is a common method to

check multicollinearity (O'brien, 2007). A VIF value above 10 suggests multicollinearity. While PCDM has a VIF close to 10 (9.02), suggesting potential concerns, the other variables have VIF values well below 10, BCBD (3.68); FD (2.97), GE (2.67), Z-score (2.46), NPL (1.79) indicating moderate to low multicollinearity. The average VIF is also below 10 (3.77), suggesting that, on average, multicollinearity might not be a severe concern in this model.

Finally, the model is estimated using the Pooled OLS estimator, the Population-averaged estimator, without and with fixed effects, country and year fixed effect, and random effects.

Table 8

Regression results

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Coefficient (t-statistic)	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*
FD	1677.256**	1673.434**	-8442.325*	-6225.46	1422.189*
	(675.706)	(651.417)	(5012.9)	(5390.653)	(805.649)
BCBD	-6.480**	-6.503**	-25.292**	-39.410***	-7.936**
	(2.854)	(2.750)	(9.793)	(14.547)	(3.254)
NPL	-36.633***	-36.699***	-15.763	-3.246	-40.700***
	(10.700)	(10.311)	(32.716)	(33.927)	(12.337)
PCDM	15.946**	15.995***	37.540**	57.641***	19.079***
	(6.226)	(5.998)	(16.048)	(20.477)	(7.074)
Z-score	-18.916**	-18.949**	74.266	32.516	-20.735**
	(8.925)	(8.603)	(51.760)	(55.884)	(10.546)
GE	-635.128***	-635.826***	-1517.698	-1408.307	-681.370***
	(186.308)	(327.674)	(3158.059)	(955.383)	(222.352)
Constant	-14.796	-12.277	5507.212	4432.524	146.938
Fixed Effect (FE)	NO	NO	YES		NO
Country FE	NO	NO	NO	YES	NO
Year FE	NO	NO	NO	YES	NO
Random Effect	NO	NO	NO	NO	YES
Observation	92	92	92	92	92

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
	Coefficient (t-statistic)	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*	*Coefficient (t-statistic)*
Adj R-squared	0.278				
R-squared (Within)			0.286	0.363	0.158
R-squared (Between)			0.130	0.160	0.607
R-squared (Overall)			0.022	0.000	0.323
Sigma_u (a)			1862.797	1644.456	212.422
Sigma_e			594.263	579.166	594.263
Rho			0.908	0.889	0.115
Theta (median)					0.222

Columns (1)-(5) report regression results for countries starting from the analysis presented in Table 2, section 3. However, the U.K. and Cyprus are excluded due to missing values in the covariates for the period from 2016 to 2021. Results are in millions of euros. T-statistics are reported in parentheses. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively. The regression includes the Pooled OLS estimator (1), the Population-averaged estimator without fixed effects (2), with fixed effects (3), combined country and year fixed effects (4), and random effect (5). Standard errors are not clustered

Column 1 of Table 8 reports the regression results using the Pooled OLS estimator, while columns 2, 3, and 4 present the regression results for the Population-averaged estimator without fixed effects (column 2), with fixed effects (column 3), country and year fixed effect (column 4), and with random effects (column 5).

We apply the Hausman test (1978) for fixed versus random effects model and the Breusch-Pagan LM test (Breusch & Pagan, 1980) for random effects versus OLS. We evaluate the coefficient consistency in a regression model, distinguishing between fixed effects and random effects models based on the null hypothesis (H0) suggesting the appropriateness of the random effects model for the data. The decision to accept or reject H0 depends on the comparison of the p-value (Prob > chi2) to the common significance level, often set at 0.05. A p-value below this threshold leads to H0 rejection, implying unsuitability of the random effects model and preference for the fixed effects model due to statistically significant coefficient differences. Conversely, a p-value exceeding the significance level results in H0 acceptance, signifying the suitability of the random effects model, as the coefficient disparities lack statistical significance. In our analysis, the Hausman test yielded chi2(6) = 16.80 with a p-value (Prob > chi2) of 0.0100, falling below the 0.05 threshold, thereby supporting H0 rejection and endorsing the fixed effects model due to statistically significant coefficient differences.

In the remaining part of this section, we delve deeper into our results derived from a

specialized type of regression analysis: the fixed-effects regression (as shown in column 3 of table 8). This method allows us to account for variables that do not change over time, ensuring a more accurate representation of the data[43]. Through this approach, we can better isolate and understand the specific factors influencing our results

There are 92 total observations in the data, and 19 unique groups in the dataset. Countries such as Cyprus and the United Kingdom are excluded because of data availability constraints. Groups have between 3 and 5 observations, averaging 4.8 observations per group, which reflects few missing data. Moreover, 28.6 percentage of the within-country variation in green loans can be explained by the independent variables, 13.05 percentage of the between-country variation is explained by the independent variables. Overall, the independent variables explain 2.23 percentage of the variation in green loans. The F-statistic (4.48) tests if all the coefficients of the independent variables are zero. The p-value (0.0007) suggests rejecting this null hypothesis at any conventional significance level, implying that at least one predictor is significant in explaining the variation in green loans (in millions of euros).

For Financial Development, which ranges from 0 (lowest) to 1 (highest financial development), a shift from the lowest to the highest level is associated with a decrease of about €8,442 million in green loans (€ 8.44 billion). However, this is not statistically significant at the 5% level (p-value=0.097), though it is weakly significant at the 10% level. There are several potential reasons behind the observed inverse relationship. One possibility lies in mature financial systems in countries with advanced financial development. In such systems, there might be a preference for traditional or established forms of investments over green loans. Scholars like Rajan and Zingales (Rajan & Zingales, 1998) analysed how financial systems evolve and can potentially become resistant to change due to ingrained practices. Risk perception is another factor to consider; developed financial systems might perceive green loans or sustainable investments as riskier or less profitable in the short term compared to other opportunities. The regulatory environment may also play a crucial role; countries with well-developed financial systems might lack supportive regulatory measures for green initiatives. Indeed, countries with mature financial markets and institutions often have systems that evolved over extended periods, shaped by historical economic priorities and strategies (Rousseau & Sylla, 2003). These systems may have taken shape during times when

[43] For those familiar with the Stata software, we employed the *'xtreg'* command and used the *'fe'* option to conduct this analysis.

environmental concerns were not as pronounced as they are today. Consequently, the regulatory framework could align more with traditional industries and financial practices than with contemporary green or sustainable initiatives. Furthermore, the economic structure in countries experiencing high financial development might have major industries that do not focus on green practices, leading to diminished green lending activities. It is noteworthy to mention the statistical significance of this relationship. In our dataset, while the inverse relationship is not statistically significant at the 5% level, it demonstrates weak significance at the 10% level. This suggests that the observed relationship might be influenced more by random variation in the data than by a genuine underlying relationship.

Private credit by deposit money represents the financial resources provided to the private sector by domestic money banks as a share of GDP. A one percentage increase in this metric is associated with an increase of €37.54 million in green loans. This effect is statistically significant at the 5% level (p-value=0.022). One potential explanation for the observed positive relationship is the increase in financial capacity within the private sector. As the private sector gets more credit relative to GDP, it suggests that there is more financial activity and possibly more liquidity in the market. With more funds available, there might be more willingness or ability for banks or financial institutions to allocate resources (Maksimovic et al., 2000), green investments included. Another reason could be tied to risk diversification strategies employed by banks. As financial institutions provide more credit, they might attempt to diversify their loan portfolios to hedge against potential market downturns (Scholtens, 2006). Green loans, in this context, can offer a special avenue for diversification, given that their performance could deviate from traditional loans, especially in economies that are progressively shifting towards environmentally friendly initiatives. Another reason could be reputation and branding, as sustainability becomes a more prominent global concern, many banks and financial institutions are focusing on green initiatives as part of their corporate social responsibility. This not only enhances their reputation but also their competitive advantage becoming more appealing to environmentally-conscious investors and customers (Porter & Kramer, 2006).

Bank credit to bank deposits reflects the amount banks are extending as loans compared to the deposits they hold. When this lending measure rises by one percentage, we expect a decline of €25.29 million in green loans. This observation is statistically significant with a p-value of 0.012. It suggests that when banks lend more compared to their deposits, they might allocate fewer resources to green loans, possibly due to perceptions of risk.

The Bank non-performing loans to gross loans ratio provides insight into loans that are not being repaid on time. An increase of one percentage in this non-performing loan ratio leads to a decrease of €15.76 million in green loans. However, this correlation is not strongly supported by data, given its p-value of 0.632. The Bank Z score represents bank stability. Improved banking stability correlates with an increase of 74.26 million in green loans. However, this finding is not statistically strong, evidenced by its p-value of 0.156. Lastly, the Government Effectiveness measure, which varies between approximately -2.5 and 2.5, suggests that for each unit improvement in government efficiency, green loans decrease by €1,517 million (€1.51 billion). But this association is not statistically robust, as reflected by its p-value of 0.115.

In the next section, we conclude our analysis by drawing two main policy implications derived from the findings of section 3.4.

3.5 Discussion, and concluding comments

This chapter investigates whether any convergence occurred among European countries and the U.K. in the euro amount of green loans issued during the period of 2016-2022. To this end, a convergence log-t test has been performed on a panel of 20 European countries and the U.K. The results show that four clubs converge and one divergent. Hence, we perform an ordered regression model to capture potential drivers of club membership. Market maturity, environmental consumption, and banking structure appear to significantly influence the likelihood of club membership. The emergence of clubs signals the absence of a common European banking commitment for issuing green loans. Our results show that clubs of countries have adopted a common approach to green issued.

We attempt to shed light on the fragmentation of the EU green loan market by examining the economic, environmental consideration, and banking factors that contribute to it. As a result, our work addresses this issue directly from an inferential perspective. Countries with a higher stock market capitalization relative to their GDP are more likely to belong to Clubs 1 and 3 and less likely to be in Club 4. This could indicate that countries with more mature and larger stock markets relative to their economic size are typically among the more economically developed and influential green issuers. Countries with a higher ecological footprint per capita are less likely to be in Club 1

but more likely to be in Club 4. This may suggest that countries with a larger ecological footprint per person might be less stringent or less advanced in sustainable financial practices, aligning more with Club 4 countries. Bank concentration, higher bank concentration reduces the likelihood of a country being in Club 1 but increases it for Club 4. This might indicate differing financial structures among these clubs. Countries, where a few banks dominate, might have financial systems or regulations that are more characteristic of Club 4 nations. Bank cost-to-income ratio, a higher bank cost-to-income ratio, indicating possibly less efficient banking operations, increases the likelihood for a country to be in Clubs 1 and 3 and decreases it for Club 4. This suggests that Club 1 and 3 countries might have banking sectors facing higher operational challenges or different operational standards, with some banks prioritizing green financing even if it is operationally costlier compared to Club 4 countries.

Considering the presence of divergent characteristics among countries within the clubs outlined in sections 3.4.2 and 3.4.3, the policy implications derived from our empirical findings indicate a need for tailored policy approaches. While the one-size-fits-all approach may not be appropriate, policymakers should consider developing specific strategies for countries belonging to different clubs, applying a group policy perspective that accommodates many countries within the clubs (paraphs a sort of one-size-fits most). Club 1 and 3 countries may benefit from policies that address operational challenges and standards in their banking sectors to encourage green financing despite potential operational costs. Meanwhile, Club 4 countries may benefit from policies aimed at strengthening the market capitalization of their financial system. Policymakers should be aware that in countries where a few dominant banks hold significant market share, there may be challenges in diversifying loan portfolios to include green loans. To address this, measures should encourage and facilitate the participation of a broader range of financial institutions in green financing initiatives, promoting competition and innovation within the banking sector. This approach can help overcome barriers related to bank concentration and foster a more diverse and sustainable lending landscape.

Furthermore, subsection 3.4.4 reveals insights into the dynamics of green loan issuance with respect to financial and economic factors. Firstly, it highlights that financial development, as it progresses from its lowest to highest levels, exhibits a (weak) negative correlation with green loans. Possible explanations for this observation could revolve around mature financial systems favoring conventional investments over environmentally conscious ones, potentially influenced by prevailing risk perceptions within the financial landscape. When delving into the metrics associated

with private credit by deposit money, the data suggests a positive relationship, potentially reflecting increased financial capacity within the private sector, diversification strategies pursued by banks, and the conscious effort of certain financial institutions to build a reputable image through their commitment to green initiatives. Likewise, examining the inverse relationship between bank credit to bank deposits and green loans, we found that when banks extend their lending activities beyond the limits of their deposits, they allocate fewer resources toward green loans, possibly due to risk perceptions or a strategic shift towards conventional lending practices. However, we did not find any significant relationship among Bank Non-Performing Loans, Bank Z Score, and government effectiveness.

Considering the observed positive relationship between private credit by deposit money and green loans results of subsection 3.4.4, the policy implications derived from our empirical findings is promoting private sector involvement. This correlation underscores the pivotal role that the private sector can play in driving investments towards environmentally conscious initiatives. Thus, implementing measures that aim to enhance the financial capacity of the private sector. This can involve incentivizing private enterprises to invest in green projects, offering favorable terms and conditions for sustainable investments, and facilitating access to financing for environmentally friendly endeavors. Moreover, policymakers could work closely with financial institutions to develop strategies that promote a diversified portfolio of sustainable investments. This may include the creation of specialized green financing divisions within banks, offering training and guidance on green lending practices, and providing financial incentives for banks to allocate a certain portion of their resources to green loans. Additionally, the identified inverse relationship between bank credit to bank deposits and green loans in subsection 3.4.4 underscores the need for policymakers to carefully balance bank lending activities. While promoting green financing and sustainability is crucial, it is equally important to maintain a stable and resilient financial sector. Policymakers could mitigate the risk associated with an overconcentration of funds in anyone lending category by incentivizing diversification.

Our main recommendations align with the EU's commitment to increasing private capital inflow into sustainable investments. They emphasize the importance of a more inclusive sustainable finance framework that facilitates access to sustainable financing, including green loans and mortgages, for households and small businesses, as expressed in the recent Call for Advice to the European Banking Authority (2022).

Lastly, we decided to compare the convergence trends for green bonds (Chapter 2 – Table

4) and green loans (Chapter 3 – Table 4) to understand the emergence (or lack thereof) of a common trend in the green financing market.

In comparing the results of the two tables, significant variations in coefficients and T-statistics across different clubs reflect the convergence of various European countries. These tables are constructed based on two distinct financial instruments: green bonds in the first table and green loans in the second table. This analysis highlights the divergent and convergent trends among these countries, providing insights into the underlying dynamics of their green issues.

For the full sample, the first table indicates that the hypothesis of overall convergence is rejected at the 5% significance level if the T-statistic is less than -1.65. The T-statistic is -17.231, which is well below -1.65, leading to the conclusion that the test rejects the hypothesis of overall convergence with 1% statistical significance. Similarly, the second table, which is based on green loans, shows that the hypothesis of overall convergence is rejected at the 5% significance level if the T-statistic is less than -1.65. In this case, the coefficient is -1.0424 with an even more significant T-statistic of -74.570, leading to the conclusion that the test also rejects the hypothesis of overall convergence. The magnitude and significance in the second table are more pronounced, indicating a stronger rejection of the hypothesis of overall convergence. This implies that at the green loan market level, there is more fragmentation compared to the green bond level. The differences in the full sample results could be attributed to the distinct nature of green bonds and green loans. Green bonds typically have more stringent requirements and are often associated with larger, more structured projects, which leads to different economic impacts compared to green loans. The latter might be more flexible and accessible to a broader range of projects and borrowers.

Club 1 in the first table, which is calculated based on green bond issuance, includes France and Germany. It shows a log t-test result for Club 1 of -2.321, with a statistical t-value of -0.898. In contrast, Club 1 in the second table, based on green loan issuance and comprising France, Germany, Spain, and the United Kingdom, has a positive coefficient of 0.168 and a T-statistic of 3.989. This suggests a stronger convergence among European countries in the green loan market compared to the green bond market. The broader inclusion of countries in Club 1 within the context of green loans may indicate that green loans are more accessible and have a more immediate positive impact on the decision to issue and on economic convergence, compared to green bonds. Club 2 in the first table, which includes Austria, Belgium, Denmark, Ireland, Italy, Luxembourg, Netherlands, Spain, Sweden, and the United Kingdom and is based on green bond issuance, has a coefficient of -0.032 and a T-statistic of -0.305. This indicates weak convergence compared

to the results achieved in Club 2 of the second table. The latter, comprising only Hungary, Italy, and Sweden, has a positive coefficient of 0.115 and a T-statistic of 0.827. The change in member countries indicates a small shift towards a positive outcome, resulting in fewer countries with stronger convergence.

Similar considerations apply to Clubs 3 and 4, which account for 13 countries in the case of green bonds and 12 countries for green loans. The remarkable results are twofold. The first is the shift toward stronger convergence in the second case, with T-statistics of 8.162 and 27.984, indicating a more cohesive behaviour in green loan issuance. The second consideration is the shift in the countries that comprise the club memberships. Club 3 in the first table includes Finland, Hungary, Portugal, and Slovakia, while in the second table, Club 3 consists of Austria, Denmark, Finland, Luxembourg, Poland, and Portugal, based on green loan issuance. The inclusion of additional countries and the shift in membership have led to a stronger and statistically significant positive effect, indicating improved issuance convergence among these nations. The stronger positive impact in the second table might be attributed to the flexible nature of green loans, which can support a wider range of projects and investments compared to green bonds. The first table does not identify a non-convergent group, whereas the second table highlights a non-convergent group consisting of Belgium and the Netherlands, based on green loan issuance.

As a result, our analysis reveals the following trends. At overall level, there is more divergence in the green loans market than the green bonds market. This means that when considering the entire market, the adoption of green loans is more varied or spread out than that of green bonds. This divergence could be due to several factors, such as differences in loan terms, borrower profiles, regulatory environments, or market maturity. However, at the club level, there is more convergence in the green loans market than in the green bonds market, indicating that the performance or characteristics of green loans are becoming more similar within these smaller groups.

However, we remain cautious about interpreting our results in terms of causal effects. We emphasize the importance of further disentangling the green finance for the scholarly debate. We hope that future scholarship can build upon our results and refine the empirical analysis to ascertain the causality from financial institutions to countries' commitment to green finance. In a world characterized by growing environmental fragmentation, club decisions to issue green loans for ecological transition or adaptation are likely to persist in the future.

References

Abd Karim, M. Z., Sok, G. C., & Hassan, S. (2010). Bank efficiency and non-performing loans: Evidence from Malaysia and Singapore. *Prague Economic Papers*.

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Chapter 6 Institutions as a Fundamental Cause of Long-Run Growth. In P. Aghion & S. N. Durlauf (Eds.), *Handbook of Economic Growth* (Vol. 1, pp. 385–472). Elsevier.

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2022). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance & Investment*, *12*(4), 1241–1264.

Alamgir, M., & Cheng, M.-C. (2023). Do Green Bonds Play a Role in Achieving Sustainability? *Sustainability*, *15*(13), 10177.

Anginer, D., & Demirguc-Kunt, A. (2014). Has the global banking system become more fragile over time? *Journal of Financial Stability*, *13*, 202–213.

Arogundade, S., Hassan, A., Akpa, E., & Mduduzi, B. (2023). Closer together or farther apart: Are there club convergence in ecological footprint? *Environmental Science and Pollution Research*, *30*(6), 15293–15310.

Bartkowska, M., & Riedl, A. (2012). Regional convergence clubs in Europe: Identification and conditioning factors. *Economic Modelling*, *29*(1), 22–31.

Bătae, O. M., Dragomir, V. D., & Feleagă, L. (2020). Environmental, social, governance (ESG), and financial performance of European banks. *Accounting and Management Information Systems*, *19*(3), 480–501.

Beck, R., Jakubik, P., & Piloiu, A. (2015). Key determinants of non-performing loans: New evidence from a global sample. *Open Economies Review*, *26*, 525–550.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (2003). Law and finance: Why does legal origin matter? *Journal of Comparative Economics*, *31*(4), 653–675.

Berger, A. N., Herring, R. J., & Szegö, G. P. (1995). The role of capital in financial institutions. *Journal of Banking & Finance*, *19*(3), 393–430.

Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, *175*, 121378.

Boot, A. W. A., Greenbaum, S. I., & Thakor, A. V. (1993). Reputation and Discretion in Financial Contracting. *The American Economic Review*, *83*(5), 1165–1183.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. *The Review of Economic Studies*, *47*(1), 239–253.

Brosio, G., Pelosi, R., & Zanola, R. (2022). Short-term exit from pandemic restrictions: Did European countries' speed converge? *The European Journal of Comparative Economics*, *19*(2), 145–159.

Chan, R. (2021). Ensuring impactful performance in green bonds and sustainability-linked loans. *The ADELAIDE LAW REVIEW*, *42*(1), 221–258.

Čihák, M., Demirgüç-Kunt, A., Feyen, E., & Levine, R. (2012). Benchmarking financial systems around the world. *World Bank Policy Research Working Paper*, *6175*.

Claessens, S., Demirgüç-Kunt, A., & Huizinga, H. (2000). The role of foreign banks in domestic banking systems. In *The internationalization of financial services: Issues and lessons for developing countries* (pp. 117–138). Boston: Kluwer Academic Press.

Debrah, C., Chan, A. P. C., & Darko, A. (2022). Green finance gap in green buildings: A scoping review and future research needs. *Building and Environment*, *207*, 108443.

Debrah, C., Darko, A., & Chan, A. P. C. (2023). A bibliometric-qualitative literature review of green finance gap and future research directions. *Climate and Development*, *15*(5), 432–455.

Demirgüç-Kunt, A., & Huizinga, H. (1998). *Determinants of Commercial Bank Interest Margins and Profitability: Some International Evidence*. World Bank Publications.

Demirgüç-Kunt, A., & Huizinga, H. (2010). Bank activity and funding strategies: The impact on risk and returns. *Journal of Financial Economics*, *98*(3), 626–650.

Dimitrios, A., Helen, L., & Mike, T. (2016). Determinants of non-performing loans: Evidence from Euro-area countries. *Finance Research Letters*, *18*, 116–119.

Djankov, S., McLiesh, C., & Ramalho, R. M. (2006). Regulation and growth. *Economics Letters*, *92*(3),

D'Orazio, P., & Popoyan, L. (2019). Fostering green investments and tackling climate-related financial risks: Which role for macroprudential policies? *Ecological Economics*, *160*, 25–37.

ECB. (2007). *Guidance to banks on non-performing loans*.

European Banking Authority. (2022, November 22). *EBA seeks input from credit institutions on green loans and mortgages*. European Banking Authority.

European Commission. Directorate General for Energy., COWI., BPIE., Climate Strategy., d fine., EEIP., EnergyPro., Fraunhofer ISI., ICCS NTUA., & Viegand Maagøe. (2022). *The quantitative relationship between energy efficiency improvements and lower probability of default of associated loans and increased value of the underlying assets: Final report on risk assessment.* Publications Office.

Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. *International Journal of Green Economics*, *14*(2), 159.

Flammer, C. (2020). Green Bonds: Effectiveness and Implications for Public Policy. *Environmental and Energy Policy and the Economy*, *1*, 95–128.

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, *142*(2), 499–516.

Foos, D., Norden, L., & Weber, M. (2010). Loan growth and riskiness of banks. *Journal of Banking & Finance*, *34*(12), 2929–2940.

Gilchrist, D., Yu, J., & Zhong, R. (2021). The limits of green finance: A survey of literature in the context of green bonds and green loans. *Sustainability*, *13*(2), 478.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica*, *46*(6), 1251–1271.

Jeucken, M. (2001). *Sustainable finance and banking: The financial sector and the future of the planet*. Routledge.

Johnston, C., McDonald, J., & Quist, K. (2020). A generalized ordered Probit model. *Communications in Statistics - Theory and Methods*, *49*(7), 1712–1729.

Karadima, M., & Louri, H. (2021). Economic policy uncertainty and non-performing loans: The moderating role of bank concentration. *Finance Research Letters*, *38*, 101458.

La Porta, R., Lopez-De-Silanes, F., & Shleifer, A. (2002). Government Ownership of Banks. *The Journal of Finance*, *57*(1), 265–301.

Laeven, L., & Levine, R. (2009). Bank governance, regulation and risk taking. *Journal of Financial Economics*, *93*(2), 259–275.

Laeven, L., & Majnoni, G. (2003). Loan loss provisioning and economic slowdowns: Too much, too late? *Journal of Financial Intermediation*, *12*(2), 178–197.

Li, Z., Liao, G., Wang, Z., & Huang, Z. (2018). Green loan and subsidy for promoting clean production innovation. *Journal of Cleaner Production*, *187*, 421–431.

Lin, X., & Zhang, Y. (2009). Bank ownership reform and bank performance in China. *Journal of Banking & Finance*, *33*(1), 20–29.

Loan Market Association. (2018). *Green Loan Principles. Supporting Environmentally Sustainable*.

Louzis, D. P., Vouldis, A. T., & Metaxas, V. L. (2012). Macroeconomic and bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios. *Journal of Banking & Finance*, *36*(4), 1012–1027.

LSTA University. (2023). Guidance on Green Loan Principles (GLP). *LSTA*.

Lupo-Pasini, F. (2022). Sustainable finance and sovereign debt: The illusion to govern by contract. *Journal of International Economic Law*, *25*(4), 680–698.

Maksimovic, V., Beck, T., Demirgüç-Kunt, A., & Levine, R. (2000). *Financial Structure and Economic Development: Firm, Industry, and Country Evidence* (SSRN Scholarly Paper 632494).

McGarry, C., Bark-Jones, M., & Hauman, M. (2018). Green loans pave the way for green CLOs and green RMBS. *Banking LJ*, *135*, 177.

McKelvey, R. D., & Zavoina, W. (1975). A statistical model for the analysis of ordinal level dependent variables. *The Journal of Mathematical Sociology*, *4*(1), 103–120.

Mendez, C. (2020). Convergence Clubs in Labor Productivity. In C. Mendez, *Convergence Clubs in Labor Productivity and its Proximate Sources* (pp. 33–39). Springer Singapore.

Migliorelli, M. (2021). What do we mean by sustainable finance? Assessing existing frameworks and policy risks. *Sustainability*, *13*(2), 975.

Naceur, S. B., & Omran, M. (2011). The effects of bank regulations, competition, and financial reforms on banks' performance. *Emerging Markets Review*, *12*(1), 1–20.

Naudé, W. (2009). *The financial crisis of 2008 and the developing countries*. WIDER Discussion Paper.

Nkusu, M. M. (2011). *Nonperforming Loans and Macrofinancial Vulnerabilities in Advanced Economies*. International Monetary Fund.

O'brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality & Quantity*, *41*, 673–690.

O'Connell, M. (2023). Bank-specific, industry-specific and macroeconomic determinants of bank profitability: Evidence from the UK. *Studies in Economics and Finance*, *40*(1), 155–174.

Okazaki, T., & Sakai, K. (2020). *Capital Market Integration with Multiple Convergence Clubs: The Case of Prewar Japan*. The Canon Institute for Global Studies.

Ozili, P. K. (2015). How bank managers anticipate non-performing loans. Evidence from Europe, US, Asia and Africa. *Evidence from Europe, US, Asia and Africa*, 73–80.

Ozili, P. K. (2018). Banking stability determinants in Africa. *International Journal of Managerial Finance*, *14*(4), 462–483.

Ozili, P. K. (2019). Non-performing loans and financial development: New evidence. *The Journal of Risk Finance*, *20*(1), 59–81.

Ozili, P. K. (2022). Green finance research around the world: A review of literature. *International Journal of Green Economics*, *16*(1), 56.

Park, S. K. (2018). Investors as regulators: Green bonds and the governance challenges of the sustainable finance revolution. *Stan. J. Int'l L.*, *54*, 1.

Phillips, P. C. B., & Sul, D. (2007). Transition Modeling and Econometric Convergence Tests. *Econometrica*, *75*(6), 1771–1855.

Phillips, P. C. B., & Sul, D. (2009). Economic transition and growth. *Journal of Applied Econometrics*, *24*(7), 1153–1185.

Porter, M. E., & Kramer, M. R. (2006). The link between competitive advantage and corporate social responsibility. *Harvard Business Review*, *84*(12), 78–92.

Rahman, S., Moral, I. H., Hassan, M., Hossain, G. S., & Perveen, R. (2022). A systematic review of green finance in the banking industry: Perspectives from a developing country. *Green*

Financ, *4*, 347–363.

Rajan, R., & Zingales, L. (1998). Financial development and growth. *American Economic Review*, *88*(3), 559–586.

Rousseau, P. L., & Sylla, R. (2003). Financial systems, economic growth, and globalization. In *Globalization in historical perspective* (pp. 373–416). University of Chicago Press.

Scholtens, B. (2006). Finance as a Driver of Corporate Social Responsibility. *Journal of Business Ethics*, *68*(1), 19–33.

Scholtens, B. (2017). Why finance should care about ecology. *Trends in Ecology & Evolution*, *32*(7), 500–505.

Scholtens, B., & Dam, L. (2007). Banking on the Equator. Are Banks that Adopted the Equator Principles Different from Non-Adopters? *World Development*, *35*(8), 1307–1328.

Svirydzenka, K. (2016). *Introducing a new broad-based index of financial development*. International Monetary Fund.

Tolliver, C., Fujii, H., Keeley, A. R., & Managi, S. (2021). Green Innovation and Finance in Asia. *Asian Economic Policy Review*, *16*(1), 67–87.

Ulucak, R., Kassouri, Y., İlkay, S. Ç., Altıntaş, H., & Garang, A. P. M. (2020). Does convergence contribute to reshaping sustainable development policies? Insights from Sub-Saharan Africa. *Ecological Indicators*, *112*, 106140.

Vanishvili, M., & Katsadze, I. (2022). Bank financing of green economy: Review of modern research. *Scientific Collection «InterConf+»*, *18 (95)*, 120–143.

Von Lyncker, K., & Thoennessen, R. (2017). Regional club convergence in the EU: Evidence from a panel data analysis. *Empirical Economics*, *52*, 525–553.

Wolfe, R. (1997). *Omodel: Stata modules to perform tests on ordered probit and ordered logit models*. https://econpapers.repec.org/software/bocbocode/s320901.htm

World Bank. (2019). *Global Financial Development Report 2019/2020: Bank Regulation and Supervision a Decade after the Global Financial Crisis*. The World Bank.

Zahedi, A. (2010). Australian renewable energy progress. *Renewable and Sustainable Energy Reviews*,

14(8), 2208–2213.

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, *98*, 39–60.

Appendix A

Chapter 2

Appendix 2.1 - Pairwise correlation

	GDP PPP	EF	CRI	RL	FMD
GDP PPP	1				
EF	0.764	1			
	(0.000)				
CRI	0.574	0.607	1		
	(0.003)	(0.0013)			
RL	0.793	0.542	0.689	1	
	(0.000)	(0.005)	(0.000)		
FMD	0.691	0.282	0.271	0.644	1
	(0.000)	(0.171)	(0.189)	(0.000)	

Note: The p-value is enclosed in parentheses.

Chapter 3

Appendix 3.1 - What determines membership in the Green Loan Club? Marginal effects on probabilities with robust SE.

		Ordered logit model		Ordered probit model	
Variables	**Club**	**dy/dx**	**Std. Err.**	**dy/dx**	**Std. Err.**
Market capitalization	1	0.003***	0.001	0.003***	0.001
	2	0.002	0.001	0.001	0.001
	3	-0.000	0.000	-0.000	0.001
	4	-0.004***	0.001	-0.005***	0.001
Ecological Footprint	1	-0.055***	0.016	-0.060***	0.018
	2	-0.028	0.019	-0.024	0.017
	3	0.002	0.010	0.002	0.011
	4	0.081***	0.023	0.008***	0.024
Bank concentration	1	-0.007***	0.002	-0.007***	0.002
	2	-0.003	0.002	-0.003	0.002
	3	0.000	0.001	0.000	0.012
	4	0.001***	0.003	0.001***	0.003
Deposit money banks to GDP	1	0.003**	0.001	0.003**	0.001
	2	0.001*	0.000	0.001*	0.000
	3	-0.000	0.001	-0.000	0.001
	4	-0.004**	0.001	-0.004**	0.002

*** Significance at 1%, **Significance at 5%, *Significance at 10%.

Appendix 3.2 - Data description and source

Indicator	Indicator Name	Source
GL	Green loans (in millions of euros)	Refinitiv
FD	Financial Development	IMF
BCBD	Bank credit to bank deposits ratio (%), measuring banking sector liquidity	World Bank
NPL	Bank nonperforming loans to gross loans ratio (%)	World Bank
PCDM	Private credit by deposit money banks to GDP ratio (%), measuring extent of financial intermediation	World Bank
Z-score	Bank Z-score, measuring banking stability	World Bank
GE	Government effectiveness	World Bank

Note: The financial development index **(FD)** is constructed using a standard three-step approach found in the literature on reducing multidimensional data into one summary index: (i) normalization of variables, (ii) aggregation of normalized variables into the sub-indices representing a particular functional dimension, and (iii) aggregation of the sub-indices into the final index (Svirydzenka, 2016); The Bank credit to bank deposit ratio **(BCBD**) is the financial resources provided to the private sector by domestic money banks as a share of total deposits. Domestic money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Total deposits include demand, time and saving deposits in deposit money banks; The Bank nonperforming loans to gross loans ratio **(NPL)** is the ratio of defaulting loans (payments of interest and principal past due by 90 days or more) to total gross loans (total value of loan portfolio). The loan amount recorded as nonperforming includes the gross value of the loan as recorded on the balance sheet, not just the amount that is overdue; The Private credit by deposit money banks to GDP ratio **(PCDM)** is the financial resources provided to the private sector by domestic money banks as a share of GDP. Domestic money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits; The Bank Z-score **(Z-score)** it captures the probability of default of a country's commercial banking system. Z-score compares the buffer of a country's commercial banking system (capitalization and returns) with the volatility of those returns. The Government effectiveness **(GE)** captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.

Appendix 3.3 - Pairwise correlation

	GL	FD	BCBD	NPL	PCDM	Z-score	GE
GL	1						
FD	0.392	1					
	(0.000)						
BCBD	-0.066	0.236	1				
	(0.4884)	(0.0113)					
NPL	-0.156	-0.213	0.011	1			
	(0.1127)	(0.030)	(0.918)				
PCDM	0.310	0.724	0.727	-0.074	1		
	(0.001)	(0.000)	(0.000)	(0.469)			
Z-score	0.068	0.488	0.065	-0.370	0.515	1	
	(0.450)	(0.000)	(0.498)	(0.000)	(0.000)		
GE	0.076	0.576	0.363	-0.465	0.637	0.563	1
	(0.396)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Note: The table shows the correlation coefficients between each pair of variables and their respective significance levels. The p-value is enclosed in parentheses.