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Green bonds under financial stress

Ichwan*, Taufiq C. Dawood, Zia Thahira, Wisnu Satria, Mirzatul Kadri
Faculty of Economics and Business, Universitas Syiah Kuala, Indonesia

*) Corresponding Author (e-mail: ichwan@usk.ac.id)

Abstract
This study analyzed the relationship between financial stress and green bond issuance using a balanced panel of ten countries over the 2018 to 2023 period. A two-way fixed effects panel regression was employed to control for unobserved country specific and time specific factors. The findings showed that higher financial stress was associated with increased green bond issuance, indicating that green bond markets remained active during periods of financial pressure. GDP and domestic credit to the private sector also exhibited positive and statistically significant relationships with green bond issuance, highlighting the importance of macroeconomic capacity and financial intermediation. Inflation, by contrast, displayed a positive but statistically insignificant association. Additional analysis revealed no meaningful differences between advanced and non-advanced economies, and robustness checks confirmed the stability of the findings. Overall, the results suggested that green bonds represented a relatively resilient financing instrument under varying financial conditions and underscored the importance of supportive policy frameworks in fostering green bond market development.

Keywords: Financial Stress, Green Bond, Green Finance, GDP, Domestic Credit

Abstrak
Penelitian ini menganalisis hubungan antara *financial stress* dan penerbitan *green bond* menggunakan *balanced panel data* dari sepuluh negara selama periode 2018–2023. Analisis dilakukan dengan menggunakan regresi panel *two-way fixed effects* untuk mengendalikan perbedaan tidak teramati antarnegara dan antarwaktu. Hasil penelitian menunjukkan bahwa *financial stress* berpengaruh positif dan signifikan terhadap penerbitan *green bond*, yang mengindikasikan peningkatan penerbitan pada periode tekanan keuangan. GDP dan *domestic credit to the private sector* juga berpengaruh positif dan signifikan, yang menegaskan peran kapasitas ekonomi dan intermediasi keuangan dalam mendukung pembiayaan hijau. Inflasi menunjukkan hubungan positif namun tidak signifikan secara statistik, sehingga perannya relatif terbatas dalam keputusan penerbitan. *Heterogeneity analysis* menunjukkan bahwa tidak terdapat perbedaan yang signifikan dalam pengaruh *financial stress* terhadap penerbitan *green bond* antara *advanced* dan *non-advanced economies*. Selain itu, *robustness checks* mengonfirmasi bahwa hasil penelitian tetap stabil dalam berbagai spesifikasi model. Secara keseluruhan, temuan ini mengindikasikan bahwa *green bond* memiliki ketahanan yang relatif baik dalam menghadapi berbagai kondisi keuangan, serta menegaskan pentingnya kebijakan yang mendukung pengembangan pasar *green bond* secara berkelanjutan.

Kata kunci: Financial Stress, Green Bond, Green Finance, GDP, Domestic Credit

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1. Introduction

Green bonds constitute an increasingly prominent component of sustainable finance, functioning as a mechanism to channel funds toward investments with explicit environmental objectives. Their growing role is closely linked to the expansion of global climate policy frameworks, such as the Paris Agreement and the Sustainable Development Goals, which have reinforced institutional and regulatory support for environmentally oriented financing instruments. Following the first issuance by the European Investment Bank in 2007, the green bond market experienced sustained expansion, reflecting a broader reorientation of investor preferences toward assets that integrate financial performance with environmental considerations. Empirical studies document that green bond issuance supports the financing of renewable energy and low carbon projects, thereby strengthening the connection between financial market activity and environmental outcomes (Flammer, 2020; Tolliver et al., 2019).

A strong upward trend in global green bond issuance, as illustrated in Figure 1, clearly reflects the increasing relevance of green bonds. Issuance activity remained marginal in the early years but began to rise steadily after 2013, followed by a sharp acceleration in the late 2010s. Remarkably, green bond issuance continued to expand throughout the early 2020s, even as global financial stress intensified during the COVID-19 period (IMF, 2025). The persistence of this growth suggests that green bonds may exhibit greater resilience than conventional bonds, potentially driven by stronger policy support, increasing environmental awareness among investors, and the integration of sustainability considerations into investment strategies.

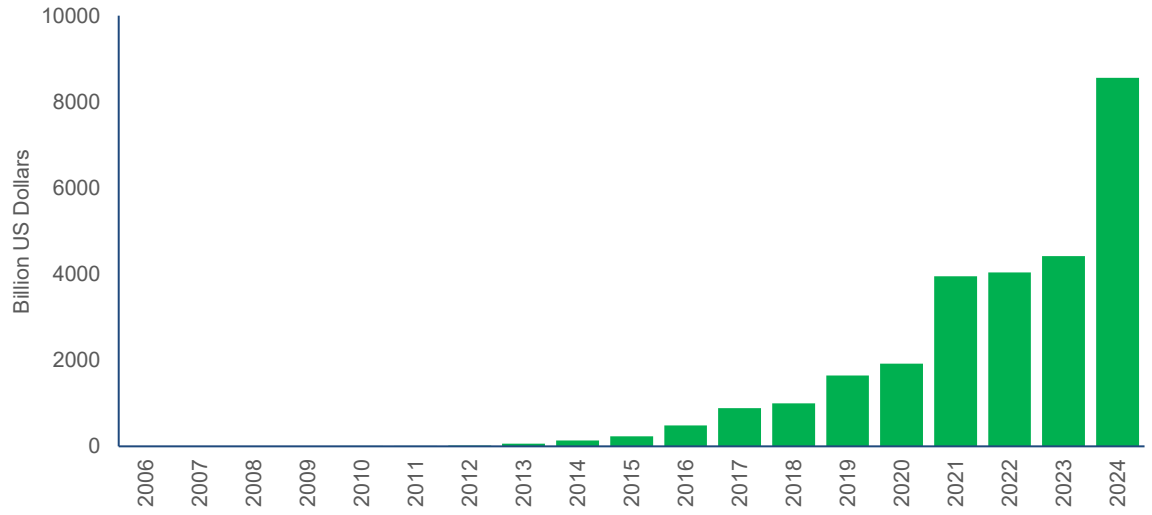

Figure 1. Green Bonds Issuance, Billion US Dollars
Source: IMF, 2025

The persistent growth of green bond issuance raises important questions regarding the factors that drive this expansion. This upward trend reflects the increasing role of green bonds in global financial markets and simultaneously indicates that issuance behavior across countries and over time is influenced by broader economic and financial conditions. Existing studies suggest that green bond markets evolve

alongside macroeconomic fundamentals, financial market conditions, and investor preferences for sustainable assets. As green bonds become an integral component of global bond markets, understanding the economic and financial environment in which issuance decisions are made becomes increasingly important.

One key factor shaping bond market dynamics is financial stress. Periods of heightened financial stress are typically characterized by increased uncertainty, liquidity constraints, and shifts in investor risk appetite, all of which influence capital allocation and issuance activity in bond markets. The financial stress literature shows that elevated stress conditions disrupt financial intermediation, affect risk pricing, and alter investor behavior across asset classes (Vermeulen et al., 2015; Monin, 2019; Ahir et al., 2023). While financial stress is commonly associated with contractions in conventional bond issuance due to widening credit spreads and higher borrowing costs, recent evidence indicates that green financial assets may respond differently to such conditions. Evidence shows that green financial assets can respond positively to financial stress, with green bonds acting as refuge assets during periods of market distress (Mar'I et al., 2024; Mensi et al., 2023). These findings suggest that financial stress may not uniformly suppress bond market activity but instead reshape investor preferences and capital flows, potentially favoring green bonds during episodes of heightened stress.

In addition to financial stress, macroeconomic fundamentals influence green bond issuance by shaping issuers' financing capacity and investors' willingness to allocate capital toward sustainable assets. Given their close link to capital-intensive renewable energy and low-carbon projects, green bonds are embedded in broader macroeconomic conditions governing investment activity, financing costs, and market confidence (Gianfrate and Peri, 2019; Flammer, 2021). Economic growth plays a central role, as higher GDP levels reflect stronger economic capacity, greater fiscal space, and higher demand for sustainable infrastructure, which facilitate access to bond markets and support green bond issuance (Flammer, 2021; Ozyesil and Tembelo, 2025). Recent evidence further suggests that GDP may exert nonlinear effects on green bond market development, highlighting the role of economic size and capacity (Kim et al., 2024).

Inflation and domestic credit conditions further shape the macro-financial environment for green bonds. Inflation affects issuance indirectly through its impact on macroeconomic stability, borrowing costs, and expected real returns, with stable inflation supporting bond market activity and high or volatile inflation weakening investor demand for long-term bonds (Hale et al., 2020; Anh Tu et al., 2020; Macchiarelli, 2014). Domestic Credit to Private Sector, which is widely applied as an indicator of financial development, captures both credit availability and the effectiveness of financial intermediation (Levine, 2005; Beck et al., 2010). Greater availability of domestic credit is linked to easier access to financing and lower financial frictions, which supports participation in bond markets and promotes green bond issuance by strengthening issuer credibility and reinforcing investor confidence (Gianfrate and Peri, 2019; Flammer, 2021; Taghizadeh-Hesary and Yoshino, 2019).

Despite the expanding literature on green bonds and sustainable finance, existing research has largely focused on their environmental role or on pricing and return characteristics, while comparatively less attention has been paid to green bond issuance dynamics at the cross-country level. In particular, the influence of financial stress on green bond issuance insufficiently explored, as financial stress is more commonly examined in relation to conventional bond markets or broader macroeconomic outcomes, often without being jointly analyzed alongside key macroeconomic fundamentals. In addition, existing research offers limited insight into whether the association between financial stress and green bond issuance differs across countries at varying stages of economic development and financial market maturity, or whether observed patterns are primarily driven by exceptional crisis episodes such as the COVID-19 period.

In this context, this study addresses three interrelated research questions. First, how does financial stress influence green bond issuance across countries? Second, to what extent do macroeconomic conditions, including economic growth, inflation, and domestic credit to the private sector, shape green bond issuance dynamics? Third, does the impact of financial stress differ between advanced and non-advanced economies?

Addressing these questions, the study adopts a cross-country panel data framework covering multiple green bond–issuing countries over time. Green bond issuance is specified as the dependent variable and is analyzed as a function of financial stress and selected macroeconomic indicators using fixed-effects estimators that account for unobserved country-specific heterogeneity as well as common time effects, with statistical inference based on clustered and bootstrap-adjusted standard errors. The analysis further incorporates interaction terms to examine heterogeneity across country groups and robustness checks that exclude the COVID-19 period to assess the stability of the results. By focusing on issuance activity rather than asset prices, and by jointly examining financial stress and macroeconomic fundamentals, this study contributes to the literature in three ways. First, it provides new cross-country evidence on the relationship between financial stress and green bond issuance, a link that has been underexplored relative to conventional bond markets. Second, it jointly examines the role of key macroeconomic fundamentals alongside financial stress in shaping issuance dynamics. Third, it explicitly tests for heterogeneity across countries at different levels of economic development, offering insight into whether green bond market resilience is broadly shared or concentrated among particular economies.

2. Research Method

This study examines the relationship between financial stress and green bond issuance using a balanced panel dataset covering ten countries over the period 2018–2023. The sample includes Indonesia, Malaysia, the Philippines, Singapore, Thailand, Australia, Japan, India, the United Kingdom, and the United States. These countries were selected based on two considerations. First, they represent economies with substantial and sustained participation in global green bond markets, ensuring

meaningful variation in issuance activity. Second, all ten countries have complete Financial Stress Index data from the Asian Development Bank's Asia Regional Integration Center for the study period. The resulting sample covers both advanced economies (Australia, Japan, Singapore, the United Kingdom, and the United States) and non-advanced economies (Indonesia, Malaysia, the Philippines, Thailand, and India), allowing the analysis to capture cross-country heterogeneity in financial conditions while preserving comparability over time. The balanced structure of the panel yields 60 country-year observations and enables the identification of within-country variation, which is central to the fixed-effects estimation strategy adopted in this study.

The sample size of ten countries and 60 observations is relatively limited for cross-country macro panel analysis, mainly because country coverage is constrained by the availability of the Financial Stress Index. Nevertheless, the sample remains informative for the purposes of this study. It includes both advanced and non-advanced economies across several regions and represents a substantial share of global green bond issuance, allowing the analysis to capture broad market patterns rather than country-specific anomalies. In addition, the study employs wild cluster bootstrap inference to improve the reliability of statistical inference under a limited number of clusters. Although these features do not fully eliminate concerns regarding external validity, they strengthen the empirical value of the analysis and support a cautious interpretation of the findings.

Table 1. Variable Definitions and Data Sources

Variable	Definition	Unit	Source
Log Green Bond Issuance	Natural logarithm of total annual green bond issuance, including sovereign and non-sovereign bonds	ln (USD million)	Climate Bonds Initiative (CBI)
Financial Stress Index (FSI)	Composite index capturing stress in banking, securities, and foreign exchange markets	Index	Asian Development Bank
GDP Growth	Annual growth rate of real gross domestic product	Percent	World Bank
Inflation	Annual percentage change in the consumer price index	Percent	World Bank
Domestic Credit to Private Sector	Credit provided to the private sector by financial institutions	Percent of GDP	World Bank
Advanced Economy	Dummy variable equal to 1 for advanced economies and 0 otherwise	Binary	Authors' classification

Data on green bond issuance are collected from the Climate Bonds Initiative (CBI) and measured at the annual country level in U.S. dollars. Given the pronounced skewness in issuance volumes, the empirical analysis applies a logarithmic transformation to total annual green bond issuance in order to ensure a more balanced distribution. Financial stress is captured by the Financial Stress Index (FSI) compiled by the Asia Regional Integration Center of the Asian Development Bank, which

measures systemic stress across the banking, foreign exchange, equity, and debt markets and serves as the main explanatory variable in this study.

A detailed description of variable construction, measurement units, and data sources is summarized in Table 1. The empirical specification incorporates several macroeconomic control variables that are widely linked to financial market development and investment activity. In particular, the analysis accounts for real GDP growth, consumer price inflation, and the level of credit extended to the private sector relative to GDP. These macroeconomic indicators are obtained from the World Bank's World Development Indicators and are included together with the financial stress measure to capture the broader economic environment in which green bond issuance decisions are made.

The baseline relationship between financial stress and green bond issuance is examined within a two way fixed effects panel regression framework. By accounting for unobserved country specific characteristics that remain constant over time, including institutional quality and long term policy frameworks, as well as global shocks common to all countries in a given year, this approach provides appropriate control for sources of unobserved heterogeneity. The baseline econometric specification is given by:

$$\ln(\text{GreenBond}_{it}) = \beta_1 \text{FSI}_{it} + \text{X}_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$$

Where $i$denotes countries and $t$denotes years, X_{it}represents the vector of control variables, α_i captures country fixed effects, and δ_t captures year fixed effects. Substituting the control variables explicitly, the baseline specification can be written in its expanded form as follows:

$$\ln(\text{GreenBond}_{it}) = \beta_1 \text{FSI}_{it} + \beta_2 \text{GDP}_{it} + \beta_3 \text{Inflation}_{it} + \beta_4 \text{Credit}_{it} + \alpha_i + \delta_t + \varepsilon_{it}$$

In this specification, β_1 measures the semi-elasticity of green bond issuance with respect to the Financial Stress Index, β_2 captures the effect of GDP growth, β_3 reflects the effect of consumer price inflation, and β_4 measures the effect of domestic credit to the private sector as a share of GDP. Not all control variables are included simultaneously in every specification. GDP growth is retained in all models as the baseline control, while inflation and domestic credit are introduced separately in Models (2) and (3), respectively, as reported in Table 3. This approach allows the study to assess whether the estimated effect of financial stress remains stable across alternative model specifications without adding unnecessary complexity to the model.

To examine whether the effect of financial stress differs across country groups, the baseline model is extended by interacting the Financial Stress Index with an indicator for advanced economies. This interaction specification allows the association between financial stress and green bond issuance to vary systematically between advanced and non-advanced economies while preserving the core identification strategy. The heterogeneity model is specified as:

$$\ln(\text{GreenBond}_{it}) = \beta_1 \text{FSI}_{it} + \beta_2 (\text{FSI}_{it} \times \text{Advanced}_i) + \text{X}_{it}\gamma + \alpha_i + \delta_t + \varepsilon_{it}$$

Because the advanced economy indicator is time invariant, it is absorbed by the country fixed effects and therefore does not appear separately in the regression. The interaction term between financial stress and the advanced economy indicator captures the differential association between financial stress and green bond issuance across country groups. This specification provides a parsimonious and internally consistent approach to assessing heterogeneity while preserving the baseline identification strategy.

Estimation is conducted using fixed effects estimators, with inference based on standard errors that are clustered at the country level in order to address potential heteroskedasticity and serial dependence within panels over time. Because the number of country clusters in the sample is relatively limited, reliance on conventional cluster robust methods may lead to an overstatement of statistical significance. For this reason, inference regarding the Financial Stress Index is instead derived from wild cluster bootstrap methods, which have been shown to yield more reliable results in panel settings with a small number of clusters (Cameron et al., 2008).

The stability of the empirical findings is assessed through a series of robustness exercises. These robustness checks include alternative sets of control variables, the exclusion of the year 2020 to account for the potential influence of the COVID-19 shock, and interaction specifications to further examine heterogeneity across country groups. Collectively, these additional analyses are intended to confirm that the main results are not sensitive to particular modeling assumptions or to the composition of the sample.

3. Results and Discussion

3.1. Results

This section presents the empirical outcomes based on a balanced panel covering ten countries over the 2018 to 2023 period. The results begin with descriptive statistics that outline the key features of the variables used in the study. These statistics serve to illustrate the overall distributional patterns and the degree of variation observed across countries and over time, thereby providing a contextual foundation for the subsequent panel regression analysis.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Log Green Bond Issuance	60	7.94	1.68	4.21	12.09
Financial Stress Index	60	−10.49	41.52	−116.38	117.91
GDP Growth (%)	60	2.59	4.28	−10.05	9.76
Domestic Credit to Private Sector (% of GDP)	60	119.54	55.19	35.29	223.78
CPI Inflation (%)	60	2.97	2.43	−1.61	8.48

The descriptive evidence reported in Table 2 highlights substantial heterogeneity in green bond markets and financial conditions across the observed countries and years. The log value of green bond issuance displays a mean of 7.94 and a standard deviation of 1.68, suggesting marked differences in issuance intensity both cross-sectionally and over time. Financial stress conditions also vary considerably, as reflected by the

Financial Stress Index, which records an average level of −10.49 and spans a broad range from −116.38 to 117.91. This wide dispersion indicates that the sample period encompasses episodes of both low and elevated systemic stress, providing a diverse macro-financial environment for the subsequent empirical analysis.

The macroeconomic variables show meaningful variation as well. GDP growth averages 2.59 percent, with observations spanning from negative growth episodes to higher expansion rates, while domestic credit to the private sector averages 119.54 percent of GDP and varies considerably across countries. Inflation has a mean value of 2.97 percent and displays moderate dispersion over time. Overall, the descriptive statistics suggest sufficient cross-country and temporal variation in the data to support the subsequent panel regression analysis.

Based on the descriptive statistics, the empirical relationship between financial stress and green bond issuance is subsequently evaluated through a series of two way fixed effects panel regressions, with the corresponding baseline and robustness outcomes summarized in Table 3. In these estimations, total annual green bond issuance is expressed in natural logarithmic form, such that the resulting parameter estimates capture semi elasticity effects. The regression results consistently yield a positive coefficient for the Financial Stress Index across alternative specifications, with limited variation in magnitude, thereby suggesting that higher levels of financial stress are systematically associated with greater green bond issuance at the country level.

Table 3. Financial Stress and Green Bond Issuance: Baseline and Robustness

Variables	Model (1)	Model (2)	Model (3)	Model (4)
Financial Stress Index (FSI)	0.0056*	0.0056*	0.0055*	0.0069
	(0.0022)	(0.0022)	(0.0022)	(0.0027)
GDP Growth (%)	0.1012 **	0.1024*	0.0969 **	0.1286*
	(0.0323)	(0.0308)	(0.0360)	(0.0626)
Inflation (CPI)		0.0272		
		(0.0960)		
Domestic Credit to Private Sector (% of GDP)			0.0251*	
			(0.0130)	
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Within R^2	0.361	0.363	0.388	0.352
Observations	60	60	60	50
Countries	10	10	10	10

Notes: Model (4) excludes the year 2020 from the sample. All specifications control for both country-specific and time-specific fixed effects. Standard errors are clustered at the country level and reported in parentheses. Statistical significance is indicated by ***, **, and *, corresponding to the 1%, 5%, and 10% levels.

The baseline estimates presented in Model (1) indicate a positive association between financial stress and green bond issuance. The coefficient on the Financial Stress Index is estimated at 0.0056 and is statistically significant, implying that an increase of one unit in financial stress corresponds to an approximate 0.56 percent rise in green bond issuance, holding other factors constant. Given the substantial variation in financial stress observed across the sample, the magnitude of this relationship is economically meaningful. Taken together, the results indicate that

periods of heightened financial stress tend to coincide with higher levels of green bond issuance, indicating that these markets tend to expand rather than contract during periods of financial strain.

The stability of the baseline findings is examined using the alternative specifications reported in Model (2) and Model (3). When consumer price inflation is added in Model (2), the estimated coefficient on the Financial Stress Index remains positive and statistically significant at 0.0056, while inflation itself is not statistically significant. Model (3) further extends the specification by including domestic credit to the private sector as a share of GDP. Under this specification, the estimated effect of financial stress on green bond issuance remains positive and statistically significant, with the coefficient valued at 0.0055. Moreover, domestic credit exhibits a positive and statistically significant relationship with green bond issuance, indicating that more developed credit conditions are associated with higher issuance activity.

Model (4) excludes the year 2020 as a robustness check. Under this restricted sample, the coefficient on the Financial Stress Index remains positive and increases to 0.0069, although with weaker statistical significance. This pattern suggests that the observed relationship between financial stress and green bond issuance is not solely attributable to conditions prevailing in 2020. Across all specifications, GDP exhibits a consistently positive association with green bond issuance. In quantitative terms, a one percentage point increase in GDP growth corresponds to an approximate 10.1 percent increase in green bond issuance in the baseline specification, rising to about 12.9 percent when the year 2020 is excluded, suggesting a stronger role for economic growth in more stable periods. Taken together, the regression results indicate that the main findings remain stable across alternative specifications.

Table 4. Heterogeneity Analysis: Financial Stress and Advanced Economies

Variables	Heterogeneity Specification
Financial Stress Index (FSI)	0.0090*
	(0.0049)
FSI × Advanced Economy	−0.0064
	(0.0063)
GDP Growth (%)	0.1041**
	(0.0321)
Country Fixed Effects	Yes
Year Fixed Effects	Yes
Observations	60
Countries	10
Within R^2	0.379

Furthermore, The heterogeneity analysis reported in Table 4 evaluates whether the association between financial stress and green bond issuance differs between advanced and non advanced economies. The estimates indicate that, for non advanced economies, financial stress is positively and statistically significantly associated with green bond issuance, with a one unit increase in the Financial Stress Index linked to an approximate 0.9 percent increase in issuance, holding other covariates constant. In contrast, the interaction between financial stress and the advanced economy indicator yields a negative but statistically insignificant coefficient,

suggesting that the estimated relationship does not vary systematically with development status. the evidence points to a broadly similar response of green bond issuance to financial stress across countries, rather than being driven by a specific group of economies.

3.2. Discussion

The empirical results indicate a positive and statistically robust association between financial stress and green bond issuance, suggesting that periods of elevated systemic stress are accompanied by increased activity in green bond markets. This pattern is consistent with recent findings in the literature, particularly by Mar'I et al. (2024), where it is shown that positive shocks to green financial assets may be generated by financial stress under certain market conditions. It is further documented that green bonds tend to exhibit lower volatility than conventional bonds during stress episodes and may respond more favorably to stress-related shocks, indicating a form of relative resilience. In this context, heightened financial stress does not uniformly suppress green bond markets but may instead increase their attractiveness relative to conventional financial instruments.

Financial stress is commonly associated with disruptions in financial intermediation, liquidity shortages, and heightened uncertainty, all of which affect credit markets in an asymmetric manner. Vermeulen et al. (2015) show that increases in Financial Stress Index (FSI) values are closely associated with deteriorating financial system fundamentals, including heightened uncertainty, liquidity shortages, sharp asset price fluctuations, and increased probabilities of banking and currency crises. While their study emphasizes the negative macroeconomic consequences of financial stress, it also highlights that stress fundamentally alters financial market behavior rather than merely reducing overall activity. Such systemic disruptions can change investor preferences and risk perceptions, creating conditions in which certain asset classes, including green bonds, may benefit from reallocation effects.

Evidence from bond market studies further illustrates how financial stress constrains conventional bond issuance. Using the OFR Financial Stress Index framework, Monin (2019) finds that higher financial stress is associated with widening corporate bond credit spreads, increased borrowing costs, and impaired market liquidity. Similar patterns are documented in studies examining heterogeneous bond market responses to stress, which find that conventional bonds often experience stronger negative effects than alternative debt instruments during periods of heightened uncertainty (Fu et al., 2022; He et al., 2021). These dynamics reveal that financial stress disproportionately affects traditional corporate bond markets.

A substitution effect within bond markets can be inferred from the positive association between financial stress and green bond issuance in this environment. As conventional bonds become less attractive due to rising risk premia and tighter financing conditions, investors may rebalance portfolios toward assets perceived as more resilient or less exposed to credit risk. Financial stress has been shown to affect asset returns and market behavior in a state-dependent manner, reshaping investor

preferences rather than uniformly depressing all assets (Aziz et al., 2021; Reboredo & Ugolini, 2020). In this context, green bonds may benefit from shifts in portfolio allocation during stress periods.

This interpretation is further supported by studies focusing explicitly on green bond markets. Research by Pham & Nguyen (2022) shows that green bond market dynamics are sensitive to financial stress and macro-financial conditions, while evidence from Mensi et al. (2023) indicates that green bonds may assume the role of refuge or safe-haven assets during periods of severe financial distress. These findings indicate that green bonds may retain or even increase their attractiveness when market volatility rises, reinforcing the substitution mechanism identified in this study.

Bond issuance behavior under conditions of financial stress is also shaped by the surrounding institutional and policy environment. Evidence from recent crisis episodes indicates that the effect of financial stress on bond issuance is contingent on the availability of policy support and prevailing market structures. For example, During the Global Financial Crisis, bond issuance was markedly curtailed, whereas a sharp expansion was observed during the COVID 19 period following extensive monetary and fiscal interventions (Bruno et al., 2024). At the same time, higher financial stress is associated with tighter financing conditions and reduced investment, particularly in emerging economies, which further constrains conventional financing channels (Ahir et al., 2023).

Finally, financial stress operates as a systemic and cross-asset phenomenon that influences liquidity, risk pricing, and portfolio allocation decisions across markets. Stress indices incorporate information from credit and interest rate markets and reflect vulnerabilities that are transmitted rapidly across asset classes through portfolio rebalancing and liquidity channels (Liang et al., 2023). These systemic adjustments can amplify relative differences across assets, making certain instruments more attractive during stress periods. Under such conditions, green bonds may gain relative prominence within bond markets as investors adjust to changing risk environments.

Evidence from this study indicates that variations in green bond issuance are systematically linked to underlying macroeconomic conditions alongside financial stress. In particular, the statistically significant association identified between GDP and green bond issuance indicates that market expansion is closely related to broader economic capacity. Higher GDP reflects stronger productive capacity, greater fiscal space, and more developed financial systems, which facilitate the mobilization of resources toward sustainable investments. This interpretation is consistent with findings showing that countries with stronger economic fundamentals are more actively involved in issuing green bonds to support renewable energy development and environmentally oriented infrastructure investment (Ozyesil & Tembelo, 2025), and with the argument that economic strength enhances fiscal capacity, institutional stability, and investor confidence, thereby fostering green bond market activity (Flammer, 2020).

Favorable macroeconomic conditions also support green bond issuance through financial market mechanisms. Existing evidence indicates that financing via green bonds is generally associated with lower funding costs compared to conventional debt instruments, a pattern that issuers are more willing to accept when economic conditions are favorable and funding constraints are limited (Baker et al., 2018). In addition, GDP captures a range of intertwined economic factors that may generate nonlinear effects on green bond market development. Kim et al. (2024) show that while economic growth generally supports green bond issuance, its impact varies across stages of market maturity, reinforcing the importance of economic size and strength in shaping long run green bond market outcomes.

By comparison, inflation appears to exert only a limited influence on green bond issuance once financial stress and GDP are taken into account. Although a modest positive relationship between inflation and green bond issuance is observed, this relationship does not attain statistical significance, indicating that changes in price levels do not directly shape issuance decisions. Instead, inflation mainly reflects broader macroeconomic stability and affects bond markets indirectly through borrowing capacity and investor confidence (Hale et al., 2020). While moderate inflation may accompany economic expansion and support green bond growth in some emerging economies (Kim et al., 2024), higher inflation can reduce real returns and dampen investor demand (Anh Tu et al., 2020; Macchiarelli, 2014), resulting in offsetting effects that explain the weak overall impact observed in this study.

Moreover, the the analysis reveals a statistically significant positive relationship between domestic credit to the private sector and green bond issuance, indicating that more developed credit markets facilitate green bond market growth. As a commonly used proxy for financial development, domestic credit reflects the capacity of financial institutions to ease financing constraints and support firms' access to bond markets (Beck et al., 2009; Levine, 2005). Consistent with prior evidence, financially developed economies tend to experience stronger green bond issuance, as deeper credit markets enhance issuer credibility and investor confidence and complement market-based green finance in mobilizing private capital for sustainable projects (Flammer, 2021; Gianfrate & Peri, 2019; Taghizadeh-Hesary & Yoshino, 2019).

Furthermore, no statistically meaningful heterogeneity is detected how financial stress is connected to green bond issuance when countries are differentiated by development status. The interaction terms do not yield significant estimates, indicating that the association identified in the baseline analysis is not confined to a particular group of economies. As a result, the positive effect of financial stress on green bond issuance appears to operate in a broadly similar manner across both advanced and non advanced countries. From a policy perspective, this pattern suggests that green bonds may represent a comparatively resilient financing channel during episodes of financial stress, underscoring the relevance of policy frameworks that enhance market infrastructure and sustain investor confidence across diverse economic environments.

4. Conclusion

This study offers empirical evidence on the dynamics of green bond markets during periods of financial stress, based on a balanced panel dataset covering ten countries from 2018 to 2023. The results indicate that elevated financial stress is linked to higher levels of green bond issuance, suggesting that green bonds do not retreat during periods of market tension but instead remain an active source of financing. This finding points to the capacity of green bonds to function as a relatively resilient instrument when conventional financial conditions deteriorate. The analysis further shows that macroeconomic fundamentals matter for green bond market development, as stronger economic growth and more developed domestic credit markets are linked to higher issuance levels. By contrast, inflation does not appear to exert a statistically significant direct influence, implying that its role operates mainly through broader macroeconomic stability rather than through issuance decisions.

These results contribute to the sustainable finance literature by showing that financial stress does not always weaken capital market activity. In this context, green bonds appear to have a degree of resilience that distinguishes them from conventional instruments. The findings also suggest that green bond market development is closely tied to economic capacity and financial depth. In addition, the absence of significant differences between advanced and non-advanced economies implies that the role of green bonds as a financing instrument may extend across diverse development settings.

From a policy perspective, the results suggest that sustaining green bond issuance during periods of financial stress requires supportive market and macroeconomic conditions. Strengthening green bond frameworks and improving regulatory clarity can reduce uncertainty and maintain market confidence when financial conditions deteriorate. At the same time, stronger economic growth and stable macroeconomic conditions remain important for expanding green bond markets, as they enhance both issuer capacity and investor confidence. Policies aimed at deepening domestic credit markets can also support green bond development by improving access to financing and reducing issuance frictions. Moreover, the absence of significant differences between advanced and non-advanced economies suggests that green bond policies may produce broadly similar outcomes across diverse economic settings, reinforcing the role of green bonds as an effective financing channel for the transition to a low-carbon economy.

This study should, however, be interpreted with caution. The sample is limited to ten countries and 60 country-year observations, which may restrict statistical power and external validity, although wild cluster bootstrap inference helps reduce this concern. The use of aggregate country-level data also prevents a more detailed analysis across issuer types and bond categories. In addition, the Financial Stress Index used in this study was developed primarily for Asian economies, which may limit comparability for the United Kingdom and the United States. Future research should therefore expand country coverage, use more disaggregated issuance data, and examine institutional

factors that may influence the relationship between financial stress and green bond issuance.

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