AGORA International Journal of Economical Sciences, http://univagora.ro/jour/index.php/aijes
ISSN 2067-3310, E-ISSN 2067-7669
Vol. 18, No. 1 (2024), pp. 157-170

THE IMPACT OF FINANCIAL POLICIES ON PROMOTING THE DEVELOPMENT OF GREEN INNOVATION

T. NASIRLI

Turgay Nasirli
University of Bonn, Germany
https://orcid.org/0009-0004-0190-4148 , E-mail: nesirli.turqay@gmail.com

***Abstract**: This research investigates the factors influencing the development of green patents and their implications on green innovation. Green financing has the purpose of funding environmental initiatives by directing capital from financial institutions to eco-friendly projects. Through a review of existing literature and empirical analyses, we identify the influence of financial variables and economic policy strategy as key contributors. Preliminary findings suggest that these factors significantly impact the prevalence of green patents, highlighting the importance of policy and financial decisions in fostering environmentally sustainable technological advancements. Our findings reveal a positive correlation between environmental R&D expenditure and green innovation. Moreover, venture capital emerges as a significant driver of green innovation, facilitating the development of environmentally conscious solutions by mitigating financial risks. Additionally, the stringency of environmental policies and the presence of green bonds and carbon taxes demonstrate positive associations with green innovation. Consequently, the main objectives of this article are to examine the impact of financial policies such as R&D, Venture Capital, Debt financing and environmental regulations on the development of green patents and innovation as well as investigate the relationship between green bonds, carbon taxes and green innovation. Ultimately, this research contributes to the ongoing discourse on sustainable development, offering a nuanced understanding of the dynamics driving green innovation.*

***Keywords**: green innovation, financial policies, green patents*

1. Introduction

With the ever-evolving global economy and industry, environmental sustainability has become a crucial topic in recent times, particularly in the field of eco-friendly technologies and further development related to this sector. This, in turn, raises interest in patents and financial factors that affect environmentally friendly technological advancements. There is no universally accepted definition of green banking (Alexander, 2016), and it varies widely between countries. However, some researchers and organizations have tried to come up with their own definitions. Obtaining and using capital for projects that both preserve the environment and provide lenders or investors with a reasonable return is known as “green finance” (Berensmann & Lindenberg, 2019; Ozili, 2021).

In order to achieve sustainable development goals, green finance aims to enhance the amount of money flowing from financial institutions to economic agents engaged in environmental preservation initiatives and activities (Lee & Baral, 2017; Force, 2015). The distribution of cash for environmental preservation, the flow of funds to sustainable trade and

investment operations, low-risk financing, and the creation of green investment and financing instruments are some of the advantages of green finance (Sachs, Woo, Yoshino, & Taghizadeh-Hesary, 2019). Green finance has become increasingly common in the banking industry in recent decades as a means of safeguarding banks and society from unforeseen economic challenges (such as climate change, financial instability, social unrest, and so on) (Ziolo, Filipiak, & Bak, 2019).

Banks have assisted in the policy-making process by implementing green finance principles through the provision of green loans, bonds, investments, and other financial instruments. Banks play a crucial role in funding the shift to a green economy by facilitating private investment, balancing supply and demand, while considering all potential risks and assessing projects from an environmental and economic point of view (European Fiscal Board, 2017). In our paper, we embark on the intersection of green patents and finances - R&D investment for environmental objectives, environmental-related venture capital investment, financial structure (leverage), and the index of stringency of environmental policies to conduct empirical analysis. The central importance of our empirical analysis is the development of green patents in OECD countries and factors that affect it. Green patents, alternatively termed as eco-patents or environmentally conscious patents, are patents awarded for inventions or innovations possessing environmentally advantageous features or supporting sustainability. These patents are commonly linked with technologies, procedures, or goods that strive to confront environmental issues, advance resource efficiency, diminish pollution, or alleviate the consequences of human actions on the environment.

This study looks into the variables that affect the growth of green patents and how they affect green innovation. This article's main goal is to examine the ways in which financial regulations and environmental tactics impact the spread and encouragement of green innovation. The study's specific objectives are to evaluate how spending on environmental R&D and venture money promotes the green innovation in OECD economies. Furthermore, analyze the impact of strict environmental regulations on the number of green patents and examine how financial structure affects green innovation, with a focus on the debt-to-equity ratio. Lastly this article aims to examine the connections between carbon taxes, green bonds, and green innovation.

2. Methods

2.1 Dependent variable

As a preliminary measure of green innovation, scholars worldwide use the number of patents in respective countries and firms according to the classification of patents (Bo Wang, Lin, & Lingshan, 2021). We obtained the green patent data of the main economies of the world from the OECD database. Main countries of interest are EU members, United States, and Japan, which are the main drivers of green patents and green innovation. The patents data and indicators are convenient for statistical analysis are developed according to the Science, Technology, and Industry directory of OECD. Its coverage includes, but is not limited to, the patent grants and applications to European Patent Office (EPO), US Patent and Trademarks Office (USPTO), as well as patents filed under and belonging to IP5 Patent families. The patent indicators are selected in line with the classes of IPS-International Patent Classification for the

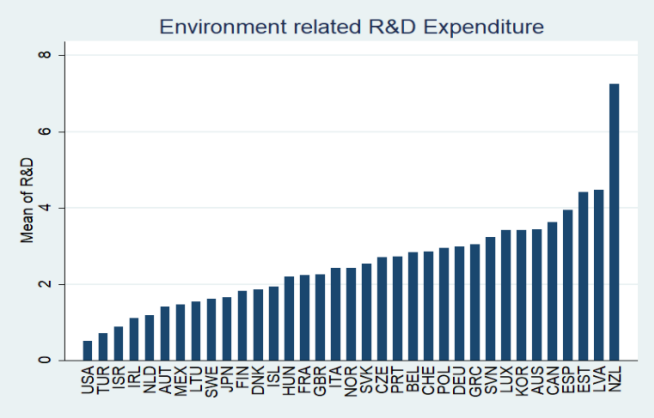
environment-related technology domain. The residence country of the inventor is taken as the reference country of patents. In the case of several joint inventors from more than one country, fractional counts are applied: If there are 3 inventors, then each country gets 0.33 shares of the patent, and so on. The reference date is the priority filing date of the patents, which is the worldwide first filing date and therefore nearest to the invention date of the patent. It is worth noting that patent grants are disclosed 1.5 years after filing, causing a lag in the processing of patent-based indicators, and respectively, our data range covers the period till 2019.

As the patents show the innovative achievement of countries, they are a key measure of the innovation output. They are also useful to quantify the spreading of between technological areas, sectors, firms, and level of international collaboration. Since the criteria for patent grants are well defined, such as being novel, non-obvious, and useful application, and having widely available quantitative data makes patent data a good measure of innovation. Yet, not all innovations are patentable and not all patentable innovations are patented because there are other regimes to protect intellectual property rights, for example, trademarks, copyrights, etc. (Haščič & Migotto, 2015). Although patents are investigated as output indicators, they can also be used as input indicators for subsequent innovation. The identification and classification of the patents are done mainly through the keywords, codes (e.g., CPC, IPC), manual selection, or a combination of several techniques. The data used for the purposes of our analysis is collected according to the methodology of OECD (ENV-TECH), which is deemed to have more coverage in comparison to two other existing methodologies to determine environmental patents based on the code classification, namely Y02/Y04S Tagging scheme (EPO), IPC Green Inventory (WIPO) (Favot, Vesnic, Priore, Bincoletto, & Morea, 2023). The absolute number of green patents per country is normalized by the population size of the country and expressed as the number of patents per 1 million population.

2.2 Independent variables

The first chosen explanatory variable is the amount of environmental-related R&D expenditure as a percentage of gross domestic product, quantified as the total of government, business enterprise, higher education, and non-profit expenditure in different socio-economic objectives. The related data has been obtained from the OECD Science, Technology, and R&D statistics database. This measure is based on the objective of "environment," which includes studies related to the development of monitoring technologies, to elimination, measurement, and prevention of pollution (Green growth indicators). R&D expenditure has an essential role in innovation by providing the necessary financial support by which new services and products can be developed or existing ones improved (J. Liu & X. Liu, 2023). As shown in Graph 1, we plot the R&D expenditure on environmental factors for selected samples. There exists noticeable heterogeneity amongst the sample countries, particularly in Europe. New Zealand leads the list with more than 7% of the GDP dedicated to environmental-related Research and Development expenses.

Graph 1. Environmental Research and Development Expenditure

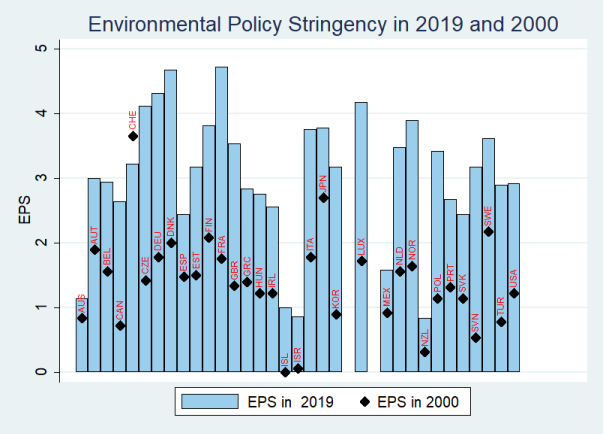


Source: OECD Green growth indicators

The next explanatory variable we chose is the OECD Environmental Policy Stringency Index (EPS), an internationally comparable index of how strict are environmental policies of specific countries. It defines the extent to which a country's environmental policies put an implicit and explicit price on damaging effects and pollution. The index is built on the stringency of 13 environmental policy factors predominantly related to weather pollution and climate change and ranges from 0 (not stringent) to 6 (very stringent). CO2 Trading schemes, Emission and Fuel taxes, emission limits, technology supports are the policy factors to name but a few (Kruse et al., 2022). There has been a considerable increase on average in the Environmental Policy Index over the past two decades.

All countries in the sample increased their stringency score between 2000 and 2019. Furthermore, France, Denmark, and Germany had the highest stringency index in 2019 compared to the other countries in the list. In a similar way, some countries have improved their score more than others. Observing the change in the absolute values, France and the Czech Republic made the largest progress. It is also noteworthy that there exists a large heterogeneity across the countries. As a result of our analysis, moving a country from the 25th percentile to the 75th increases its green innovation—the number of patents—more than one standard deviation at the 1 percent significance level.

Graph 2. Stringency of Environmental Policies in 2000 and 2019

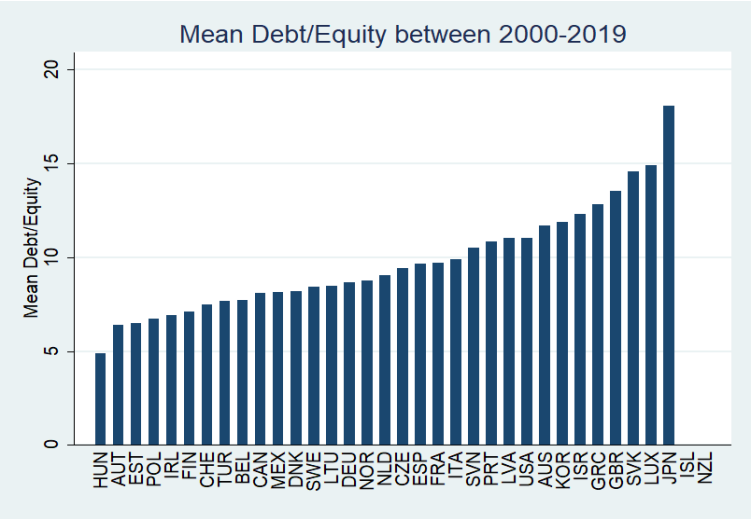


Source: OECD Green growth indicators.

The next explanatory variable we took was the debt-equity ratio of the financial and non-financial entities in the selected sample countries. It reflects the degree to which debt finance is used as a method of financing in the selected countries or how debt-based they are. We extracted data from the OECD's national accounts statistics database. The

debt-to-equity ratio indicates how much a company is using debt or equity to support its operations and it is a measurement of its financial leverage. It is computed by dividing the entire debt of financial firms by the total equity liabilities of the same industry, including shares of investment funds. The total of the obligation categories that include currencies and deposits, debt securities, loans, insurance, pension plans, and other standardized guarantee schemes is known as debt. The market value of the issued shares, including investment fund shares, represents the equity on the denominator side. All governmental and private organizations involved in the financial industry are included in the financial company's sector (S12). For instance, if the ratio is 1.5, the market value of the existing stock is 1.5 less than the amount of outstanding debt. European countries have heterogeneity in terms of their financial structure. That is, some of them have high levels of mean debt value, such as Luxembourg and Slovakia, at more than 14 percent, while others, for example, Hungary, have 4.9 percent, which is the lowest rate in our sample. Japan has the highest mean rate of debt capital in the list, with more than 18 percent.

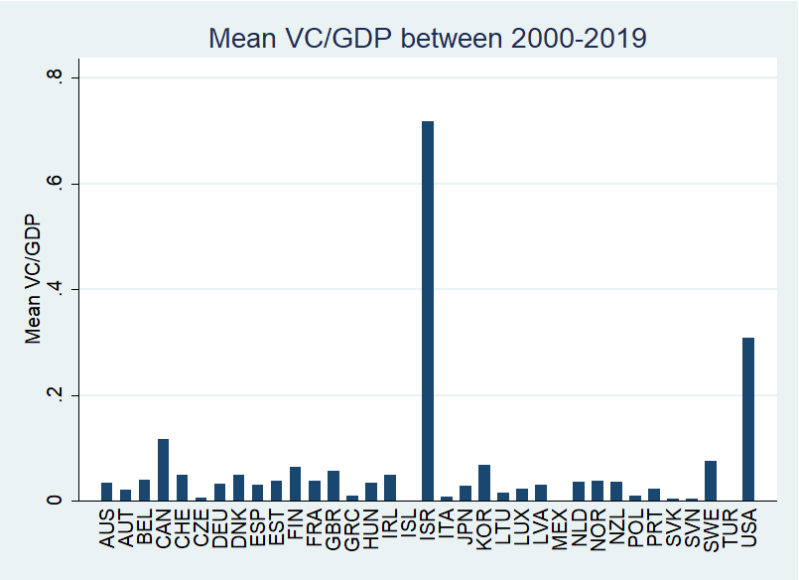
Graph 3. Mean Leverage Ratio



Source: World Bank financial structure database

Next, we change our focus to the impact of equity capital, more specifically the venture capital, on green innovation. We obtained data again from the OECD database about the amount of Venture capital investment in the selected countries for the time period between 2000-2019 normalized by gross domestic product. It becomes clear that the venture capital investment in European countries is considerably low compared to international peers. Mean value of VC investment for sample period ranges from 0.005 percent in Slovakia to 0.8 percent in Sweden (highest in EU). On the other hand, Israel has 0.72 percent mean value of the VC investment, which is the global leader in the world for per capita VC investment.

Graph 4. Mean Venture Capital per GDP



Source: OECD Green growth indicators

2.3 Estimation Approach

We employed a country fixed effects model to estimate the empirical model and for hypothesis testing. We also used the Hausman test to justify the use of fixed effects models rather than random effects. Equation 1 analyzes the effect of selected explanatory variables more precisely, environmental Research and Development investment, environmental policy stringency index, financial structure, and venture capital on the green innovation in the country.

$$P_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \beta_4 X_{4it} + \gamma_t + u_i + \varepsilon_{it} \quad (1)$$

where:

- P_{it} ($Patent_{it}$) is the number of green patents per 1 million population i at time t.
- β_0 is the constant term (fixed effects)
- X_{1it} - (RD_{it}) is the environmental related research and development expenditure normalized by gross domestic product for country i at time t.
- X_{2it} - (VC_{it}) is venture capital investment per gross domestic product for country i at time t.
- X_{3it} - ($debt_{it}$) represents the financial structure of the country calculated as debt/equity ratio
- X_{4it} - ($stringency_{it}$) is the index expresses the stringency of the environmental related policies
- u_i represents the country-specific fixed effects, which control for all time invariant characteristics of each entity.
- γ_t represents year-fixed effects (to control for any time-specific factors)
- ε_{it} is the overall error term for country i at time t

We used panel data of the 35-member countries of OECD for the years between 2000 and 2019 to evaluate the effects of selected variables on the green technological evaluation. This selection criterion is the most appropriate one as an overwhelming share of the world's green innovations (more than 90 percent) are either developed or patented in these countries. Moreover, they account collectively for more than 80 percent of the global investment and trade. Because of the time lags in the patent filing and application period, we restricted our

sample period until 2019. We presume this time period is also representative in order to eliminate the possible exogenous effects of the Covid-2019 pandemic on global investment and innovation. The research data is collected for the most part from the OECD green growth indicators database and combined together.

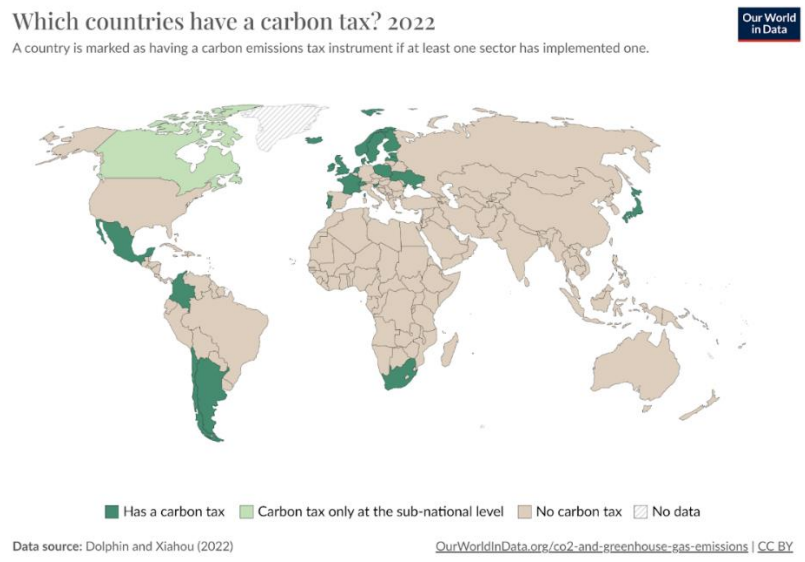
2.4 Carbon Tax

Carbon tax is one of the key mechanisms to provide financial motivation for developing environmentally friendly technologies by increasing the demand for such technologies to mitigate increased costs caused by the carbon tax (Cantone, Evans, & Reeson, 2023). It sets a price directly on the carbon content of the fossil fuels that cause greenhouse gas emissions (GHG). It is different from the ETS, which allows the entities with lower carbon emission to trade their rights with those causing higher pollution levels. Consequently, ETS can define the reduction proportion of the emissions while carbon tax defines the price for it. Burning fossil fuels comes with costs, all of which are not necessarily reflected in the monetary price of them. This includes social costs, air pollution, contribution to climate change, and CO2 emissions. The purpose of putting a price on carbon is to drive its monetary cost to its true cost with environmental and social impact. First, it makes fossil fuels more expensive in comparison to cleaner alternatives, that is, it encourages the change to greener products.

Second, it makes the GHG emitters pay for it (Ritchie & Rosado, 2022). The opponents of the carbon tax claim that it harms domestic energy-intensive industries in the absence of an international agreement on carbon tax because their competitors would not face a similar policy in their homeland. Hence, unilateral imposition of carbon tax would place the country at a disadvantage and have no effect on the climate (Macaluso et al., 2018).

According to Ojha and Pohit (2020), in spite of the fact that the carbon tax can effectively help to reduce carbon emissions, at the same time it reduces GDP, leading to an undesirable tradeoff between GDP and carbon emissions. We showed the map of countries with the carbon tax as of 2022 (Graph 5).

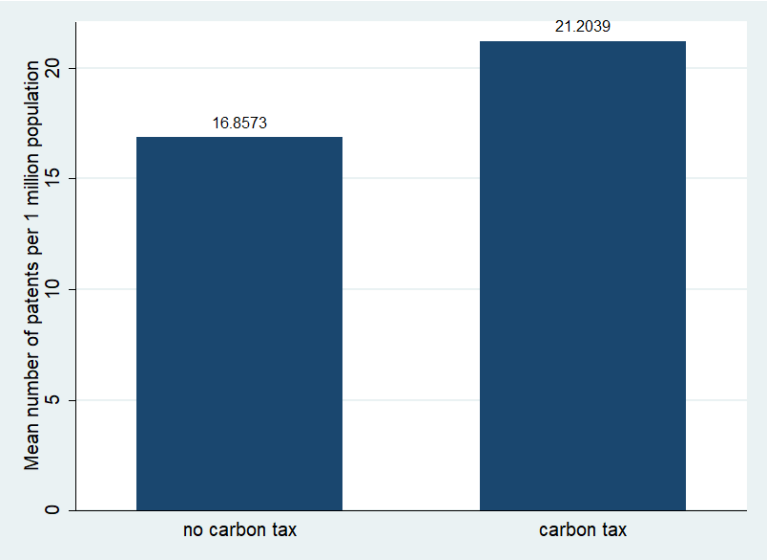
Graph 5. Countries with the Carbon Tax



Source: Dolphin & Xiahou (2022)

The degree and existence of carbon tax varies between the industry sectors. For instance, while the metallurgy industry might have a higher rate of carbon tax, the road transportation may not have at all. Consequently, the countries with the carbon price in any sector have been marked, and the graph does not illustrate the economy-wide tax. It should be noted that only the taxes on CO2 emission were considered. We divided our sample of countries into two groups: First, those with some form of carbon tax and second, those without one. The number of green patents per capita are comparatively higher on average in the first group at 16 patents than the second one, 21 patents per capita. Although this finding does not imply causal relationship between the two variables, the existence of carbon tax pushes firms to find environmentally friendly alternatives and hence stimulates green innovation.

Graph 6. Carbon Taxes and Green Patents per Million 2000-2019



Source: Dolphin & Xiahour (2022)

2.5 Green Bonds

An increasingly greater role is played by green bonds in the last decade in the field of green financing and reduction of environmental impact. Green bonds are similar to traditional bonds in many respects except their proceeds are used for projects that are intended for energy efficiency, renewables, sustainability, and meet certain compliance requirements. In the field of green finance, green bonds are significant. This holds regarding green bonds just as there isn't a universally accepted definition of green finance. The EU Green Bond Standard, the Climate Bonds Standard and Certification, and the Green Bond Principles are only a few of the voluntary principles and standards that are in place. These guidelines should guard against greenwashing and aid investors as well as green and sustainable bond issuers. The green bond market is the one that is expanding the fastest; still, more work is required to bring this market segment up to speed with the rest of the bond market both from the supply and demand sides.

The first ever green bond was issued by the European Investment Bank in 2007 followed by the World Bank in 2008 November after increasing demand for climate-friendly investments, especially from Swedish pension funds. The issuance of USD 1 billion bonds by

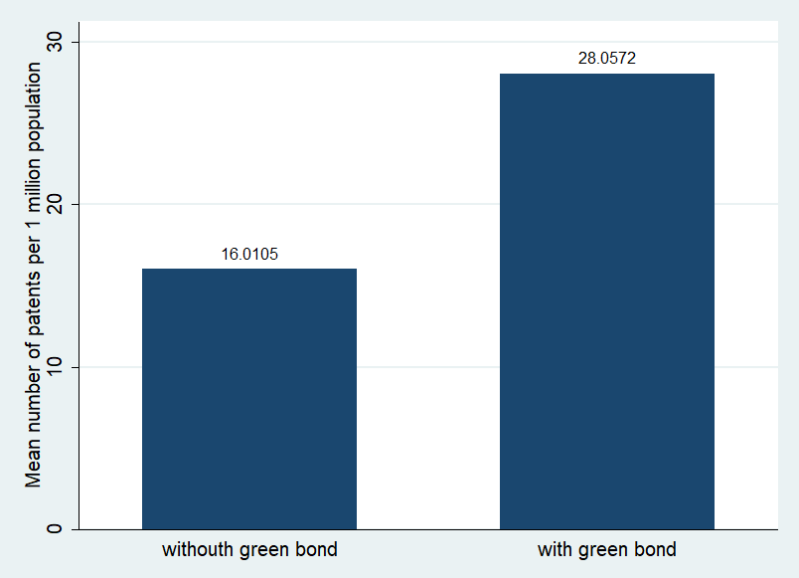
the International Finance Corporation as the largest green bond in the market at the time of issuance in 2013 boosted the expansion of the market (World Bank, 2022). Since then, they have gained particular popularity and enjoyed strong growth from USD 36.7 Billion to USD 487.1 Billion between 2014 and 2022 and peaked in 2021 with USD 582.4 Billion (Statista, 2022). The market outlook for this market moreover seems positive. To limit global warming to 1.5°C in comparison to pre-industrial levels as imposed by the Paris Climate Agreement, cumulative energy investment of 53 trillion is needed by 2035 (International Energy Agency, 2014). In this respect, green bonds can be effective tools to reallocate the investment from high carbon to low carbon projects. The bond financing is especially suitable for financing renewable energy investments as they generally require high initial investment, are long term, and their income stream is linked to inflation. In fact, three-quarters of these infrastructure projects consist of debt financing. Hence, governments need to think of relevant tools and policies to transform the capital from emission-intensive investments to low carbon and climate resilient (LCR) infrastructure.

Moreover, green bond investments till now seem to make a remarkable impact on the green transition. More than USD 10 Billion investment through green bonds by the International Finance Corporation between 2010 and 2022 is expected to reduce greenhouse gas emissions by 25.6 million metric tons of CO2-equivalent per year and to save 868 Million kilowatt hours of energy annually (International Finance Corporation, 2022). A noticeable shift to green finance is already to be observed in public and private institutions. The European Commission intends to issue 30 percent of the Next Generation EU plan's financing with green bonds for sustainable investment. The green reforms are expected to boost the liquidity of the market. If implemented at full scale, all those projects are expected to shrink CO2 emissions by 44 Million tonnes equivalent to 1.2 percent of total emissions of the EU in 2022. This amount of reduction, for example, corresponds to 80 percent reduction of emissions from the building industry in 2022 in the EU (European Commission, 2023). The impact of the investment varies naturally depending on the base emission level, location, type of project, and so on. Projects relating to renewable energy have approximately one thousand tons of carbon emission savings for each USD 1 Million invested, but transportation projects have on average 600 tons (SP Global). According to Born et al. (2021), although the sustainable debt markets in the Euro area are expanding quickly, sustainable financial instruments—such as environmental, social, and governance (ESG) funds and green, sustainable, and sustainability-linked bonds—represent less than 10 percent of their respective markets. Since 2015, the amount of assets managed by institutional investors and investment funds with a specific focus on sustainability or the green economy has almost doubled. As part of the EU recovery fund, Next Generation EU, the European Commission plans to sell up to 250 billion euros in green bonds between mid-2021 and 2026, therefore increasing the proportion of green financing in the Euro area. Green bonds can contribute to climate objectives mainly through two ways: Firstly, their proceeds are invested in the development of cleaner technology, cleaner energy production, lower carbon footprint, etc. Second, they influence the behavior of the issuer firms positively because of green reporting disclosure and more scrutiny. Hence, they also reduce the company's ability to use proceeds of bonds and moreover compliance and standardization costs further questions the motive to use green bonds.

It is yet claimed that green bonds are still a choice of preference because of their signaling effect about firms' commitment to environmental standards - signaling argument or just pretending to do so without having tangible results - greenwashing argument (Flammer, 2020). Even if there are a lot of projects and green finance is becoming more and more relevant numerically, there are still not enough funds allocated to achieve a 1.5°C trajectory. According to Delimatsis (2021), a successful strategy towards a relevant sustainable finance sector necessitates a combination of bottom-up initiatives like investor demand or the implementation of financial institutions' social responsibility strategies in addition to top-down engagement by actors like the European Commission, central banks, or other international organizations. It is important to keep in mind that different climate policy measures have an indirect impact on the growth of green finance in this context.

The countries with the green bonds are compared in terms of green innovation with the ones where no green bond has been issued over the sample period 2000-2019. We divided them into two categories: First, the countries where in a particular year a green bond has been issued. Second, the countries where no green bond has been issued at the time. It turns out the first category on average has a higher number of green patents per capita, more precisely 28, than the second one, 16 patents per 1 million. Yet the relationship of the causality is unclear—whether the entities who issue green bonds increase their green innovation or the entities who already have intention to make green innovation prefer to use the green bonds. Nevertheless, green bonds become an increasingly popular tool to finance green innovation globally.

Graph 7. Green Bonds and Patents per 1 Million 2000-2019



Source: International Monetary Fund

3. Results

Table 1. Regression results with and without FE

	(1)	(2)	(3)
VARIABLES	OLS No FE	Fixed effects	Robust fixed effects
Rd	0.876**	0.822**	0.822**

	(0.406)	(0.403)	(0.288)
Vc	38.56***	43.91***	43.91***
	(8.052)	(5.593)	(8.824)
Debt	0.583**	0.587***	0.587***
	(0.235)	(0.213)	(0.150)
stringency	10.53***	12.04***	12.04***
	(0.837)	(0.995)	(0.945)
Constant	-19.52***	-23.91***	-23.91***
	(2.866)	(3.697)	(2.129)
Observations	548	548	548
R-squared	0.327	0.272	0.272
Number of years		20	20
Country FE		YES	YES
Time FE		YES	YES

Source: OECD

Table 1 illustrates the descriptive statistics of the sample. The results of regression analysis presented using 3 methods, namely simple regression, fixed effects, and robust fixed-effects. R&D expenditure appears to be positively correlated with the green innovation in all three models with 5 percent statistical significance and 0.82 coefficient value. However, Venture Capital has, in a similar fashion, a coefficient of 43.91 at 1 percent significance level for all methods. The scope of the coefficient is higher with the inclusion of the fixed effects and in comparison, to the other explanatory variables in our model. Next, the capital structure of the entities expressed as the debt/equity ratio has a coefficient of 0.6 with a standard error of 0.21, indicating a positive correlation between patents and leverage at high confidence level (1 percent statistical significance). The last variable in our explanatory variables, namely environmental stringency, has a high coefficient value of 12.04 with 1 percent significance level across three methods. The consistency of the coefficient for explanatory variables across the methods confirms robustness of the model. The interpretation of independent variables is one of the most crucial parts of the regression model. Venture capital plays a vital role in the development of green patents through several factors. Since innovation is capital-intensive and has high up-front costs and risks, the role of venture capital in mitigating the costs of conducting experiments, trials, and tests to make an innovation breakthrough in the field of green innovation is crucial. Furthermore, venture capitalists are more likely to be risk-taking compared to other investors, which positively influences green innovation over the years of development. The stringency of the index of environmental policies measures the strictness of government over the application of environmental regulations, which in turn can highly incentivize green innovation. This index motivates companies and individual researchers to develop new solutions and technologies that should also comply with the environmental policy of the country, depending on how rigorous the government is on implying the policy. Moreover, the recent competition among the countries on reducing carbon footprint and more environmentally friendly solutions incentivizes the countries in improving their environmental policies. This competition can lead to a surge in green innovation and solutions.

4. Discussion

Based on the information provided in the empirical study, we may draw a number of conclusions concerning the effects between environmental-related R&D expenditure, leverage ratio, venture capital, the stringency index of environmental policies, and green innovation. Our analysis reveals a significant positive correlation between environmental R&D expenditure and green innovation, confirming the findings of previous studies (J. Liu & X. Liu, 2023). Increased investment in R&D dedicated to environmental objectives facilitates the development of new technologies and solutions aimed at reducing pollution and enhancing resource efficiency. This finding aligns with the conclusions of Haščič and Migotto (2015), who emphasized the crucial role of R&D in driving innovation.

The regression results show that venture capital investment has the highest coefficient among the explanatory variables, indicating its substantial impact on green innovation. Venture capitalists' willingness to absorb high risks and upfront costs is essential for funding groundbreaking projects in green technology. This result is consistent with the arguments presented by Berensmann and Lindenberg (2019), who highlighted the importance of venture capital in financing environmentally conscious solutions.

Green innovation and the debt-to-equity ratio are positively correlated, suggesting that businesses with higher levels of leverage are more likely to make investments in green technologies. This finding aligns with the past research findings (Ziolo, Filipiak, & Bak (2019), where the role of financial structure in supporting sustainable projects discussed. A high level of leverage could give businesses the money they need to launch big environmental projects.

One of the noticeable conclusions is the increase in the level of EPS index from between years 2000-2019. Regression results also show how EPS has a considerable influence on green innovation, which can be explained by its effects on creating incentives in the countries, which develops motivation for the green patents.

We also conclude that venture capital has the most considerable effect on the level of green innovation in our sample. The fact that venture capital has the ability to absorb risk and high upfront costs of projects for developing environmentally friendly technology and solutions makes it a suitable way of financing for green patents. Our study demonstrates that the existence of green bonds and carbon taxes is positively associated with the number of green patents. These financial instruments provide incentives for firms to invest in environmentally friendly technologies. This finding is consistent with the conclusions of Sachs et al. (2019), who emphasized the role of green bonds and carbon pricing in promoting sustainable development.

Moreover, we have found a positive correlation between the existence of green bonds and as well as carbon tax on the average level of patents in the selected countries. Although this finding does not imply causality or the direction of it, green patents and carbon incentivize entities to increase their amount of green innovation. In conclusion, the results emphasize how crucial it is to implement focused financial and regulatory initiatives in order to increase green innovation and facilitate the shift to a more environmentally friendly sustainable economy.

REFERENCES

1. Alexander, K. (2016). Greening banking policy. Support of the G20 Green Finance Study Group. Retrieved from https://unepinquiry.org/wpcontent/uploads/2016/09/10_Greening_Banking_Policy.pdf
2. Berensmann, K., & Lindenberg, N. (2019). Green Finance: Across the Universe. in S. Boubaker & D. K. Nguyen (ed.), *Corporate Social Responsibility, Ethics and Sustainable Prosperity*, chapter 11, pages 305-332, World Scientific Publishing Co. Pte. Ltd. Retrieved from https://ideas.repec.org/h/wsi/wschap/9789811206887_0011.html
3. Bo Wang, Lin, X., & Lingshan, C. (2021). Factors affecting green innovation: An analysis of patent and regional heterogeneity. *Chinese Journal of Population Resources and Environment*, 19(1), 12-21. https://doi.org/10.1016/j.cjpre.2021.12.002
4. Cantone, B., Evans, D. & Reeson, A. The effect of carbon price on low carbon innovation. *Sci Rep* 13, 9525 (2023). https://doi.org/10.1038/s41598-023-36750-9
5. Delimatsis, P. (2021). Sustainable finance. In P. Delimatsis, & L. Reins (Eds.), *Trade and environmental law* (pp. 783-797). (Elgar Encyclopedia of Environmental Law; Vol. XI). Edward Elgar Publishing Ltd. Retrieved from https://research.tilburguniversity.edu/en/publications/sustainable-finance
6. Dolphin, G., Xiahou, Q. World carbon pricing database: sources and methods. *Sci Data* 13, 573 (2022). https://doi.org/10.1038/s41597-022-01659-x
7. European Commission. (2021 June 21). *European Commission endorses Austria's recovery and resilience plan*. [Press Release]. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3122
8. European Fiscal Board. (2017). *2017 annual report of the European Fiscal Board*. https://commission.europa.eu/publications/2017-annual-report-european-fiscal-board_en
9. Favot, M., Vesnic, L., Priore, R., Bincoletto, A., & Morea, F. (2023). Green patents and green codes: How different methodologies lead to different results. Resources, Conservation & Recycling Advances, 18, 200132. https://doi.org/10.1016/j.rcradv.2023.200132
10. Flammer, C. (2020). Corporate Green Bonds. *Journal of Financial Economics*. 1-54. https://dx.doi.org/10.2139/ssrn.3125518
11. Haščič, I., & Migotto, M. (2015). *Measuring environmental innovation using patent data*. (OECD Environment Working Papers No. 89), OECD Publishing. https://doi.org/10.1787/19970900
12. International Energy Agency. (2014). *World Energy Outlook 2014*. https://www.iea.org/reports/world-energy-outlook-2014
13. International Finance Corporation. (2022). *Green and Social Bond Impact Report*, https://www.ifc.org/content/dam/ifc/doc/2023/IFC-GreenSocialBondReport-Final.pdf
14. J. Liu, & X. Liu. (2023). Effects of carbon emission trading schemes on green technological innovation by industrial enterprises: Evidence from a quasi-natural experiment in China. *Journal of Cleaner Production*.8(3). Article 100410, https://doi.org/10.1016/j.jik.2023.100410
15. Kruse, T., et al. (2022). Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator. *OECD Economics Department Working Papers*, No. 1703, OECD Publishing, https://doi.org/10.1787/90ab82e8-en

16. Lee, C. F., & Baral, P. (2017). Green Finance Opportunities in ASEAN. *UNEP Report*, Nairobi, Kenya. https://unepinquiry.org/wp-content/uploads/2017/11/Green_Finance_Opportunities_in_ASEAN.pdf
17. Macaluso, N., Tuladhar, S., Woollacott, J., McFarland, J. R., Creason, J., & Cole, J. (2018). The impact of carbon taxation and revenue recycling on US industries. *Clim Chang Econ*, 9(1), Article 184005 https://doi.org/10.1142/S2010007818400055
18. Ojha, V. P., & Pohit, S. (2020). Recycling carbon tax for inclusive green growth: A CGE analysis of India. *Energy Policy*, 144, 111708. https://doi.org/10.1016/j.enpol.2020.111708
19. Ozili, P. K. (2021). Digital finance, green finance, and social finance: is there a link? *Financial Internet Quarterly*, 17(1), 1-7. https://doi.org/10.2478/fiqf-2021-0001
20. Ritchie, H., & Rosado, P. (2022). *Which countries have put a price on carbon?* [Data Set]. Our World in Data. https://ourworldindata.org/carbon-pricing
21. Sachs, J., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2019). Importance of Green Finance for Achieving Sustainable Development Goals and Energy Security. In: Sachs, J., Woo, W., Yoshino, N., & Taghizadeh-Hesary, F. (eds) *Handbook of Green Finance. Sustainable Development* . Springer, Singapore. https://doi.org/10.1007/978-981-13-0227-5_13
22. Statista. (2022). *Green bond issuance worldwide from 2014 to 2021* [Data set]. Statista. https://www.statista.com/statistics/752832/global-green-bond-issuance/
23. United Nations. (2015). *Establishing China's Green Financial System*. https://www.unep.org/resources/report/establishing-chinas-green-financial-system
24. World Bank. (2021). *What you need to know about IFC's green bonds*. https://www.worldbank.org/en/news/feature/2021/12/08/what-you-need-to-know-about-ifc-s-green-bonds
25. Ziolo, M., Filipiak, B. Z., & Bak, I. (2019). How to Design More Sustainable Financial Systems: The Roles of Environmental, Social, and Governance Factors in the Decision-Making Process. *Sustainability*, 11(20), Article 5604 doi.org/10.3390/su11205604