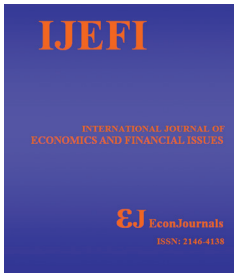

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Fiscal Policies, Green Trade, and Green Bond Market Development: An Empirical Study using Cross-Country Data

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ABSTRACT

The global transition toward sustainable finance has elevated green bonds as a pivotal instrument for mobilizing capital toward climate-aligned investments. Yet, empirical understanding of the policy drivers behind green bond issuance remains incomplete, particularly regarding the combined roles of fiscal policy and trade integration. In this study, we examine how environmental taxes, fossil fuel subsidies, public environmental expenditure, and international trade of low-carbon technologies and environmental goods simultaneously affect the development of green bond markets. We use a panel of 11 countries between 2014 and 2022 and estimate fixed effects regression models, concluding that, though environmental taxes are positively related to the issuance of green bonds, they significantly diminish when fossil fuel subsidies persist. Conversely, direct public environmental expenditure and participation in foreign environmental trade, are consistently and robustly significant drivers of green bond issuance. These results highlight the need for coherent policy frameworks, that is, public interventions aiming at scaling up green finance through a recalibration of fiscal signals, an elimination of perverse subsidies and a boost of cross-border trade in green technologies.

Keywords: Green Bonds, Green Finance, Fiscal Policy, Environmental Taxes, Fossil Fuel Subsidies, Climate Policy.
JEL Classifications: F18, Q56, Q58, H23

1. INTRODUCTION

In the 21st century, green finance has gained increasing recognition as a vital mechanism for achieving sustainable objectives on a global scale, particularly in response to mounting climate and environmental challenges. By strategically directing financial capital toward projects with explicit environmental benefits such as climate mitigation, biodiversity conservation, resource efficiency, and low-carbon economic growth, green finance contributes to aligning financial systems with long-term sustainability goals (Fu et al., 2024; Ali, 2024). One of the main instruments through which green finance operates are green bonds; which are debt securities specifically issued to fund projects that will have positive environmental effects such as renewable energy installations, energy-efficient infrastructure, pollution control measures, and sustainable resource management (Mecu et al., 2024; Zhang et al., 2024).

The growth in the global green bond market reflects increasing investor awareness and institutional demand for financial instruments that combine environmental integrity with competitive financial returns. Green bonds have gained tremendous popularity worldwide primarily due to their investment ability to generate financial returns while helping to achieve environmental objectives, an aspect that proves to be an attractive investment for institutional investors looking for sustainable solutions (Yumnam et al., 2024; Işık et al., 2024). The United Nations' (UN) introduction of the 2015 Sustainable Development Goals (SDGs) gave a detailed blueprint of how the world would be able to achieve sustainable development in 2030, by addressing a number of critical global challenges such as the world economy, social welfare and the environment (Yumnam et al., 2024; Işık et al., 2024). Green bonds assist in the transition from conventional industrial methods to sustainable practices through financing projects which decrease energy consumption

per unit output, improve resource efficiency or reduce solid waste (Uwuigbe et al., 2024).

To ensure that green bonds effectively contribute to sustainability goals, the Climate Bonds Initiative (CBI) has established rigorous criteria that enhance market credibility and attract responsible investment (Doan and Trinh, 2024; Mohamed, 2024). Through such efforts, governments and corporations have leveraged green bonds to finance large-scale sustainable projects. One notable example is France, who issued €7 billion worth of such bonds for funding both renewable energy initiatives and biodiversity conservation (Climate Action, 2017; Green Finance Platform, 2017). Similarly, Apple Inc. relied on such green bonds to support their own projects which involved constructing alternative energy plants by borrowing money from the public using this method of financing (Climate Bonds Initiative, 2016; Apple Inc., 2024). This initiative offers transparency and promptness of action as issuers are often forced into revealing environmental impacts of their projects which are sponsored by these funds.

Policy interventions have been crucial to encouraging green bond issuance, yet certain targeted interventions fell short of their objectives because they didn't address structural, institutional, and market-level deficiencies. For instance, the People's Bank of China (PBoC) introduced green bond guidelines in 2015 that permitted financing all the way up to "clean coal" projects, which did not meet international green standards and undermined investor trust in the environmental integrity of such instruments (Sustainalytics, 2022; Climate Policy Initiative, 2020). This mismatch hampered global participation and underscored the risks of insufficiently harmonized taxonomies. Similarly, Nigeria's introduction of Africa's first sovereign green bond in 2017 was symbolically meaningful, but did not spur wider market development because of lack of private sector participation, follow-up policy support and lack of institutional frameworks for sustained issuance (APRI, 2024; LSEG Africa Advisory Group, 2018; Saka and Akinde, 2023). The European Union (EU) also faced a tough time with its first drafts of taxonomy, which faced scrutiny for being vague and a product of political compromise, especially on the inclusion of natural gas and nuclear energy, leaving issuers and investors unsure (The Club of Rome, 2021; Eurosif, 2021). These cases highlight how poorly green bond policies whether designed badly or weakly enforced can undermine confidence in the market, limit cross-border investments, and not spur growth in key sectors like transportation, manufacturing and agriculture. A green bond policy will therefore need to be supported by clear and consistent definitions, consistent implementation, and mechanisms that enhance issuer capacity and investor assurance across regions.

Targeted policy interventions have proven instrumental in advancing the adoption of green bonds across emerging markets and underdeveloped sectors, unlocking opportunities for climate-resilient and sector-specific development (World Bank, 2022). This has enabled issuances in sectors usually neglected by conventional finance, facilitated by government-backed pathways such as green bond frameworks, fiscal incentives and risk-sharing mechanisms (Klymenko and Ukhnal, 2024). Policy mandates in countries such as India and Indonesia have catalyzed green bond financing for renewable energy and public transportation infrastructure, resulting in scalable models of sustainable urban development (IFC and Amundi, 2023; Okeke et al., 2024). Africa has undertaken efforts to finance agricultural resilience and water resource management which are key sectors to ensure livelihoods and ecological sustainability, through the issuance of green bonds, supported by regulatory reform and partnerships with multilateral institutions (Taghizadeh-Hesary et al., 2022; LSEG Africa Advisory Group, 2018). These cases confirm that, when policies de-risk investments, harmonize disclosures, and enhance issuer capacity, green bonds can help unlock transformative change in sectors key to national development goals, but constrained by limited access to capital. The ongoing alignment of national policies for green bond market development is therefore also a strategy to pave the way for inclusive development that advances climate and environmental goals.

Although green bonds continue to gain global traction and recognition, some key areas remain underexplored in the existing literature. Importantly, while prior literature has extensively examined the individual effects of fiscal and trade-related policies, much less attention has been paid to how these policies interact and jointly influence green bond issuance particularly through mechanisms such as environmental taxes, fossil fuel subsidies, public environmental expenditures, and international green trade (Riaz et al., 2024; Zijl et al., 2022; Herlina and Dewayanto, 2024; Ozili, 2022; Maltais and Nykvist, 2020). As a result, policymakers struggle to garner full understanding on how to better connect these potential arrangements between the different policy instruments to develop green bonds. Moreover, much of the existing literature focuses on advanced economies, leaving a significant gap in understanding the context and impacts of integrated policy models in emerging and transitional economies, particularly on their effectiveness in addressing the conflicting trade-offs between promoting economic growth, energy security, and environmental sustainability objectives. This study is critically important given that advanced economies, with their more advanced financial markets and complex fiscal measures, are powerful role models, and the successful incorporation into common practice of these measures represents a useful blueprint. Indeed, the effective alignment and coordination of these policy tools in developed countries could serve as a normative reference point, easily transferable and replicable for other advanced economies, and encourage developing countries to adopt similar integrated approaches to sustainable finance.

Recognizing these gaps, we aim to empirically test the central hypothesis of this study that fiscal policies (environmental taxes, fossil fuel subsidies and environment-related expenditures) and trade integration in environmental goods and low-carbon technologies jointly affect green bond issuance at country level. More specifically, the research examines the hypothesis that coherent and complementary policy environments (characterized by high environmental expenditure, low fossil fuel subsidies, adequate environmental taxation, and proactive global green trade integration) add significantly to the green bond market development. By filling these gaps and testing this hypothesis, the study offers actionable insights for both policy makers and

investors, clarifying the circumstances under which green bonds can most effectively support national and global sustainability targets. The results clearly indicate that the study's objective was achieved, providing robust evidence that coherent fiscal and trade policies are key drivers of green bond market development.

2. LITERATURE REVIEW

In recent times, decarbonization across producing and non-producing industries has resulted in taxation to drive systemic change and advance global sustainability. Economies have used taxation policy as an economic incentive to significantly influence the demand for green bonds thereby encouraging investment in sustainable projects (Dobrovolska et al., 2024; Agliardi and Agliardi, 2019). These taxes encompass environmental, energy, and transportation levies, varying by country. A clear example is the Netherlands, where carbon taxes serve as a threshold mechanism, applied when prices in the emissions trading system fall below a certain level; in comparison, Norway and the United Kingdom operate flexible excise tax systems designed to strike a balance between revenue generation and environmental objectives (Korytin et al., 2023; Mengden, 2024).

The growth prospects for the green bond market remain substantial, despite challenges such as limited market awareness and diverse regulatory frameworks, as global sustainability commitments continue to strengthen (Zhang, 2025). Different regions experience varying adoption rates of green bonds due to unique policy environments and differing levels of market development and economic goals (International Finance Corporation, 2021). Through solid regulatory frameworks and strong investor trust, the EU demonstrates leadership in green finance which enables substantial investments in sustainable projects (Kumpan, 2024; Mohammed et al., 2024). Developing countries in Africa and Asia have begun using green bonds to fund climate adaptation projects and sustainability initiatives but struggle with regulatory inconsistencies and insufficient data transparency (Jenei et al., 2024). Major economic powers such as China and the United States are demonstrating green finance integration within their economic structures to prove green bonds can facilitate substantial sustainability changes (Ogunsola et al., 2024).

A persistent barrier to low-carbon transitions, especially in developing economies, is the issue of limited financial capacity, which hampers the deployment of clean technologies and sustainable infrastructure. Green bonds offer a promising solution by providing an avenue to mobilize international and domestic capital specifically for environmentally beneficial projects (Chaudhary et al., 2024). Limited access to capital markets coupled with investor skepticism and weak regulatory enforcement acts as barriers against green bond adoption in developing regions (Singh, 2024). According to Gorelick et al. (2024), green bonds present multiple challenges such as increased issuance costs and poor investor demand which makes the financial landscape more complex. International financial institutions alongside development banks promote green finance more actively using risk management strategies and policy incentives to boost investor confidence and direct capital into sustainable projects.

Some sectors have become primary targets for green financing because of their disproportionate share of carbon emissions (Gu et al., 2024). Emissions from the energy sector is quite high. A study by IEA (2025) noted that, in 2024, the total energy-related emissions from the energy sector increased by 0.8%, reaching an average high of 37.8 Gt CO_2. The transport sector, which consists of roads, aviation, and marine, primarily relies on oil and gas, and is responsible for nearly 21% of direct energy-related greenhouse gas emissions, with road transportation making 75.2% of that emissions and the United States the largest producer of transport emissions worldwide (Statista, 2024; Statista, 2025). Heavy industries like steel and cement, alongside the mining industry, are also major contributors of CO_2 emissions due to their high consumption of resources and energy services (Belaïd, 2022; Gross, 2021). This has driven emissions growth in the industrial sector, especially in developing regions experiencing rapid industrialization (Kim et al., 2022). The industrial sector, which is the second largest in terms of emissions after transportation, contributes to 30% of total GHG emissions (Zhang et al., 2024; IEA, 2022). All these carbon-emitting sectors are now widely shifting toward the use of green bonds or green financing for easier decarbonization.

While green bonds offer a market-driven approach to sustainability, tax policies remain a critical tool for balancing economic growth and environmental objectives. However, achieving an optimal balance is challenging, as tax measures can have significant economic impacts on both industries and households (Yan and Wang, 2024). According to a study by Lazarishyna et al. (2023), administering environmental taxes will undoubtedly reduce emissions but may harm economic growth, whereas policies like subsidies for green bond projects will incentivize businesses to lower emissions and, at the same time, support economic growth. Complementing this, research by Boz and Onur (2024) indicates a positive relationship between environmental taxes and economic growth, while carbon emissions negatively impact growth. These findings suggest that the effects of environmental taxes on economic growth are more pronounced in developing countries than in developed ones, highlighting the need for context-specific policy design. This demands an optimization of tax structure such as the one employed in China, where a low-implemented non-energy intensive goods consumption tax and a near-zero carbon tax shows a double-dividend for emissions and economic growth (Liu et al., 2022).

Countries like Canada and France have significantly proven to stimulate green innovation in environmentally sustainable technologies (Günel, 2024), with tightened energy tax policies to meet regional energy structures to ensure the effectiveness of green bonds (Zhang et al., 2024). For instance, Canada's energy tax policy takes into consideration fuel excise taxes, carbon pricing, and investment tax credits, that is, a 10% excise tax per liter is imposed by the federal government on gasoline, while a 4% excise tax per liter is applied to diesel (Finances of the Nation, 2024). Likewise, the United States uses the Energy Tax Act of 1978 and subsidies for the efficient allocation and distribution of energy resources to fiscal objectives. The revenue generated from these taxes are sometimes utilized to support energy sources,

which include green bonds for renewable energy projects aimed at promoting environmental sustainability (Better Buildings, 2025).

Energy taxes imposed on non-green activities from fossil fuels activities play a crucial role in promoting green financing as they increase the operational costs of heavily induced fossil fuel industries. In this regard, fossil fuel-dependent industries are pressurized to shift investment toward renewable energy projects and energy-efficient technologies which are financed through green bonds. Kuzior et al. (2023) found that businesses seek an alternative production approach when higher energy taxes raise the cost of fossil fuel consumption. Countries, where higher energy taxes such as carbon taxes are implemented, have seen a fall in emissions, and producing industries have progressively invested in renewable energy (Wahyudi and Leny, 2025; Chenge, 2024). Evidence of this can be found in Sweden where carbon taxes implemented in 1991 resulted in a 26% decrease in CO_2 emissions as of 2019 while maintaining a positive economic outlook (Zheng, 2024). Feng, et al. (2024) also highlighted that carbon tax can serve as a mechanism for achieving a double dividend, reducing emissions while promoting economic growth through revenue recycling or strategic reinvestment. In most cases, revenues from energy taxes such as carbon taxes act as a stimulant for investment in renewable energy which can further be reinvested into green technologies (Dobrovolska et al., 2024).

Enabling a worldwide shift to a greener economy depends critically on international trade in low-carbon technologies, including renewable energy equipment, electric vehicles (EVs), and energy-efficient systems. International trade accelerates the adoption of renewable energy solutions and the reduction of carbon emissions by facilitating access to advanced technologies (Weijian et al., 2023). The export and import of wind turbines, solar panels, and battery storage systems allow countries to expand their renewable energy infrastructure more efficiently and cost-effectively (Stojanović, 2020). This flow of technologies has a direct impact on green bond activity by supporting technically grounded sustainable initiatives. In many cases, green bonds are issued specifically to finance the deployment of these technologies, resulting in tangible environmental benefits. Research shows that countries actively engaged in green technology trade are more likely to issue green bonds to finance additional green infrastructural projects, creating a virtuous cycle of sustainable investment (Baker et al., 2022; Sreelekshmi and Biju, 2023). Flammer (2021) further notes that this relationship between international trade and green bond issuance accelerates funding for low-carbon projects and enables countries to transition to cleaner technologies while attracting capital from global markets. By reducing technology costs and improving project feasibility, international trade ultimately incentivizes both governments and corporations to issue green bonds for large-scale green investments.

In addition, the connection between green bond activity and international trade in low-carbon technologies is particularly clear in the financing of electric vehicles and energy-efficient systems. These technologies call for infrastructure investments including EV charging stations or smart grids, often supported by green bonds, as they become more widely available via imports and exports (Pablo et al., 2024). Enabling trade helps nations to lower the expenses linked with these innovations, thereby making green projects more profitable and enticing to investors. In developing nations, green bonds offer a critical source of funding for projects that would otherwise have difficulty obtaining conventional capital. The study by Zhang et al. (2023) shows that, areas with robust imports of green technology usually have greener bond issuance, which implies a direct relationship between trade flows and green project financing availability, emphasizing how crucial international commerce is a major enabler of green finance as well as for green innovation. Maltais and Nykvist (2020) contends that the issuance of green bonds rises in tandem with trade in low-carbon technologies and hence supporting the worldwide drive toward a sustainable and low-carbon future.

3. DATA AND METHODOLOGY

The data for this study were sourced from internationally recognized databases to ensure reliability and comparability across countries. Green bond issuance[1] data was obtained from Refinitiv. Data on trade in low-carbon technology[2] and environmental goods[3] (imports, exports, and aggregate flows) were sourced from the United Nations Comtrade database. Environmental taxes data[4] were drawn from the OECD Environmentally Related Tax Revenue database. Data on fossil fuel subsidies[5] were obtained from International Monetary Fund (IMF) Fossil Fuel Subsidies database. Lastly, environmental expenditure[6] data including expenditure on pollution abatement, waste management, biodiversity protection, and research and development were sourced from the Government Finance Statistics (GFS) Database of the IMF.

To evaluate the determinants of green bond issuance across countries, this study employs a series of fixed effects panel regression models using data from 11 countries spanning the period 2014 to 2022. The analysis is conducted on the basis of three core model specifications, which are all focused on environmental taxes as the primary explanatory variable and analyze the impact of additional green policy and trade instruments. These models are estimated with fixed effects to account for heterogeneity across countries, so that differences in institutional structure, market development, or baseline emissions profiles do not confound the estimated effects. Standard errors are clustered at the country level in order to account for serial correlation and heteroscedasticity. The first specification examines the role of environmental taxation with respect to a single complementary policy channel, i.e., either trade in low-carbon technology (LCT) products or trade in environmental goods. This baseline model is expressed as Equation (1):

1 Total issuance of green bonds, which are debt securities earmarked to raise funds for climate and environmental projects.
2 Trade in goods that produce less pollution than traditional energy counterparts, aiding the transition to a low-carbon economy.
3 Trade in goods used to prevent or minimize environmental damage, including pollution control and resource management products.
4 Taxes levied on activities harmful to the environment, such as energy production, transport emissions, and resource extraction.
5 Total government financial support for fossil fuel consumption or production, encompassing both direct and indirect subsidies.
6 Government spending on environmental protection activities, including pollution control and biodiversity conservation.

$$ln(Green\ Bonds_{it}) = \alpha_i + \beta_1\ ln(Environmental\ Tax_{it}) + \beta_2\ ln(X_{it}) + \varepsilon_{it} \quad (1)$$

Where $ln(Green\ Bonds_{it})$ is the natural logarithm of green bond issuance in country i and year t, and $ln(Environmental\ Tax_{it})$ denotes the log-transformed environmental tax revenue. The variable represents the log of a single green policy or trade-related metric, such as trade in low-carbon technologies or environmental goods. The term $ln(X_{it})$ captures unobserved, time-invariant country-specific effects, while ε_{it} is the idiosyncratic error term. Coefficients β_1 and β_2 measure the elasticities of green bond issuance with respect to environmental taxes and the specified policy or trade channel, respectively. Also, α_i captures unobserved, time-invariant country-specific factors.

To better capture the broader interplay of fiscal policy instruments affecting green bonds, the second and third models (Equation 2 and 3 respectively) extends the baseline framework by including additional explanatory variables:

$$ln(Green\ Bonds_{it}) = \alpha_i + \beta_1 ln(Environmental\ Tax_{it}) + \beta_2 ln(X_{it}) + \beta_3 ln(Fossil\ Fuel\ Subsidy_{it}) + \varepsilon_{it} \quad (3)$$

$$ln(Green\ Bonds_{it}) = \alpha_i + \beta_1 ln(Environmental\ Tax_{it}) + \beta_2 ln(X_{it}) + \beta_3 ln(Fossil\ Fuel\ Subsidy_{it}) + \beta_4 ln(Environmental\ Expenditure_{it}) + \varepsilon_{it} \quad (4)$$

In equation 2, β_3 represents the extent to which the output of green bond issuance is sensitive to fossil fuel subsidies and offers the model to examine whether support from subsidies has a weakening or strengthening effect on environmental tax and trade policies. Equation 3 widens this analysis by including β_4 that shows the elasticity of green bond issuance to total government environmental spending. The presence of both β_3 and β_4 allows us to have more in-depth insights on how subsidy reform and public spending (on the green bond sector) jointly impact green bond market development in the presence of environmental taxation and trade integration.

To operationalize these equations, the study estimates a number of models where the combinations of explanatory variables are systematically varied across three main policy areas: environmental taxation; trade in environmentally relevant goods and technologies; and government fiscal interventions. Table 1 below provides a matrix summary of the independent variables included in each regression table, with each row corresponding to a distinct estimation setup. Specifically, columns 1-3 in each table pair environmental taxes with either low-carbon technology trade or environmental goods trade, while columns 4-6 replicate the structure but substitute the trade variable with a complementary policy instrument, either fossil fuel subsidies or environmental expenditure, depending on the model. This structure enables consistent comparison of partial and joint effects across policy channels, while maintaining environmental taxation as an autonomous control variable in all specifications.

4. RESULTS AND DISCUSSION

Table 2 reports the summary statistics for all variables used in the regression analysis. The mean value for green bond issuance is 1.82, with a range from −1.93 to 4.60, indicating notable variation across countries over time. This variation reflects uneven levels of financial market development, policy support, and institutional readiness to facilitate green finance. Some countries may lack credible project pipelines or supportive regulatory frameworks, while others may be in earlier stages of market formation or rely more heavily on other channels of climate finance. Across the green trade variables, most countries appear to be active participants in global green value chains. Trade in environmental goods and low-carbon technology (LCT) products averages just over 24 across all categories, with total trade values slightly higher than imports or exports individually. This implies a strong baseline level of

Table 1: Model specification matrix: Overview of independent variable combinations across estimation tables

Table	Column (s)	Environmental Tax	Trade (X_{it})	Fossil fuel subsidy	Environmental expenditure
4	1-3	✓	Trade in Low Carbon Technology Products (Total, Imports, Exports)	✗	✗
4	4-6	✓	Trade in Environmental Goods (Total, Imports, Exports)	✗	✗
5	1-3	✓	Trade in Low Carbon Technology Products (Total, Imports, Exports)	✓	✗
5	4-6	✓	Trade in Environmental Goods (Total, Imports, Exports)	✓	✗
6	1-3	✓	Trade in Low Carbon Technology Products (Total, Imports, Exports)	✓	✓
6	4-6	✓	Trade in Environmental Goods (Total, Imports, Exports)	✓	✓

Table 2: Summary statistics of key variables

Variable	Observations	Mean	Standard deviation	Min	Max
Green Bonds	99	1.82	1.48	−1.93	4.60
Trade in Environmental Goods; Imports	92	24.43	0.91	22.46	26.16
Trade in Environmental Goods; Exports	92	24.28	1.35	21.89	26.59
Trade in Environmental Goods	92	25.09	1.06	22.96	26.98
Trade in Low Carbon Technology Products; Imports	99	23.98	0.95	21.90	25.74
Trade in Low Carbon Technology Products; Exports	99	23.81	1.42	21.11	26.15
Trade in Low Carbon Technology Products	99	24.65	1.09	22.42	26.61
Environmental Taxes	85	25.36	1.60	23.84	29.63
Fossil Fuel Subsidies	88	24.52	2.23	19.12	28.44
Environmental Expenditure	79	25.15	1.90	23.65	30.24

green trade, but subsequent regression results reveal that export performance tends to be more closely associated with green bond issuance. This may reflect the reputational and capacity signals that exporting countries send to international markets, indicating not only domestic green demand but also innovation, competitiveness, and regulatory maturity in clean sectors.

Turning to fiscal variables, the average environmental tax is 25.36, which denotes that numerous countries have introduced market-based instruments in the economy to internalize environmental externalities. The fossil fuel subsidies mean of 24.52 suggests that fossil fuel subsidies are widespread despite the fact that green reforms are taking place, indicating dual policies on climate adverse mechanisms be it subsidies or carbon pricing. This coexistence is not strictly contradictory but instead reflects competing policy goals. For example, in order to remain consistent with global climate agreements, governments might end up introducing environmental taxes, at the same time keeping fossil fuel subsidies in place to keep energy affordable, preserve industrial competitiveness or protect poorer populations against fluctuations in energy prices. Skovgaard and Drake (2024) observe that in fossil fuel–dependent or low-income economies, subsidies are often framed as tools to ensure energy security and promote social equity, despite being in direct opposition to decarbonization efforts.

The co-existence of both types of policies in the same fiscal environment is likely to send mixed signals to investors, undermining the overall credibility and coherence of climate finance ecosystems. That dualism, empirically illuminated in Tables 3 and 4, illustrates the need for policy coherence. Green bond markets are more likely to flourish in contexts where environmental taxation is not diluted by simultaneous support for fossil fuels. Finally, environmental expenditure averages 25.15, similar to tax levels, but signaling a different policy approach, that is, direct public investment, as opposed to price-based incentives. When governments invest in environmental infrastructure, conservation programs or clean energy transitions, they reduce investment risk, and create demand for specific green financing instruments. As the results would later reveal, such spending seems to be one of the most reliable facilitators of green bond issuance, especially when coupled with outward-facing trade in green goods and technologies.

Table 3: Country-level summary of green bond issuance

Issuers	Country	Mean	Standard deviation	Min	Max
Low issuers	Australia	0.48	0.95	−0.89	1.56
	Norway	1.02	1.30	−1.03	2.60
	United Kingdom	1.13	1.56	−1.20	4.01
Lower-middle issuers	Japan	1.13	1.50	−1.31	3.13
	Canada	1.32	1.24	−0.76	2.78
	Sweden	1.77	1.00	0.22	2.83
Upper-middle issuers	Netherlands	2.47	1.07	0.29	3.51
	United States	2.51	1.05	0.76	4.03
	China (Mainland)	2.67	2.16	−1.9	4.60
High issuers	Germany	2.68	1.23	1.30	4.43
	France	2.88	0.82	1.77	4.05

Table 3 classifies countries into four tiers according to their average green bond issuance: low, lower-middle, upper-middle, and high issuers. The low issuer group contains high-income economies with robust financial infrastructure yet only modest green bond activity (Australia (0.48), Norway (1.02), and the United Kingdom (1.13)). This could be due to dependence on carbon pricing, lack of developed sovereign green bond frameworks, or fragmented subnational activity. The lower-middle band: Japan (1.13), Canada (1.32), and Sweden (1.77) exhibits a higher tendency to issue green bonds even though the issuance is moderate and may be less coordinated by the national strategy than by its municipal or corporate issuers. Countries in the upper-middle tier: Netherlands (2.47), United States (2.51), and China (2.67) see deeper market participation because of potentially larger project pipelines, stronger investor ecosystems, and more institutionalized regulatory frameworks. The last group, high issuer group, Germany (2.68) and France (2.88) reflects countries with mature green bond ecosystems, stable sovereign issuance, solid climate finance architecture, and help with broader EU's sustainable finance initiatives.

Distinct patterns emerge among the highest issuers within each of these groups. Within the low issuer group, the United Kingdom has the highest maximum value at 4.01, indicating episodic but

Table 4: Effects of environmental taxes and green trade channels on green bond issuance

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Taxes	4.21** (1.55)	5.14** (1.73)	4.16** (1.50)	3.96** (1.51)	5.45** (1.73)	4.34** (1.72)
Trade in Low Carbon Technology Products, Total	3.54*** (0.67)					
Trade in Low Carbon Technology Products; Imports		2.48*** (0.52)				
Trade in Low Carbon Technology Products; Exports			3.45** (1.12)			
Trade in Environmental Goods, Total				4.44*** (0.93)		
Trade in Environmental Goods; Imports					3.23*** (0.71)	
Trade in Environmental Goods; Exports						3.72** (1.37)
Constant	−192.32*** (29.97)	−187.92*** (36.91)	−185.88*** (25.30)	−210.10*** (24.38)	−205.16*** (33.00)	−198.72*** (25.59)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.479	0.408	0.374	0.441	0.384	0.324
Observations	85	85	85	85	85	85

All models include country fixed effects. Dependent variable is the natural log of green bond issuance. Trade variables represent total, import, or export flows of low-carbon technology Products and environmental goods. Standard errors are clustered at the country level. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

substantial issuance. Sweden is at the top of the lower-middle group, with an average score of 1.77, benefiting from strong environmental policies, though relatively lower bond volumes. China leads the upper-middle ranks, the average of 2.67 peaking at 4.60, supported by centralized control, large-scale issuance by state-owned entities. The high issuer group, with an average score of 2.35, is led by France (2.88). This is a direct consequence of France being a leader in sovereign green bonds and its position as a leading light in climate-related financial regulation. Collectively, these leaders illustrate that policy coherence, institutional capacity, and strategic alignment with green investment needs are critical to scaling and sustaining green bond markets.

Table 4 examines the joint effects of environmental taxes with the green trade channels (i.e. trade in LCT products and environmental goods) on green bond issuance. Environmental taxes yield a consistently positive and statistically significant effect on green bond issuance across all six model specifications, with coefficients ranging from 3.96 to 5.45. This implies that, besides serving as a signal of market commitment on the part of regulators, fiscal measures internalizing environmental costs lead to conducive conditions for the subsequent development of a green capital market. The importance of green trade is equally strong across specifications. LCT imports (2.48) and exports (3.45) in models 2 and 3 are positively associated with issuance of green bonds; total trade in LCT products (column 1) renders a strong effect (3.54). The same pattern applies to environmental goods where total trade (4.44), imports (3.23) and exports (3.72) all show large, statistically significant effects. The results highlight that technology diffusion across borders and trade integration are important channels to improve the institutional and financial ecosystems of green bond markets.

These results reinforce how both commercial environmental fiscal policy and green trade have a complementary and mutually reinforcing role in the greening of capital markets. The sustained

Table 5: Effects of environmental taxes, fossil fuel subsidies, and green trade on green bond issuance

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Taxes	1.51 (1.37)	2.49 (1.58)	0.25 (1.08)	0.73 (1.49)	1.93 (1.72)	−0.04 (1.37)
Fossil Fuel Subsidies	0.14* (0.07)	0.10 (0.07)	0.38 (0.24)	0.12** (0.05)	0.07 (0.06)	0.35 (0.27)
Trade in Low Carbon Technology Products, Total	3.48*** (0.60)					
Trade in Low Carbon Technology Products; Imports		2.52*** (0.57)				
Trade in Low Carbon Technology Products; Exports			4.40*** (0.59)			
Trade in Environmental Goods, Total				4.51*** (0.79)		
Trade in Environmental Goods; Imports					3.37*** (0.76)	
Trade in Environmental Goods; Exports						4.99*** (0.81)
Constant	−125.39*** (30.82)	−124.00*** (36.85)	−118.24*** (21.43)	−132.75*** (31.69)	−130.92*** (38.06)	−127.00*** (25.27)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.546	0.446	0.538	0.525	0.438	0.465
Observations	75	75	75	75	75	75

All models include country fixed effects. Dependent variable is the natural log of green bond issuance. Fossil fuel subsidies are included as total values (aggregating both explicit and implicit subsidies) and expressed in natural logs. Trade variables represent total, import, or export flows of low-carbon technology products and environmental goods. Standard errors are clustered at the country level. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

Table 6: Fiscal and trade drivers of green bond issuance

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Taxes	−0.14 (1.30)	−0.38 (1.63)	−1.84 (1.23)	−0.89 (1.40)	−0.76 (1.54)	−2.37 (1.54)
Fossil Fuel Subsidies	0.15 (0.10)	0.13 (0.10)	0.32** (0.11)	0.14 (0.10)	0.11 (0.10)	0.30** (0.11)
Environmental Expenditure	2.86* (1.37)	4.34*** (1.19)	3.60** (1.16)	3.21** (1.19)	4.44*** (0.92)	4.19*** (0.92)
Trade in Low Carbon Technology Products, Total	2.39** (1.03)					
Trade in Low Carbon Technology Products; Imports		1.24 (0.82)				
Trade in Low Carbon Technology Products; Exports			3.05** (0.96)			
Trade in Environmental Goods, Total				2.95** (1.26)		
Trade in Environmental Goods; Imports					1.67 (0.99)	
Trade in Environmental Goods; Exports						3.24** (1.09)
Constant	−128.52*** (29.51)	−130.41*** (34.62)	−121.98*** (27.51)	−133.38*** (32.27)	−133.91*** (34.82)	−128.97*** (35.56)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.566	0.506	0.619	0.559	0.510	0.588
Observations	68	68	68	68	68	68

All models include country fixed effects. Dependent variable is the natural log of green bond issuance. Environmental expenditure variables reflect total government spending on environmental protection, pollution control, and biodiversity. Trade variables are disaggregated by import/export. Fossil fuel subsidies are included only as total values. Standard errors are clustered at the country level. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level

presence of positive coefficients in all specifications buttresses our hypothesis that both market-based taxation and international trade in green products co-evolve with the institutional and financial maturity necessary for the development of green bonds. Policies need to be more integrated, from a tax and trade perspective, as part of national climate finance frameworks. From a policy perspective, this reinforces the need for tax and trade strategies to be included in national climate finance markets. Countries that are imposing stringent environmental taxation while actively participating in green trade networks are likely better positioned to scale green bond markets and mobilize private capital on sustainability goals.

Table 5 extends the previous analysis by introducing fossil fuel subsidies. Environmental taxes continue to be positively signed across the majority of models, but their statistical significance diminishes as seen in Table 4 and their coefficients fluctuate between –0.04 and 2.49. The diminished effect indicates that existing fossil fuel subsidies could counteract the desired green pricing signals caused by green taxation, which in turn lowers green bond issuance incentives. Fossil fuel subsidies have small positive coefficients in all specifications, though only achieving weak significance in models 1 and 4. Counterintuitively, these findings capture potentially transitional fiscal contexts wherein green bond issuance increases along with more general energy sector expenditure, even when some of that spending includes subsidies. In addition, green trade variables are consistently significant and positive, where LCT exports (4.40) and exports of environmental goods (4.99) have the largest effects, providing further evidence that global trade competitiveness in green sectors plays a key role in enabling green finance.

Enabling green finance to be as impactful as possible requires a coordinated policy architecture. Although trade in green goods continues to be a strong and steady engine of green bond issuance, the role of fiscal policy, particularly the combined presence of environmental taxes and fossil fuel subsidies emerges as more context-dependent. In environments where they co-exist with subsidies, the effect of environmental taxes can be blunted, potentially exposing more cases where counterbalancing fiscal signals undermine environmental taxation effectiveness. Taxing carbon while still subsidizing fossil fuels may muddle market expectations and dilute the financial argument for sustainable investments. From a policy perspective, the results imply that the most successful development of the green bond market occurs when environmental taxes are supported by the gradual removal of fossil fuel subsidies. In this context, countries interested in expanding sustainable finance must not only put in place positive incentives such as environmental taxation and green trade facilitation, but also do away with regressive or distortionary fiscal policies that undermine climate outcomes. A coherent and credible policy framework including aligned pricing signals, transparent subsidy structures, and deep integration into global green trade, looks crucial to unlock the full potential of green bonds as a tool for climate finance.

Table 6 incorporates environmental expenditure as an additional control along with environmental taxes, fossil fuel subsidies, and green trade to examine their combined effect on green bond issuance. For environmental taxes, in contrast to previous tables, we find strongly negative and statistically insignificant coefficients across all specifications (from -0.14 to -2.37). This flip suggests that environmental taxes alone are not that effective in stimulating green finance when other fiscal tools, particularly direct environmental spending, are present. Environmental expenditure stands out as a robust and consistent predictor of green bond issues with positive coefficients (2.86 to 4.44) that are statistically significant in each of the models. This clear-cut finding emphasizes the role of direct public outlays in terms of these environmental infrastructure and programs as a key driver for the development of the green bond market. Fossil fuel subsidies were significantly positive but low in models 3 and 6, indicating the indirect role fiscal preference plays when transitioning from one fiscal policy to another. Green trade variables are still significant and positive, confirming that these variables remain key enablers of green finance.

The results in Table 6 highlight the role complementary fiscal policy tools play in determining green financial markets. The relative underperformance of environmental taxes in the model, particularly when green spending is introduced indicate that, even in conditions favorable to reform, the market-based policy instruments may not be sufficient, especially if fossil fuel subsidies are widespread or institutional capacity for implementing and monitoring environmental taxes are weak. Most importantly, the robust importance of environmental expenditure is a sign that strategic public investment continues to be a pillar of successful green bond development.

We run a robustness check using Tobit models with robust standard errors, presented in Table A1 to examine the consistency of the results from the fixed effects models presented in Tables 4 through 6. The models chosen for this exercise were based upon the highest statistically significant estimates of the key trade variables (low-carbon technologies and environmental goods), and models which included the most pertinent and significant fiscal policy variables including fossil fuel subsidies and environmental expenditure. Columns (1) and (2) of Table A1 correspond to columns (1) and (4) of Table 4, and the results show strong consistency in direction and magnitude: environmental taxes remain positive, though slightly smaller, while trade in low-carbon technology products and environmental goods continue to exhibit stable and significant effects. Columns (3) and (4) of Table A1 correspond to columns (1) and (4) of Table 5. In these models, the trade variables remain strong and statistically significant, while the effect of environmental taxes weakens and becomes statistically insignificant, indicating some sensitivity to model specification. Fossil fuel subsidies, which were marginally significant in the fixed effects models, are less consistent under Tobit. Finally, columns (5) and (6) of Table A1 align with columns (3) and (6) of Table 6. Here, environmental taxes remain negative and insignificant across both estimations, while environmental expenditure and exports of green technologies retain their strong and significant effects, underscoring the robustness of trade and direct public investment channels. Overall, the Tobit results confirm that the core conclusions of the paper remain intact under alternative

estimation: green trade and public environmental expenditure are reliable and consistent drivers of green bond issuance, whereas the effectiveness of environmental taxes is more dependent on the broader fiscal policy environment.

These results support a three-pronged policy approach: (1) continued public investment in environmental programs to augment market readiness, (2) phased removal of fossil fuel subsidies to eliminate distortive signals, and (3) carefully designed environmental taxation to promote synergism within a credible and cohesive policy mix. The most common way of issuing green bonds is to use revenue from green public expenditure as collateral, however, policymakers that want to increase green bond issuance should not only consider it as a complementary mechanism but rather the main driver of the market. In this way, they can build the institutional foundation for a mature green finance ecosystem that provides both long-term signaling and the scale necessary to attract private capital.

5. CONCLUSION

The empirical analysis identifies important connections between fiscal policy instruments, trade relations and the development of the green bond market. We find that while environmental taxes have clear potential as policy instruments to increase green bond issuance, environmental taxes are much less effective in the presence of fossil fuel subsidies which highlights the importance of consistent policies. In fact, trade in low-carbon technologies and environmental goods are found to be robust drivers of green bond activity, highlighting the benefits of global market integration and competitiveness in promoting green finance. Most strikingly, direct public expenditure on environmental programs emerges as a particularly robust catalyst, reinforcing the idea that tangible government commitments are essential to attract private investment into green markets. These findings collectively emphasize the importance of coordinated policy frameworks, that is, integrating fiscal incentives, eliminating conflicting subsidies, and strategically engaging in green trade to fully realize the potential of green bonds as tools for sustainable economic transition.

The findings also suggest that, further development of green bond markets will require comprehensive and coordinated policy measures. Governments should focus on sustained public investment in environmental infrastructure in order to build a robust project pipeline and phase out subsidies for fossil fuels that skew market signals and work against green finance objectives. Reinforcing participation in the global trade networks for low-carbon technology and environmentally friendly goods, in addition to promoting the transfer of technologies will also serve to further consolidate investor confidence, demonstrating a commitment to innovation and environmentally sustainable economic transformation. Integrated financial policies, including environmental taxes and direct spending, subsidy reform, and trade facilitation, are key to establishing mature green financial ecosystems that could foster diversified sources of capital. In a world where countries are increasingly in competition for sustainable investment flows, those that can best harmonize trade and fiscal policies with the long-term goals of decarbonization will be the best placed to reach not just environmental targets, but also to achieve resilient economic growth in the decades ahead.

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APPENDIX

Table A1: Robustness check using tobit models with robust standard errors

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Taxes	3.59* (2.02)	3.31 (2.07)	1.39 (2.14)	0.57 (2.14)	-1.91 (1.93)	-2.51 (2.06)
Trade in Low Carbon Technology Products, Total	3.60*** (0.46)		3.49*** (0.41)			
Trade in Environmental Goods, Total		4.55*** (0.63)		4.55*** (0.54)		
Fossil Fuel Subsidies			0.13 (0.11)	0.12 (0.11)	0.34*** (0.12)	0.32*** (0.12)
Environmental Expenditure					3.64*** (1.08)	4.26*** (0.95)
Trade in Low Carbon Technology Products; Exports					3.14*** (0.66)	
Trade in Environmental Goods; Exports						3.44*** (0.75)
_cons	−170.29*** (44.87)	−187.74*** (45.74)	−117.49** (50.17)	−124.09** (49.77)	−116.37** (54.01)	−125.87** (54.04)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.340	0.316	0.400	0.386	0.446	0.426
Observations	85	85	75	75	68	68

Models estimated using Tobit regression with robust standard errors. Dependent variable is green bond issuance, left-censored at zero. Country fixed effects are included. Model selection is based on specifications with the highest statistically significant trade effects and the most relevant fiscal controls using total fossil fuel subsidies and disaggregated LCT, EG, and environmental expenditure variables from Tables 4-6. ***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level