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How do socio-demographic factors affect green finance growth?

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ABSTRACT

Hitherto, green finance provides lower returns as compared to their "plain" counterparts, and as such, might be less attractive to financial markets. This study aims to analyse the impact of sociodemographic factors on green finance growth at the national level. We employ a panel-pooled mean group-autoregressive distributive lag (PMG-ARDL) model to assess the long-term influence of selected sociodemographic indicators on government budget allocations for R&D (GBARD) with environmental objectives as a proxy for green finance spanning 21 European countries from 2000 to 2021. Specifically, we investigate the impact of the unemployment rate, population density, gender ratio, ratio of education expenditure to GDP, proportion of the population aged 15–64, and the Gini coefficient on the GBARD with environmental objectives. The core results demonstrate that all the examined indicators exert a positive and statistically significant long-term impact on the allocation of government budgets for the GBARD with environmental objectives, highlighting the critical role of sociodemographic contexts in shaping environmental investment strategies.

KEYWORDS

sociodemographic factors, green finance, growth, PMG-ARDL, sustainable practices

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1 INTRODUCTION

As projected by international organizations, the current state of green financing is insufficient to close the so-called "one trillion gap" required to substantially decrease the carbon footprint of humankind by 2050 (Schroeder and Havers 2021). A substantial amount of green financing is required to mitigate climate change. Accordingly, green finance has attracted immense attention from both scholars and practitioners in recent years (Kumar et al. 2022).

Green finance is often defined as 'financial instruments that support the transition to a climate-resilient economy by enabling such initiatives as environmental protection through greenhouse gas (GHG) emissions and energy use reduction, and development of climate-resilient infrastructure" (Debrah, Chan and Darko 2022). This attempt to provide a universal definition of green financing is not the only one, making green finance still an amorphous term (Berrou, Ciampoli and Marini 2019). However, all definitions have one thing in common – green finance is said to support the transition towards a more sustainable, low-carbon economy. The consensus on the effects of green finance, however, has not been reached unequivocally since several cases of greenwashing have been reported recently (Das et al. 2023).

Not only that the effects are ambiguous, but the antecedents of green finance growth are still a focal point of concurrent research streams. Sociodemographic factors, in particular, are some of the most extensively elaborated factors in relation to the development and expansion of green finance products. First, gender can be an important factor in the development of a green financial ecosystem. Second, age could be attributed to green finance, keeping in mind that younger individuals often show a greater interest in environmental issues and sustainability. Third, education has a great effect, since more educated people tend to be more aware of environmental issues and the benefits of green finance. They are likely to make informed decisions about incorporating sustainability into their financial portfolios. Fourth, income plays a significant role, since people with higher incomes have more disposable funds to invest in green finance products. They may also be more concerned about the long-term environmental sustainability, and willing to allocate funds towards green investments. Finally, urbanization is said to affect the development of green finance, at least because people living in urban areas may have more access to green finance products and sustainable investment opportunities.

Socio-demographic factors at the individual level may not be such a novel topic, but their effect at the country level has still been below the research radars. This study aims to analyse the effects of various socio-demographic factors on green finance development. For this purpose, we observe panel data from 21 European countries in the period from 2000 to 2021. The European countries included in the study are Belgium, Czechia, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia, Finland, Sweden, and Norway.

Following the main aim, the hypotheses of this study are as follows:

H1: Unemployment positively affects the development of green finance.

H2: Population density positively affects the development of green finance.

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H3: Gender ratio positively affects the development of green finance.

H4: Education positively affects the development of green finance.

H5: Aging structure positively affects the development of green finance.

H6: Gini index value positively affects the development of green finance.

The remainder of this paper is organized in the following order. Section 2 provides the theoretical background for the study. Section 3 thoroughly delineates the methodology – data, model, and analytical framework. Section 4 elaborates on the results. Section 5 contextualizes the findings and explains the main contributions and implications. The last section is reserved for the conclusions, limitations, and further recommendations.

2 THEORETICAL BACKGROUND

In this section, we explain the theoretical concept depicting the relationship between socio-demographic factors and green finance. While many papers examine the impact of green finance on environmental sustainability and economic growth, the existing literature lacks studies that deal with the factors that influence the volume of green finance. Only a couple of papers directly explain the influence of some economic and socio-demographic factors on green finance. For instance, Hamurcu (2023) finds that GDP has a positive effect on green finance. Similarly, Liang et al. (2024) discovers that education has a positive impact on green finance. To the best of our knowledge, no research directly investigates the comprehensive set of socio-demographic factors and their influence on green finance.

This chapter explains the expected impact of the six independent variables—unemployment rate, population density, gender ratio, education, aging population, and GINI index—on green finance. By examining these variables, this study aims to provide a comprehensive understanding of how socio-demographic factors affect green finance. The hypothesized model is presented in Figure 1.

X1_The unemployment rate and green finance. The relationship between unemployment and green finance is multifaceted. Generally, it might be expected that higher unemployment rates can negatively impact green investments due to reduced disposable income and lower consumer spending, which in turn can decrease the demand for green products and services. Bowen and Kuralbayeva (2015) argue that high unemployment can limit public and private sector investments in green

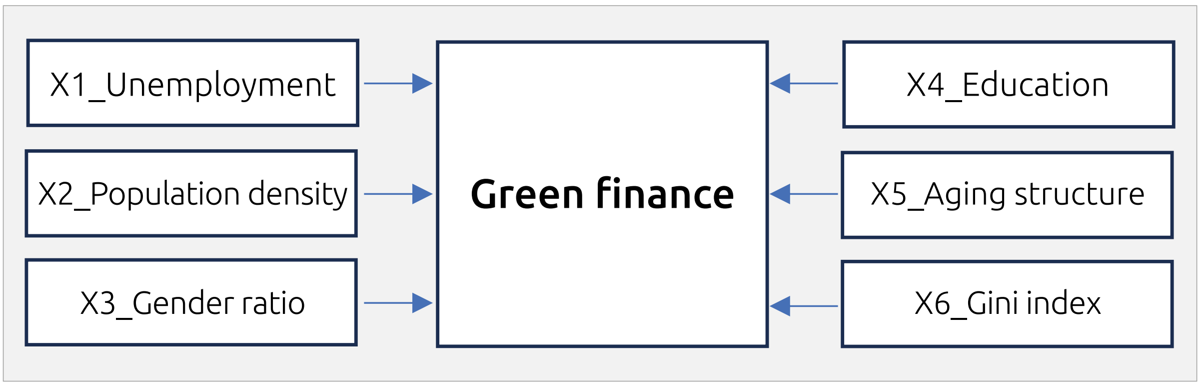

Figure 1 Hypothesized model

technologies, as economic priorities shift towards immediate job creation rather than long-term sustainability goals. However, some studies suggest that periods of high unemployment can also provide opportunities for restructuring economies towards more sustainable practices. Economic crises and high unemployment can drive policy changes that promote green investments to stimulate economic recovery and create jobs. This is supported by the findings of Barra and Ruggiero (2019) and Cui et al. (2022) who highlight that investments in green infrastructure during periods of high unemployment can lead to significant job creation and sustainable economic growth. Additionally, policies aimed at retraining unemployed workers for green jobs can also enhance the overall impact of green finance on the economy.

X2_Population density and green finance. Population density significantly impacts green finance and green investments through various channels. Higher population density may correlate with increased environmental awareness and demand for sustainable solutions due to the concentration of people and economic activities. Hsu, Johnson and Lloyd (2013) explain that dense urban areas typically have better infrastructure for implementing green initiatives, which can attract green investments. Similarly, Lee and Min (2015) demonstrate that dense populations can stimulate green R&D and innovation, further encouraging green investments. In addition, Guillochon (2022) who researched the development of renewable energy crowdfunding, found that regions with lower population density had longer campaigns with fewer investors.

X3_Gender ratio and green finance. To the best of our knowledge, there is no research that directly investigates the relationship between gender ratio and green finance. The existing publications only indicate that greater gender diversity, particularly the inclusion of women in leadership roles, is associated with greater environmental awareness. Consequently, we expect a positive relationship between gender ratio, measured as the proportion of women in the total population, and green finance. For instance, the research findings by Abuatwan (2023) show that gender diversity, as indicated by the presence of women in banking institutions, significantly enhances the relationship between green finance initiatives and sustainability performance in the sector. Similar conclusions are derived by Gör and Tekin (2023) who find that one of the factors influencing green financing practices in commercial banks is female representation on boards. In addition, Al Mamun et al. (2024) stress that increased female political empowerment has a positive correlation with the development and execution of green finance initiatives.

X4_Education and green finance. Higher education levels are generally associated with greater awareness and understanding of environmental issues, which is expected to translate into a stronger demand for sustainable financial products. Ma (2022) proves that higher education is vital for advancing green finance and green economic growth. Its potential for promoting coordinated development between these areas underscores the importance of enhancing educational initiatives in fostering a more sustainable economic system. Similarly, An and Madni (2023) conclud that policymakers can support green investments using policy instruments such as grants and potential investor education. Finally, the findings of Niamir, Ivanova and Filatova (2020) show that socio-demographic factors such as education and age amplify differences between households and regions in the diffusion of green investments.

X5_The aging population and green finance. Many studies emphasize the need to consider population dynamics in environment-related topics. For instance, Olumekor and Oke (2024) highlighted the impact of demographic factors, including age, on support for sustainable finance among people in 27 EU countries. Their findings indicate that younger people are more supportive of sustainable finance than older people. The literature presents varying evidence on the impact of an aging population on support for sustainable practices, with some findings indicating no significant differences between age groups (Gray et al. 2019), while others suggesting that older individuals are less likely to engage in environmentally friendly behaviour (Blankenberg and Alhusen 2019). From a green finance perspective, it is important to notice the evidence provided by Sheng, Ding and Yang (2024) who propose that population aging affects corporate green innovation activities by boosting corporate ESG performance.

X6_GINI index and green finance. The literature evidences the detrimental effects of the widening income gap on green growth, noting that while it promotes economic growth, it simultaneously harms people's well-being and the environment (Zhao, Dong and Taghizadeh-Hesary 2023). Further evidence shows a correlation between income inequality and lower levels of investment in green technologies and sustainable finance initiatives (Vona and Patriarca 2011), which results from a set of complex factors. These factors include prioritizing short-term financial gains over long-term investments in green technologies, or as Murshed et al. (2020) state, "growing up in the short-run and cleaning up in the long-run". Other factors include uneven affordability of green technologies among different income groups (Barbieri et al. 2023), which may also result in governments spending less on sustainable practices due to reduced overall support and funding (Arpad 2018).

3 DATA AND METHODOLOGY

This research primarily aims to examine the long-term effects of the selected sociodemographic indicators on green finance growth. For the purpose of this research, we used OECD data for the government budget allocations for R&D with environmental objectives as a proxy for green finance. OECD data on gross domestic expenditure on R&D (GBARD) by socio-economic objective is based on the NABS 2007 classification. According to the NABS classification, environmental objectives are related to the elimination and prevention of all forms of pollution in all types of environments including the protection of the atmosphere, climate, air, and water. These objectives generally align with the goals of green finance that directly support the achievement of sustainable practices. In addition, public investments in the environmental sector are particularly important, as they often provide the foundation for national energy transitions (Semieniuk and Mazzucato 2019), support the development of green technologies, and help de-risk future private investments in this area (Jaffe, Newell and Stavins 2005). Furthermore, these investments reflect government priorities in addressing environmental challenges and fostering innovation

(Popp 2019), which are important components of green finance growth.

More precisely, we investigate the impact of the unemployment rate, population density, gender ratio, ratio of education expenditure to GDP, proportion of the population aged 15–64, and the Gini coefficient on the distribution of funds for environmental research and development. To achieve this, we utilize yearly data spanning from 2000 to 2021 across 21 European countries, applying panel time series analysis. Data sources include the OECD database for government budget allocations for R&D, and the Eurostat database for the unemployment rate, population density, gender ratio, ratio of education expenditure to GDP, proportion of the population aged 15–64, and the Gini coefficient.

Definitions and basic descriptive statistics including mean, standard deviation, minimum, and maximum values of considered variables, are given in Table 1. After missing data removal, a total of 484 observations per variable has been used for further analysis. The correlation matrix for the observed variables is presented in Appendix Table A1.

As a preliminary step, we checked for cross-sectional dependence using Pesaran's test and Friedman's test (Pesaran 2004), both of which concluded that there was no cross-sectional dependence in our data. Based on these results, we decided to use the first generation of panel unit root tests to examine the stationarity of the variables. These tests include the Levin, Lin, and Chu t* (LLC) test (Levin, Lin and Chu 2002), the Im, Pesaran, and Shin W-stat (IPS) test (Im, Pesaran and Shin 2003), the ADF – Fisher Chi-square test and the PP – Fisher Chi-square test (Maddala and Wu 1999; Choi 2001), all assuming cross-sectional independence among the units in the panel. The LLC test assumes a common unit root process across cross-sections, and uses a pooled t-statistic for evaluation. The IPS test allows for heterogeneous autoregressive coefficients and averages individual ADF t-statistics.

Table 1 The definition and descriptive statistics of considered variables

Variable name	Definition	Min	Max	Mean	St.Dev	Median	N
R&D	Government budget allocations for R&D in the environmental sector (2015 Dollars – Constant prices and PPPs)	0.00	1435.68	121.28	223.75	38.29	515
Unemp_Rate	Unemployment rate in %	2.00	16.70	8.13	4.44	7.20	491
Pop_Density	Population density per 1000 residents	2.80	378.90	126.14	110.47	105.45	550
Gender_Ratio	Gender ratio	0.49	0.54	0.51	0.01	0.51	546
Edu_GDP	The ratio of education expenditure to GDP (% Education/GDP)	3.15	8.81	5.34	1.13	5.20	485
Pop_15_64	Population ages 15–64 (% of total population)	61.30	71.30	66.64	2.07	66.55	551
Gini	Gini index	10.68	22.17	16.99	2.74	17.09	484

Source: Authors' calculations

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Additionally, the ADF – Fisher Chi-square and PP – Fisher Chi-square tests combine p-values from individual unit root tests, following a chi-square distribution under the null hypothesis. All the tests test the null hypothesis of the existence of a unit root.

We subsequently conduct panel cointegration tests to evaluate the existence of long-term relationships among the variables. For this purpose, we utilize the tests developed by Pedroni (2004) and Kao (1999), which are extensions of Engle and Granger (1987). Pedroni's methodology accommodates heterogeneous intercepts and trends across different cross-sections and tests the stationarity of the residuals. Stationary residuals would suggest rejection of the null hypothesis of no cointegration. Pedroni's framework offers seven different test statistics for the same null hypothesis. Two types of alternative hypotheses are tested: the homogeneous alternative known as the panel or within-dimension approach, which includes the panel v-statistic, ρ-statistic, PP-statistic, and ADF-statistic; and the heterogeneous alternative referred to as the group or between-dimension approach, which includes the group ρ-statistic, PP-statistic, and ADF-statistic.

After confirming the existence of a long-run relationship among the variables, we utilize the Pooled Mean Group (PMG) ARDL estimation method, developed by Pesaran and Smith (1995) and Pesaran et al. (1999), to evaluate long-term dynamics. The PMG-ARDL model combines the autoregressive distributed lag approach with panel data analysis, making it well-suited for capturing the temporal dynamics and cross-sectional variations in the data. The ARDL framework is particularly useful for dealing with variables that are integrated of different orders, i.e., I(0) or I(1). This allows for a direct estimation of both short-run and long-run effects within a single equation model. This approach eases biases in standard ARDL models when used with panel data containing fixed effects. The PMG-ARDL model is advantageous compared to other dynamic models like Generalized Method of Moments (GMM) and fixed effects models because it accounts for heterogeneity in short-run dynamics while allowing for homogeneity in long-run relationships across different cross-sections (Hotak, Islam and Kakinaka 2020). This flexibility ensures more reliable and accurate parameter estimates, even when the assumption of identical coefficients across countries does not hold. The general functional form of the model is as follows:

R&D=f (Unemp_Rate, Pop_Density, Gender_Ratio, Edu_GDP, Pop_15_64, Gini),
while the specific functional form of our model is expressed as follows:

$$R\&D_{it} = \sum_{j=1}^{p} a_{it}\, R\&D_{i,t-j} + \sum_{j=0}^{q} x_{i,t-j}\, b_{ij} + \mu_i + \epsilon_{it}$$

where X_{it} represents the set of all considered independent variables. Here, p and q denote the lag lengths for the dependent and independent variables, respectively, μ_i is the cross-sectional effect, and ϵ_{it} is the error term.

Given that the variables in this model are integrated of order one and cointegrated, the error term is expected to follow an I(0) process, ensuring a long-run equilibrium relationship among the variables. The adjustment towards this long-run equilibrium can be captured through an error correction model (ECM), where the short-run dynamics are explained by deviations from the equilibrium:

$$\Delta R\&D_{it} = \sum_{j=1}^{p-1} c_{it}\, \Delta R\&D_{i,t-j} + \sum_{j=0}^{q-1} \Delta X_{i,t-j}\, d_{it} + \epsilon_{it} + \gamma_i ECT_{it}\,.$$

In this equation, Δ denotes the first difference, ECT_{it} is the error correction term defined as $ECT_{it} = R\&D_{i,t-1} - X\_it\theta$. The parameter d_{it} captures short-run dynamics, while θ represents the long run.

4 EMPIRICAL RESULTS

The cross-sectional dependence tests indicate no cross-sectional dependence in our data (Table 2). These results validate the use of the first-generation panel unit root tests in our analysis.

Table 3 presents the results of the panel unit root tests conducted for each considered variable. The panel unit root tests were conducted without explicitly including an intercept or trend in the regression. The dependent variable, government budget allocations for R&D in the environmental sector (R&D) is generally non-stationary across most tests, with the exception of the PP-Fisher Chi-square test suggesting stationarity. The unemployment rate also shows mixed results; it is found to be stationary by the IPS and ADF-Fisher tests, while the LLC and PP-Fisher tests indicate non-stationarity. Population density is confirmed to be stationary by the LLC and PP-Fisher tests, but the IPS and ADF-Fisher tests

Table 2 Cross-sectional independence test

	Statistics	p-value
Pesaran's test	0.083	0.934
Friedman's test	14.366	0.916

Source: Authors' calculations

Table 3 Panel unit root

Variable	Type	Levin, Lin, and Chu		Im, Pesaran, and Shin		ADF-Fisher		PP – Fisher Chi-square	
		Statistics	p-value	Statistics	p-value	Statistics	p-value	Statistics	p-value
R&D	Level	0.033	0.513	-0.478	0.316	55.134	0.084	75.173	0.001
	1st Diff	-7.496	0.000	-9.940	0.000	177.023	0.000	666.632	0.000
Unemp_Rate	Level	0.877	0.810	-5.461	0.000	111.318	0.000	40.797	0.760
	1st Diff	-5.222	0.000	-4.148	0.000	97.073	0.000	91.455	0.000
Pop_Density	Level	-3.914	0.000	1.267	0.897	43.429	0.733	71.979	0.023
	1st Diff	-4.214	0.000	-4.004	0.000	93.882	0.000	181.381	0.000
Gender_Ratio	Level	1.991	0.977	4.574	1.000	26.917	0.997	21.793	1.000
	1st Diff	-2.808	0.002	-7.293	0.000	153.078	0.000	330.595	0.000

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Variable	Type	Levin, Lin, and Chu		Im, Pesaran, and Shin		ADF-Fisher		PP – Fisher Chi-square	
		Statistics	p-value	Statistics	p-value	Statistics	p-value	Statistics	p-value
Edu_GDP	Level	-0.473	0.318	-3.147	0.001	78.997	0.006	74.278	0.015
	1st Diff	-1.283	0.100	-7.132	0.000	145.073	0.000	283.884	0.000
Pop_15_64	Level	1.928	0.973	7.267	1.000	14.066	1.000	18.831	1.000
	1st Diff	-8.946	0.000	-11.332	0.000	201.892	0.000	568.553	0.000
Gini	Level	-0.786	0.216	-3.292	0.000	76.565	0.009	107.714	0.000
	1st Diff	-3.351	0.000	-10.381	0.000	202.099	0.000	400.337	0.000

Source: Author's research

do not support this. The gender ratio is consistently non-stationary. The education expenditure to GDP ratio is identified as stationary by the IPS, ADF-Fisher, and PP-Fisher tests, whereas the LLC test suggests non-stationarity. The percentage of the population aged 15–64 is uniformly non-stationary according to all the tests. The Gini index shows evidence of stationarity in the IPS, ADF-Fisher, and PP-Fisher tests, with the LLC test not supporting this result.

Table 3 also presents the results of the panel unit root tests for each first-differenced variable. The tests indicate that while the variables are not stationary at their levels, they become stationary upon taking their first differences. These findings confirm that all variables are integrated of order one. Consequently, we can proceed with panel cointegration tests an-d ARDL analysis.

The panel cointegration results are given in Table 4. The results of the Pedroni panel cointegration tests indicate the presence of long-term relationships among the variables, as the null hypothesis of no cointegration is rejected at the 1% significance level for most of the tests. Both within-dimension and

Table 4 Panel cointegration tests

Pedroni (1999, 2004)				
Test Within dimension	Statistics	p-value	Weighted Statistics	p-value
v-Statistic	-2.25325	0.988	-1.71459	0.957
rho-Statistic	2.251307	0.988	1.593588	0.944
PP-Statistic	-7.37721	0.000	-9.51209	0.000
ADF-Statistic	-7.19998	0.000	-9.03251	0.000
Test Between dimension	Statistics	p-value		
rho-Statistic	4.104534	1.000		
PP-Statistic	-10.5909	0.000		
ADF-Statistic	-6.36959	0.000		
Kao, 1999				
ADF	Statistics	p-value		
	-2.28658	0.0111		

Source: Authors' calculations

Table 5 A pooled mean group with dynamic autoregressive distributed lag: PMG-ARDL(1,1,1,1,1)

	Coefficients	Std. Error	Statistics	p-value
Unemp Rate	0.7422	0.082	9.076	0.000
Pop Density	1.807	0.372	4.854	0.000
Gender Ratio	1.679	0.757	8.354	0.000
Edu GDP	0.727	0.089	8.159	0.000
Pop 15–64	5.972	0.553	10.790	0.000
Gini	5.569	0.568	9.79	0.000

Source: Authors' calculations

between-dimension test statistics confirm cointegration, except for a few tests where the null hypothesis could not be rejected. This confirms the existence of a cointegrated relationship between the variables under study.

Table 5 represents the results of the Pooled Mean Group (PMG) estimation with a dynamic autoregressive distributed lag model: PMG-ARDL(1,1,1,1,1). All variables are found to be highly significant in the model, with p-values less than 0.01, indicating their significance at the 1% level. This confirms the robustness of each variable's impact within the model.

5 DISCUSSION

In this section, we first explain the key findings by delineating the relationship between the observed socio/demographic factors on green finance. Afterward, we delineate the main contributions of our study.

5.1 KEY FINDINGS

Our quantitative findings indicate a positive and statistically significant relationship between all the observed sociodemographic indicators and the growth of green finance. The summary of the key findings is given in Figure 2.

First, the unemployment rate positively affects green finance growth (0.7422). This finding suggests a counterintuitive but positive relationship between higher unemployment rates and green finance growth. The multifaceted nature of this relationship implies that economic downturns, characterized by higher unemployment, often prompt policy interventions aimed at economic recovery. During such periods, there is also a potential shift towards sustainable practices as part of economic restructuring. The results are consistent with the previously mentioned findings of Barra and Ruggiero (2019) and Cui et al. (2022) who stressed that investments in green infrastructure during high unemployment could create jobs and stimulate economic growth. The positive effect of green policies on employment has been confirmed in other studies, at least in the short term (Naqvi, Wang and Ali 2021). Some studies find that green finance in turn decreases unemployment (Cui et al. 2022). Therefore, this result underscores the importance of strategic policymaking that leverages economic crises to promote green finance and sustainable development.

Second, population density has a positive long-term effect on green finance growth. This evidence implies that urbanization plays a crucial role in enhancing green finance through several synergistic mechanisms. Urban areas, with their higher population densities, benefit from more efficient resource

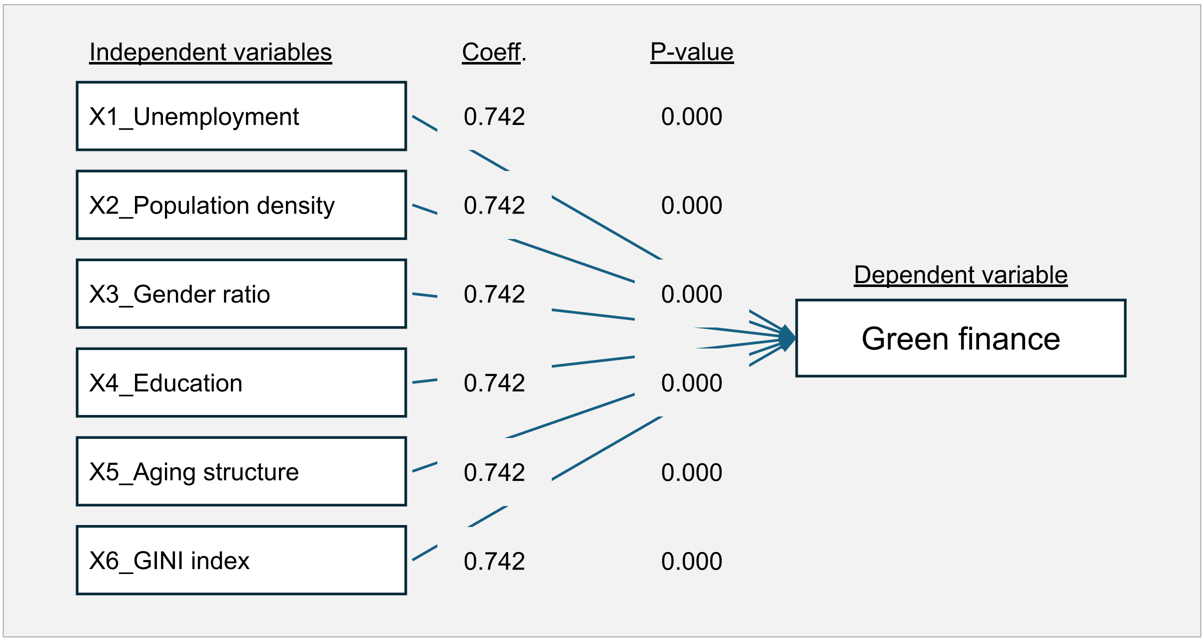

Figure 2 Key numerical findings

use and economies of scale, reducing costs for implementing green projects. Social dynamics in densely populated areas, where greater exposure to environmental issues leads to heightened environmental awareness, combined with community-driven sustainability initiatives and peer effects, work together to further encourage green investments. Higher population density areas attract more investors and financial institutions due to their sustainable infrastructure, robust economic activity, and market opportunities, which increase the availability of capital for green projects. The findings in this paper support the previously mentioned results of Hsu, Johnson and Lloyd (2013), who explain that dense urban areas typically have better infrastructure for implementing green initiatives, which can attract green investments, and Lee and Min (2015), who demonstrate that dense populations can stimulate green R&D and innovation, further encouraging these investments. Additionally, the current body of knowledge has already provided some empirical evidence on the statistically significant relationship between the ecologicalisation level of urban structures and green finance (Lin and Zhao 2022).

Third, a 1% increase in the ratio of education expenditure to GDP is associated with an approximately 0.72% increase in green finance in the long run. This result underscores the crucial role of education in fostering environmental awareness and driving demand for sustainable financial products. Higher education levels are generally associated with a greater understanding of environmental issues, which translates into stronger support for green finance initiatives. The result is consistent with the conclusions of Ma (2022), An and Madni (2023), and Niamir, Ivanova and Filatova (2020) who also showed that education amplified the population's awareness of environmental issues and advanced green finance and green economic growth, while our results show that this awareness is translated into a diffusion of green investments. This result highlights that increasing educational expenditure may enhance green finance, fostering a more environmentally conscious and proactive society.

Fourth, the gender ratio (i.e., female to total population ratio) is associated with an approximately 1.69% increase in green finance in the long run. This significant positive relationship indicates that gender diversity in the broad sense, as explained by Abuatwan (2023), Gör and Tekin (2023), and Al Mamun et al. (2024), i.e. the inclusion of women in leadership roles, may enhance green finance initiatives. Women in leadership roles are often more environmentally conscious, leading to the adoption of comprehensive and effective green finance strategies.

Fifth, we find a positive relationship between aging structure and green finance growth (5.972). This strong positive correlation can be attributed to several socio-economic factors. From a macroeconomic perspective, a larger proportion of the working-age population enhances the labour force, driving higher productivity and tax revenues. This increase in economic output provides governments with greater fiscal capacity, enabling higher investments in green R&D. Additionally, as the working-age population often drives innovation and consumption, their increasing demand for sustainable solutions could further incentivize government spending on environmental initiatives. Another possible explanation is that heightened environmental awareness among the aging population, driven by the long-term benefits of environmental sustainability and economic stability, may also support increased government allocations to green R&D. Although this evidence does not support the results of the previously mentioned work by Olumekor and Oke (2024) it is in line with the work of Sheng, Ding and Yang (2024) who argue that population aging enhances corporate ESG performance, supporting green innovation activities, and promotes industrial structure changes that further encourage green innovation.

Finally, single-percent growth in the Gini index is associated with an approximately 5.57% increase in green finance in the long run. Even though this result is not consistent with the previously mentioned findings by Zhao, Dong and Taghizadeh-Hesary (2023) and Vona and Patriarca (2011), this significant positive correlation can be explained by distinct socio-economic dynamics. As income inequality increases, governments may face greater pressure to promote green investments as a means of addressing the uneven distribution of wealth and opportunities. In response, governments might increase allocations to green R&D to foster innovation and encourage sustainable development, particularly in regions or sectors less equipped to invest in green technologies. This strategy not only supports environmental goals but also aims to reduce economic disparities by ensuring that the benefits of green investments are more widely shared, contributing to greater economic and social stability. Additionally, governments in low-income countries, in which income inequality is typically higher, may implement green finance initiatives, usually funded by multilateral agencies, as a part of broader social and economic reforms aimed at addressing inequality and reducing poverty (Owen, Brennan and Lyon 2018).

5.2 CONTRIBUTIONS

The main contributions of this study are as follows. First, we incorporate a wide range of socio-demographic variables to comprehensively analyse their impacts on green finance, going beyond the existing literature which has primarily focused on macroeconomic and institutional factors.

Then, the results of this study are to some extent counterintuitive. For instance, we find that age positively affects the development of green finance. Also, our study confirms that the higher unemployment rates create a fertile ground for green finance blossoming. Other findings are of a lower tension in terms of the statistical validation of the hypothesized relationships.

Next, our study contributes to the development of the ever-needed evidence on the main factors affecting the development of green finance. Further development of green finance is crucial for the planet and society, as it promotes sustainable development by directing investments into projects that mitigate environmental degradation, combat climate change, and foster economic resilience. By prioritizing funding for renewable energy, energy efficiency, and sustainable economic development, green finance helps reduce greenhouse gas emissions, conserve natural resources, and protect ecosystems. Additionally, it supports the transition to a low-carbon economy, driving innovation and creating green jobs, thereby contributing to social equity and economic stability. Ultimately, green finance is essential for achieving long-term environmental sustainability and enhancing the quality of life for current and future generations.

Our research enhances the understanding of the complex interaction between socio-demographic factors and technological advancements within the framework of sustainable development. By examining how variables such as population density, educational expenditure, gender ratio, and income inequality impact green finance, our study contributes to the broader discussion on the challenges of achieving a balance between economic growth, environmental sustainability, and social equity. We provide empirical evidence on how these socio-demographic dimensions facilitate sustainable growth and align with the UN Agenda 2030 for Sustainable Development's goals of inclusivity and environmental responsibility.

Our findings suggest the importance of policies that support sustainable urban development, increase investment in education, and advance gender equality, while also implying that green finance approaches must evolve to address the particular aspects associated with demographic shifts, such as the aging of population. This approach is crucial for overcoming the socio-economic disparities that could hinder the attainment of sustainable development goals. Additionally, our research offers practical insights for policymakers and financial institutions, guiding them to incorporate socio-demographic trends into green finance strategies. In reconciling demographic trends with technological progress, our research contributes to fostering equity, resilience, and environmental responsibility, thus supporting the design of strategies that achieve long-term social, economic, and environmental sustainability, and enhance overall well-being.

5.3 POLICY RECOMMENDATIONS

This study provides several points for policymakers. The study found a positive relationship between unemployment and green finance. Governments should introduce green financial stimulus packages during periods of high unemployment to capitalize on economic restructuring opportunities. Policymakers should design counter-cyclical fiscal policies that focus on green projects during periods of high unemployment, such as offering incentives for renewable energy projects, or providing grants for sustainable business initiatives.

The positive impact of population density on green finance indicates that urban areas are more conducive to green investments due to their infrastructure and environmental awareness. Accordingly, urban planning policies should integrate green infrastructure and prioritize dense urban areas for green finance projects. Cities should enhance infrastructure for green initiatives like electric transportation and energy-efficient buildings. Additionally, creating platforms for community engagement in urban areas can foster environmental awareness and stimulate local green investment. Such efforts can attract more investors and financial institutions interested in financing sustainable projects.

Education expenditure is another critical factor for boosting green finance. By increasing the education spending to GDP ratio, governments can foster a more environmentally conscious society that is better equipped to support and demand sustainable financial products. Environmental literacy programs at all educational levels could cultivate greater awareness of green finance opportunities, which may contribute to long-term growth in green investments.

The positive relationship between the gender ratio and green finance indicates the importance of gender diversity in decision-making processes. Policies that promote the inclusion of women in leadership roles within financial institutions, government bodies, and corporate boards can lead to a stronger focus on sustainable practices. Governments and organizations should establish targets for gender representation in leadership positions and provide support programs for women in leadership to encourage environmentally conscious decision-making.

The significant influence of income inequality on green finance highlights the potential for addressing economic disparities through increased investment in sustainable initiatives. Policymakers, particularly in the regions with significant inequality, should prioritize green R&D funding as a means to promote environmental sustainability and reduce economic gaps. By directing resources towards green technologies, governments can stimulate innovation in sustainable industries and create opportunities for economic growth that are accessible to a wider range of communities, including those most affected by inequality. This approach ensures that the advantages of green investments such as job creation, improved infrastructure, and better quality of life are distributed more equitably across society. Additionally, multilateral support for green finance initiatives could be crucial in low-income countries, where reducing inequality and poverty remains a key focus of development strategies.

Additionally, addressing income inequality through inclusive green finance policies—such as subsidies and tax incentives for low-income households—can help make green products more accessible and drive broader adoption of sustainable technologies. Furthermore, international cooperation with multilateral agencies should be sought to fund green initiatives, ensuring that green finance becomes a tool for both sustainable development and poverty alleviation.

6 CONCLUSION

This study examined the effects of various socio-demographic factors on green finance growth taking the GBARD with environmental objectives as a proxy. For this purpose, we observed panel data from 21 European countries in the period from 2000 to 2021. Our findings indicate that population density, educational expenditure, gender ratio, aging population, and income inequality have significant positive long-term effects on the development of green finance.

The results of this research provide several important implications for policymakers and financial institutions seeking to promote and expand green finance. Governments should focus on policies that support sustainable urban planning, increase educational spending, encourage gender diversity in leadership, and consider the unique needs of aging populations when designing green finance programs.

This study has a myriad of limitations that utterly restrict the generalization of the study findings, but open an avenue for further research based on in-depth qualitative determinants of green finance development. First, the research findings presented in this paper should be interpreted considering the limitations of the PMG-ARDL model. The model assumes homogeneity in long-term relationships across countries. Additionally, its reliance on linear relationships and sensitivity to lag selection might oversimplify complex interactions and lead to biased estimates, particularly if cross-sectional dependence is present. Second, the OECD data are based on the GBARD with environmental objectives and consequently overlook private sector investments, such as green bonds and sustainable banking. This narrow scope may not fully capture the broader dynamics of green finance. Third, the NABS 2007 classification system adopted by the OECD categorizes R&D spending based on socio-economic objectives, which might not align perfectly with the diverse and evolving definitions of green finance. This can limit the ability to generalize findings to other types of green investments that go beyond R&D. Fourth, this study includes the use of socio-demographic variables at the macro level, overlooking the important micro-level factors that could influence green finance growth. Fifth, the focus on OECD countries limits the generalizability of the findings to other regions, as the economic and institutional contexts in non-OECD countries may differ significantly.

The present study is quantitative by nature. This opens an avenue for further research by exploring qualitative determinants of green finance development. It focuses on a limited set of socio-demographic factors, and future work should incorporate additional variables such as ethnicity, race, and migration. Moreover, employing alternative indicators, like employment by activity, could provide further insights, as countries with a strong presence of professionals in technology, science, engineering, and finance may be better positioned to drive green finance initiatives.

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Data Availability Statement

Data are available from the authors upon request.

Coauthor contributions

Valentina Vukmirović: Data curation, Investigation, Writing – Original Draft, Writing – Review & Editing. **Milena Kojić:** Formal Analysis, Methodology, Validation, Writing – Original Draft. **Željko Spasenić:** Data Curation, Investigation, Writing – Original Draft, Visualization. **Miloš Milosavljević:** Conceptualization, Validation, Writing – Original Draft, Writing – Review & Editing.

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APPENDIX

Table A1 Correlation matrix

		R&D	Unemp_ Rate	Pop_ Density	Gender_ Ratio	Edu_ GDP	Pop_ 15_64	Gini
R&D	Pearson Correlation	1	.083	.196**	.016	-.171**	-.163**	.168**
	Sig. (2-tailed)		.075	.000	.722	.000	.000	.000
Unemp_Rate	Pearson Correlation	.083	1	-.205**	.268**	-.310**	.104*	.463**
	Sig. (2-tailed)	.075		.000	.000	.000	.022	.000
Pop_Density	Pearson Correlation	.196**	-.205**	1	-.224**	-.040	-.025	-.184**
	Sig. (2-tailed)	.000	.000		.000	.377	.563	.000
Gender_Ratio	Pearson Correlation	.016	.268**	-.224**	1	-.292**	.012	.526**
	Sig. (2-tailed)	.722	.000	.000		.000	.772	.000
Edu_GDP	Pearson Correlation	-.171**	-.310**	-.040	-.292**	1	-.341**	-.409**
	Sig. (2-tailed)	.000	.000	.377	.000		.000	.000
Pop_15_64	Pearson Correlation	-.163**	.104*	-.025	.012	-.341**	1	-.054
	Sig. (2-tailed)	.000	.022	.563	.772	.000		.249
Gini	Pearson Correlation	.168**	.463**	-.184**	.526**	-.409**	-.054	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.249	

Source: Author's research

Kako sociodemografski faktori utiču na rast zelenih finansija?

PROŠIRENI SAŽETAK

Ovaj rad istražuje uticaj sociodemografskih faktora na rast zelenih finansija u 21 evropskoj zemlji u periodu od 2000. do 2021. godine. Kvantitativni nalazi predstavljeni u ovom radu ukazuju na pozitivan i statistički značajan odnos između svih posmatranih sociodemografskih indikatora i rasta zelenih finansija.

Prvo, stopa nezaposlenosti pozitivno utiče na rast zelenih finansija. Ovaj nalaz sugeriše kontraintuitivan, ali pozitivan odnos između viših stopa nezaposlenosti i rasta zelenih finansija. Ekonomski padovi, karakterisani višom nezaposlenošću, često podstiču političke intervencije usmerene ka ekonomskom oporavku. Tokom ovih perioda može doći do prelaska na održive prakse kao deo ekonomskog restrukturiranja. Ovi rezultati su u skladu sa nalazima u literaturi koji naglašavaju da investicije u zelenu infrastrukturu tokom visoke nezaposlenosti mogu stvoriti radna mesta i stimulisati ekonomski rast. Drugo, gustina naseljenosti ima pozitivan dugoročni efekat na rast zelenih finansija. Ovi nalazi impliciraju da urbanizacija igra ključnu ulogu u unapređenju zelenih finansija kroz nekoliko sinergetskih mehanizama. Urbana područja sa većom gustinom naseljenosti odlikuju se efikasnijom upotrebom resursa. Takođe, socijalna dinamika u gusto naseljenim područjima, u kojima je veća izloženost ekološkim problemima, dovodi do povećane svesti o životnoj sredini, što dodatno podstiče zelene investicije. Nadalje, kao posledica ekonomije obima, urbana područja sa velikom gustinom naseljenosti povezuju se sa većim rastom zelenih finansija usled smanjenih troškova za implementaciju zelenih projekata.

Treće, povećanje udela izdataka za obrazovanje u odnosu na BDP povezano je sa rastom zelenih finansija na duži rok. Ovaj rezultat naglašava ključnu ulogu obrazovanja u unapređenju ekološke svesti i podsticanju potražnje za održivim finansijskim proizvodima. Viši nivoi obrazovanja su generalno povezani sa boljim razumevanjem ekoloških problema, što za posledicu ima jaču podršku zelenim finansijskim inicijativama. Četvrto, rodni odnos je povezan sa rastom zelenih finansija na duži rok. Ovaj značajan pozitivan odnos ukazuje da rodni paritet, posebno uključivanje žena u liderske uloge, može unaprediti inicijative u oblasti zelenih finansija. Žene na liderskim pozicijama često su ekološki svesnije, što dovodi do usvajanja sveobuhvatnih i efikasnih strategija zelenih finansija. Peto, utvrđen je pozitivan odnos između starosti i rasta zelenih finansija. Ova snažna pozitivna korelacija može biti pripisana nekolicini socio-ekonomskih faktora. Stariji slojevi populacije teže stabilnim i održivim investicijama, a njihova akumulirana novčana sredstva često se ulažu u zelene finansijske inicijative. Takođe, povećana ekološka svest među starijim generacijama, vođena brigom za buduće generacije i zdravstvene benefite, dodatno podstiče investicije u zelene inicijative. Na kraju, rast Ginijevog koeficijenta povezan je sa povećanjem zelenih finansija na duži rok. Ova značajna pozitivna korelacija može se objasniti specifičnim socioekonomskim dinamikama. Rani usvojitelji zelenih proizvoda često imaju veću kupovnu moć, što im omogućava da priušte inicijalno skuplje zelene tehnologije i proizvode. Njihova spremnost da investiraju u ove proizvode pomaže u pokretanju inovacija, dok ekonomija obima na duži rok čini zelene tehnologije priuštivijim i drugim dohodovnim grupama stanovništva.

U zaključku, studija ističe značaj sociodemografskih faktora u kreiranju politika zelenih finansija. Rezultati istraživanja naglašavaju potrebu za daljim ispitivanjem dodatnih sociodemografskih faktora i kvalitativnih aspekata razvoja zelenih finansija kako bi se stvorile efikasnije strategije za promovisanje održivog razvoja.

KLJUČNE REČI

sociodemografski faktori, zelene finansije, rast, PMG-ARDL, održive prakse

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