

Green bonds and the Sustainable Development Index in Asian countries: Panel data evidence

Ariodillah Hidayat

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: ariodillahhidayat@fe.unsri.ac.id

ORCID: [0000-0002-6520-5985](https://orcid.org/0000-0002-6520-5985)

Arum Bona Uli Septian Manurung

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: arummanurung2509@gmail.com

ORCID: [0009-0002-8839-1212](https://orcid.org/0009-0002-8839-1212)

Liliana Liliana

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: liliana@unsri.ac.id

ORCID: [0000-0002-5499-7729](https://orcid.org/0000-0002-5499-7729)

Siti Rohima

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: sitirohima@unsri.ac.id

ORCID: [0000-0002-9196-7924](https://orcid.org/0000-0002-9196-7924)

Rasyida Pertiwi

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: rasyidapertiwi@fe.unsri.ac.id

ORCID: [0000-0003-3427-9938](https://orcid.org/0000-0003-3427-9938)

Sri Andaiyani

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: sriandaiyani@fe.unsri.ac.id

ORCID: [0000-0002-4275-0059](https://orcid.org/0000-0002-4275-0059)

Xenaneira Shodroкова

Department of Development Economics, Faculty of Economics, Sriwijaya University, Indonesia

e-mail: xenaneira12@gmail.com

ORCID: [0009-0003-8034-6617](https://orcid.org/0009-0003-8034-6617)

©2024 Ariodillah Hidayat, Arum Bona Uli Septian Manurung, Liliana Liliana, Siti Rohima, Rasyida Pertiwi, Sri Andaiyani, Xenaneira Shodrokovka

This work is licensed under the Creative Commons Attribution-ShareAlike 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/>

Quote as: Hidayat, A., Manurung, S. U. B. A., Liliana L., Rohima, S., Pertiwi, R., Andaiyani, S., & Shodrokovka, X. (2024). Green bonds and the sustainable development index in Asian countries: Panel data evidence. *Argumenta Oeconomica*, 2(53), 107-119.

DOI: [10.15611/aoe.2024.2.07](https://doi.org/10.15611/aoe.2024.2.07)

JEL: Q54,C33, G28, Q58

Abstract: This study aimed to determine the relationship between green bonds issuance and the Sustainable Development Index (SDI) using panel data involving several countries in Asia, namely the Philippines, Indonesia, China, Japan, Thailand, Hong Kong, Korea, Malaysia, and Singapore. The study used secondary data sourced from publications and dynamic statistics provided by the Asian Development Bank and the Human Development Report. The authors applied qualitative analysis in the form of movement analysis of trend data patterns as well as quantitative analysis using Fixed Effect Model (FEM) panel data regression. The results show that green bonds are positively and significantly correlated with the SDI. This indicates that when a country is actively issuing green bonds to finance sustainable projects, it contributes to an overall improvement in sustainable development. To address the challenges of sustainable development, the Philippines, Indonesia, and Thailand governments need to formulate appropriate policy measures. Raising environmental awareness and education is an important priority in order to build public understanding of environmental impacts and the need for sustainable development. In addition, the government should strengthen pro-environmental policies and provide fiscal incentives to support sustainable investment, creating a conducive environment for investors. China has to accelerate the transition from fossil energy sources to renewable energy. Moreover, it is necessary to implement policies that promote energy efficiency in key sectors.

Keywords: Sustainable Development Index (SDI), green bonds, panel data

1. Introduction

Greenhouse gases are capable of causing global warming and climate extremes, resulting in many disasters. Climate change affects various areas of the economy, causing higher temperatures, low economic productivity and profitability, and reduces the country's global average income and real GDP per capita (Kahn et al., 2019; Rezai et al., 2018). Carbon dioxide (CO₂) is considered a primary greenhouse gas, impacting mergers, company acquisitions, capital structure, investment decisions, and the risk of financial disruption (Dafermos et al., 2018; Kang, 2018; Phan et al., 2022).

The various threats that climate change poses demonstrate that governments must consider taking steps to deal with global warming. The role of government is very important in reducing the amount of carbon (Sartzetakis, 2020). Climate change and environmental degradation strengthen efforts to improve economic sustainability as well as economic development (Adams et al., 2020; Salari et al., 2021; Wang and Lee, 2022), and treating financial market development as part of a key platform in combating climate as well as environmental issues. The 2019 Copenhagen Agreement stipulated that encouraging the rapid growth of green finance constitutes an impetus to support companies in

accommodating the transition to a low-carbon economy by means of which climate-unfriendly activities must be reduced (Liu, 2022).

Various proposed green economy policies are used in mitigating global climate change thus becoming a popular research topic. The proper financing of financial instruments for the transition to a green economy is necessary for green projects (Zhang et al., 2023). This has an impact on green bonds, considered the most desirable source of funding in climate-friendly projects (John and Rapp, 2022). The global green bond market has recently experienced rapid growth (Kuchtyak & Bruce, 2022).

Sustainable finance is associated with quality and sustainable development, and it is an important factor in economic growth; it also has the characteristics of continuous expansion, which provides the basis for planning that is closely related to high-quality and sustainable development. In addition, sustainable finance is also an important factor of economic growth that provides the foundation for planned prosperity (Sreenu and Mishra, 2023). The sustainable finance policy requires establishing access thresholds in the credit sector to reduce funding for companies with high levels of energy consumption and pollution. The policy also aims to develop projects that focus on environmental protection, energy conservation, and the reduction of greenhouse gas emissions. This is expected to diminish the negative impacts on the environment and increase the scale of credit for projects that contribute to environmental sustainability, as well as expand financial access for communities (Ouyang et al., 2023).

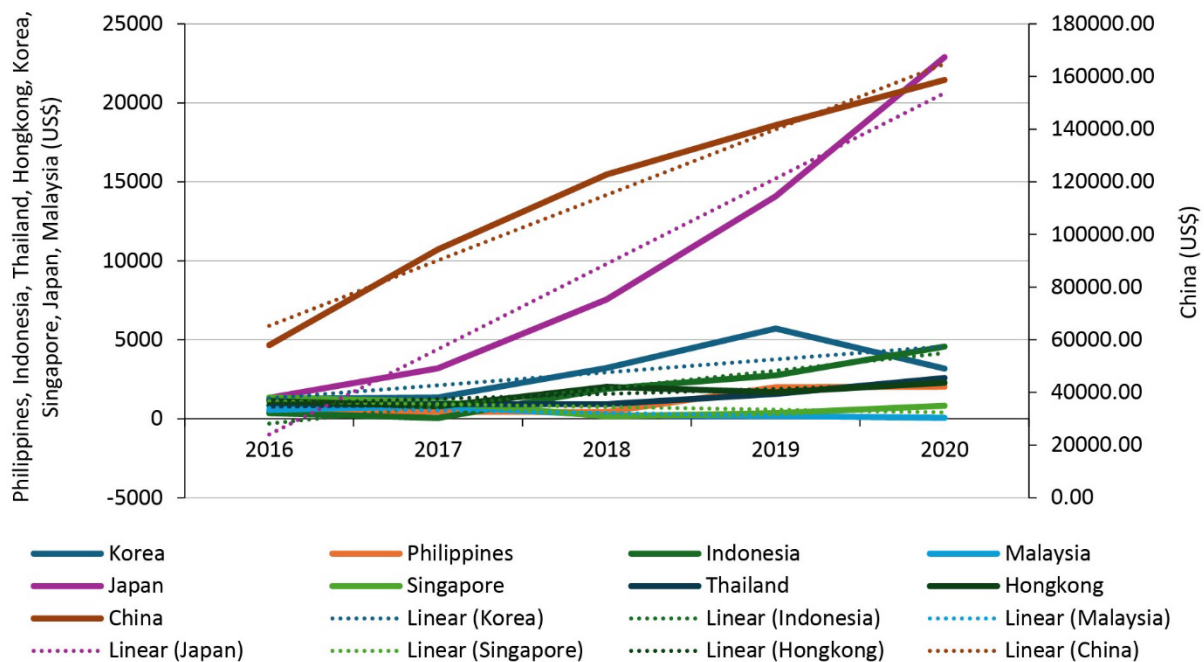


Fig. 1. Green Bonds in Asian countries

Source: Asian Development Bank (ADB), 2016-2020.

Green finance is the most efficient way to address environmental problems in the economy (Atsu and Adams, 2021; Banga, 2019). The significant growth in the bond market reflects various green financing schemes. Green bonds are a new financial instrument, whose benefits are highly marketable for issuers by lowering financing costs through long-term liquidity and engaging profitable investors (Flammer, 2021; Tang and Zhang, 2020). The funds generated from various green bond issuances encourage projects and programmes to reduce the impact of climate change such as clean energy, clean water initiatives, and the increased use of public transportation (Tu et al., 2020).

Green bonds are an important financing instrument to overcome pollution and improve environmental performance (Kanamura, 2020). The researchers reviewed various studies in terms of several aspects. The effect of green bonds on financial markets was examined by Ferrer et al. (2021) and Hammoudeh et al. (2020). Furthermore, research showed that green bonds issues bring benefits, which can be seen from the positive reaction of stock investors to the issuance of green bonds (Dorfleitner et al., 2022; Tang and Zhang, 2020). Scientists have begun researching the characteristic cause and impact role of green bonds in exploring green premiums (Zerbib, 2019).

As seen in Figure 1, green bond issuance has increased in Asian countries; in particular, China and Japan experienced significant growth in green bond issuance. Both countries have demonstrated their commitment to tackling climate change and adopting sustainable development principles (Biermann et al., 2017; Robert and Brown, 2013), whilst in other countries, the increase in green bonds is still relatively low, illustrating that awareness and understanding of the concept of green bonds remains fairly limited among governments, companies, and investors. This may hinder interest and participation in green bond issuance. Other factors, such as unfavourable regulatory conditions, the lack of available financial instruments, and uncertainty regarding return on investment also contribute to the Sustainable Development Index. Thus, the characteristics of each country need to be examined.

The discussion related to the issuance of environmentally-friendly bonds is still quite new, so the empirical evidence available is rather limited (Broadstock and Cheng, 2019). This research makes a significant contribution by providing a comprehensive understanding of the role of sustainable financial instruments, especially green bonds, in supporting sustainable development. Although several studies have explored the implications and characteristics of green bonds in Asian countries, most research related to green bonds is more in-depth in the study of price comparisons between green bonds and conventional bonds (Hachenberg and Schiereck, 2018; Larcker and Watts, 2020). By applying panel data methods, especially fixed effect model (FEM) panel data regression, this study was able to examine the complexity of cross-country and cross-time variations, increasing the validity and accuracy of analysis results. The FEM method has been applied before (cf. Gugushvili et al. (2022); Pratheepan and Banda (2016); Liu et al. (2021)). Another novelty lies in the areas of inclusivity in focus, covering the Philippines, Indonesia, China, Japan, Thailand, Hong Kong, Korea, Malaysia and Singapore. This article not only focuses on analysis, but also provides policy recommendations which include concrete steps to raise environmental awareness, as well as strengthen pro-environment policies and fiscal incentives.

The research findings show that green bonds are positively correlated and significant in influencing the SDI in Asian countries. When a country actively issues green bonds to support sustainable projects, and its environmentalist activists invest in these types of bonds, it can have a positive impact on the progress and improvement of sustainable development in the country. These results provide empirical support to the assumptions or hypotheses underlying the research that confirms that green bonds can increase and have a real effect in supporting sustainable development in Asian countries.

The article is structured as follows. After the introduction, the relevant literature is reviewed enabling to formulate the hypothesis in Section 1 (i.e. the introduction). Section 2 describes the data and methodology applied in this research, and Section 3 presents the research results and discussion. Finally, Section 4 provides the conclusions and recommendations.

2. Data and methods

2.1. Data

This study used secondary data in the form of panel data concerning nine Asian countries, namely Indonesia, Japan, China, Malaysia, Hong Kong, the Philippines, Thailand, Korea and Singapore, in the form of annual data for the period 2016-2020. The variables used and their operational definitions in this study are presented in Table 1.

Table 1. Operational variables

Variable	Description	Formula/Unit	Data source
Green Bond (<i>GB</i>)	Financial instruments issued by governments, financial institutions and companies aim to raise specific funds for projects that contribute to solutions to environmental and climate challenges. Funding obtained from green bonds is usually used in projects that have a positive impact on the environment, such as renewable energy projects, energy efficiency, waste management, sustainable transportation, and other environmental protections.	US\$	Asian Development Bank
Sustainable Development Index (<i>SDI</i>)	A comprehensive measure used in evaluating the progress of a country or region in achieving sustainable development goals. SDI integrates various economic, social and environmental indicators with the aim of providing a more complete picture of human well-being and balance with the environment.	$SDI = \frac{DI}{EII}$ <i>DI</i> = Development Index <i>EII</i> = Ecological Impact Index	Human Development Report

Source: Asian Development Bank and the Human Development Report, 2016-2020.

2.2. Method

In the use of panel data regression, three approaches were applied, selecting the common effects (CEM), fixed effects (FEM), and random effects (REM) models. The selection of the best estimation approach was carried out through model selection tests, namely the Chow test and the Hausman test. Green Bond (*GB*) was used as an independent variable, while Sustainable Development Index (*SDI*) as a dependent variable, hence the function of this study:

$$SDI = f(GB). \quad (1)$$

From the above function, a regression equation was formed for this model, which is as follows:

$$SDI_{it} = \beta_0 + \beta_1 GB_{it} + \varepsilon_{it}, \quad (2)$$

where *SDI* is the Sustainable Development Index, β is the coefficient of the independent variable, *GB* is Green Bond, *it* is time series and cross section, ε is the standard error.

3. Data trend analysis

This study examined the trends and patterns observed in the relation between green bonds and the Sustainable Development Index (*SDI*) in Asian countries. Singapore had the highest *SDI* value with a steady increase over the studied time span (Figure 2). The country showed a strong commitment to sustainable development, adopting strong policies and strategies to address environmental issues and promoting sustainable development (Cuiyun and Chazhong, 2020). Singapore has a strong infrastructure to support sustainable development, one of which is implementing green infrastructure (*GI*) as a way to reduce its water footprint; *GI* covers various strategies such as urban greening, rain parks, stormwater absorption, and sustainable land use to manage water (Liu and Jensen, 2018). *GI* helps to slow the flow of surface water, water seepage into the soil, minimising overflow into drainage systems, and thereby reducing flood risk and maintaining water quality. The country has developed a sustainable transportation system by expanding its efficient public transport network and reducing dependence on private motor vehicles (Diao, 2019). Singapore's *GB* experienced a significant decline in 2016-2018; during this period, the country faced several challenges, among which the lack of public awareness and the relatively small domestic market for green bonds (Chang, 2019). On the other hand, Japan, Korea, and Hong Kong had fairly similar relationship trends between green bonds and *SDI*, illustrating these countries' high commitment to sustainable development (van der Waal and Thijssens, 2020).

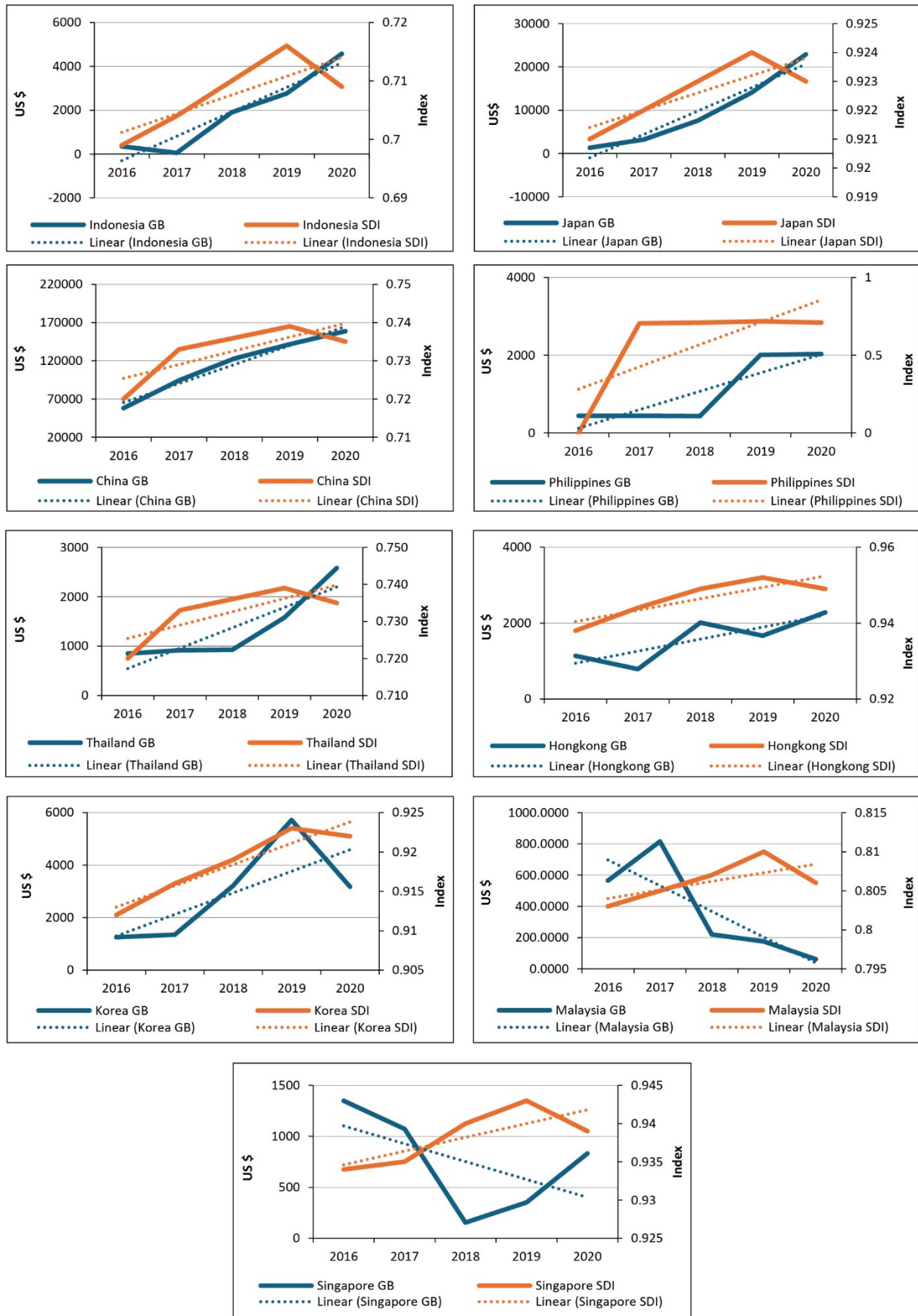


Fig. 2. Green Bond (GB) and Sustainable Development Index (SDI)

Source: Asian Development Bank and the Human Development Report, (2020)

The Philippines, Indonesia, and Thailand had relatively low SDI values, showing potential for further improvement in sustainable development efforts. These differences show that different countries have different challenges and levels of progress in achieving the sustainable development goals. These countries have abundant natural wealth, including tropical rainforests and high biodiversity, however their natural resource management often is not optimal, with illegal logging, environmental damage, and unsustainable mining activities, all of which can negatively impact environmental sustainability and lead to low SDI scores (Elliott, 2017). They also face challenges in reducing social and economic inequality. The Philippines, Indonesia, and Thailand are experiencing rapid urban population growth (Liu et al., 2018), where uncontrolled urbanisation often results in enormous pressure on the environment, including air pollution, sewage problems, and damage to ecosystems.

Meanwhile, China had the highest overall GB value with a significant increase, and shows strong commitment in green bonds issuance to support sustainable projects (Wang et al., 2020). The Chinese government has demonstrated a strong commitment to sustainable development and reduction of greenhouse gas emissions (Wei et al., 2021), adopting policies and strategic measures that support the transition to a low-carbon economy and the development of the renewable energy sector. It is a country with a large scale of sustainable projects, such as the construction of massive solar and wind power plants (Dai et al., 2016). Investing in these projects requires significant financial resources, and green bonds have become a popular instrument to support the financing of such sustainable projects.

Malaysia had a relatively low GB value with little fluctuation. Public awareness and understanding of the financial market participants regarding the concept and benefits of green bonds may still be low in Malaysia (Liu and Lai, 2021), which hampers the growth and GB issuance in that country. The lack of understanding of the potential long-term benefits and advantages of sustainable investment may be an obstacle in driving interest in green bonds.

Figure 2 shows the positive growth in the GB trend, which means that more green bonds are being issued to support sustainable investment, however there are exceptions for Malaysia and Singapore. In this case, when the GB trend shows positive growth, the SDI is negative. This shows a misalignment between the efforts made in issuing green bonds and progress in achieving sustainable development in these countries. In 2017-2020, there was a downward trend in Malaysia's GB value due to the lack of public knowledge/awareness regarding green bonds (Asian Development Bank, 2022); in 2020 SDI for Malaysia showed a significant downward trend. Malaysia, just as many other countries, experienced significant impacts from the COVID-19 pandemic, including economic, social and environmental restrictions that could affect progress in sustainable development (Mukarram, 2020). They experienced notable decline in income and economic losses, which reduced the resources available for investment in sustainable projects. Government budget priorities may have changed to focus on economic recovery rather than on sustainable development.

4. Results and discussion

4.1. Descriptive statistics

Statistical analysis shows some interesting data related to the Sustainable Development Index (SDI) and Green Bond (GB) in the sample studied. Table 2 shows that the mean SDI was 0.823667 with a standard deviation of 0.101583, indicating that in general the countries in the sample had relatively high levels of sustainable development and relatively small variations in their rankings. The lowest SDI value was 0.699, which suggests that some countries experienced challenges in achieving higher sustainable development. However, the highest SDI value reached 0.952, indicating that there were countries achieving high levels of sustainable development.

Table 2. Descriptive statistics

	Sustainable Development Index	Green Bond
Mean	0.823667	14986.04
Median	0.806000	1348.919
Maximum	0.952000	158700.8
Minimum	0.699000	49.01240
Standard deviation	0.101583	37947.47
Skewness	0.057807	2.831772
Observations	45	45
Cross sections	9	9

Source: Eviews, 2016-2020.

At that time, GB data showed an average value of 14986.04 with a standard deviation of 37947.47, which suggests that there was a significant variation in the GB value between the countries observed – these differences may reflect financial capacity and investment interest in sustainable projects in those countries. The positive skewness on the GB distribution (2.831772) indicates a tendency to have higher values in most countries, which suggests that some countries were investing significantly more resources in sustainable projects through green bonds.

4.2. Estimation results

The regression model used in this study was a panel data regression model estimated using three approaches: the common effects, the fixed effects, and the random effects. The model estimation results are presented in Table 3.

Table 3. Estimation results

Variable	Estimation model			
		Common	Fixed	Random
Constant	Coefficient		-0.821624	0.821202
	Standard error		0.000684	0.036254
	t-Statistic		-1200.889	22.65146
	Prob		0.0000***	0.0000***
GB	Coefficient	6.93E-06	1.36E-07	1.64E-07
	Standard error	2.91E-06	3.74E-08	6.14E-08
	t-statistic	2.379609	3.641753	2.678962
	Prob	0.0217	0.0009***	0.0104**
R ²		-59.458387	0.998538	0.143159
F-statistic			3340.481	7.184345
Prob (F-statistic)			0.000000***	0.010384**
Chow test			0.0044**	0.0098***
Hausman test			0.0000***	0.3824
	Individual coefficient			
Philippines	-0.113370			
Indonesia	-0.114287			
China	-0.104706			
Japan	0.099638			
Thailand	-0.089211			
Hongkong	0.124561			
Korea	0.096375			
Malaysia	-0.015474			
Singapore	0.116473			
Classical assumptions				
Lagrange Multiplier Test			0.9740	
Heteroskedasticity			0.2342	

Note: *, **, and *** indicate significance levels at levels of 10%, 5% and 1%

Source: Output EViews, 2016-2020.

Regression estimation of the panel data using the fixed effects model (FEM) delivered:

$$\widehat{SDI}_{it} = -0.821624 + 0.0000001360GB_{it} + \varepsilon_{it}. \quad (3)$$

The model estimation results were then selected as one of the best models through model specification tests. The results of the Chow test obtained a probability value of GB of 0.0044 and cross-section F of 0.000; this shows that the fixed effects model was better than the common effects model. Fixed effects model (FEM) contains the useful specifications in accommodating individual heterogeneity in panel data (Greene, 2001). FEM assumes that differences between individuals can be accommodated from different intercepts. In this study, FEM was chosen as the best method, so that not only the variable coefficients, but also the individual coefficients, were obtained as intercept differences from each country (Gujarati, 2003). FEM is able to eliminate the bias of eliminated variables as well as being a powerful tool to improve research identification (deHaan, 2020). Furthermore, the Hausman test revealed a probability value of GB at 0.0098 and cross-section F at 0.3824; both results were significant at 1% alpha (Table 3) demonstrating that fixed effects models are better than random effects. Thus, the estimation model used in this study was the fixed effects model. Based on (3), it was shown that green bonds have a positive and significant effect seen from the probability of less than $\alpha=5\%$.

5. Discussion

The regression results show that GB variable is positively correlated and significant in influencing the SDI, indicating that an increase in green bonds issuance was statistically related to an increase in the value of the SDI. Thus, when a country is active in issuing green bonds to support sustainable projects, it positively affects the progress and improvement of sustainable development in Asian countries. These results provide empirical support to the assumptions and hypotheses in this study, confirming that green bonds have a real impact in supporting the sustainable development goals. These research results are in line with the studies by Alamgir and Cheng (2023), and Bhutta et al. (2022), whereas for Versal and Sholoiko (2022), the result is insignificant. According to several authors and data, issuers in the green bond market were mostly developed countries, hence their share among green bond issuers averaged 71% in 2014-2020, while the share of developing countries was only 18%.

Based on the intercept results, the Philippines, Indonesia, China, Thailand, and Malaysia had the lowest intercept scores, with their less mature or developed financial markets in terms of sustainable financial products such as green bonds (Ng and Tao, 2016). Lack of access, knowledge, or interest in sustainable products can affect investment in green bonds and their impact on SDI (Maltais and Nykvist, 2021). The level of commitment of the government and private sector to sustainable development in the Philippines, Indonesia, China, Thailand, and Malaysia was an important factor, while the level of public awareness on environmental issues and sustainable development had a crucial role. Low awareness of demand for sustainable financial products such as green bonds results in limited investment (Babon-Ayeng et al., 2022), and the lack of regulatory support and incentives from the government in investing in sustainable projects and green bonds also hinders the process. China has experienced rapid economic growth in recent decades, its main focus being economic development and increasing production, and resulting in the lack of focus on sustainable development in the short term. China, the country with the largest population and rapid industrial growth (Chen et al., 2013) has a high demand for energy, and the environmental challenges it faces can impact its dependence on conventional energy sources. This is not in line with the principles of green bonds and sustainable development. Moreover, transparency and accountability issues in major infrastructure projects and government investment in China can affect investor perception and confidence in green bonds.

Japan, Hong Kong, Korea, and Singapore had the highest intercepts among the other countries studied, with their commitment to sustainable development and efforts to reduce environmental impact (Amran et al., 2014). This is reflected in pro-environment government policies, tax incentives for sustainable investment, and support for green technology innovation. Japan, Hong Kong, Korea, and

Singapore have more mature financial markets in terms of sustainable financial products such as green bonds. The availability of sustainable investment instruments and high demand from investors can lead to similar trends in sustainable investment, and impact on sustainable development indices. The level of public awareness on environmental issues, as well as sustainable development and support from the government, can influence the trend of investment in green projects (Solangi et al., 2021).

Green bonds are used to fund renewable energy projects, including solar, wind, and biomass power plants (Gibon et al., 2020). By financing these projects, green bonds encourage the use of clean energy sources that not only reduce greenhouse gas emissions but also reduce dependence on unsustainable fossil fuels (Sachs et al., 2017). In addition, they are used in supporting energy efficiency projects (Weber and Saravade, 2019). This includes the development of energy-efficient technologies, the renewal of energy governance systems, as well as the improvement of energy use efficiency in sectors such as buildings, industry, and transportation. Green bonds are also used in funding sustainable water management projects (Tang and Zhang, 2020), which include restoration of water ecosystems, development of clean water infrastructure, wastewater management, and conservation of water resources. Green bonds encourage the increased availability of safe clean water, reduce the risk of water shortages, and maintain sustainable water quality. Thus, they play an important role in accelerating the implementation of projects that contribute to sustainable development. Green bonds encourage the creation of a better environment for people and the planet, therefore positively impacting the Sustainable Development Index (SDI).

The stimulation of innovation and green technology is one of the significant benefits of GB issuance, providing the necessary financial resources aimed at stimulating innovation as well as the development of green technologies, which in turn can have a positive impact on the environment (Gianfrate and Peri, 2019). With the presence of green bonds, funds obtained from investors can be allocated for research, development, and the implementation of sustainable solutions (Hachenberg and Schiereck, 2018). This encourages innovators, scientists, and companies to explore and develop more efficient and sustainable green technologies. Investments in green technologies enable the more efficient use of resources, reduce waste, and reduce greenhouse gas emissions, hence green bonds play a role in reducing negative impacts on the environment. In addition, they also provide opportunities for businesses and innovators to access the capital needed to drive sustainable technology development and adoption (Maltais and Nykvist, 2021). In some cases, the development and implementation of green technologies require a large initial investment. Green bonds create financial resources that can be used to overcome these barriers and provide incentives for businesses and innovators to engage in sustainable projects (Elliott and Zhang, 2019).

6. Conclusion

GB is an important instrument that can influence the improvement of the sustainable development index (SDI) through financing sustainable projects, stimulating innovation and green technology, and attracting investors who have a socially and environmentally responsible orientation. Green bonds can aid sustainable infrastructure development, clean energy use, sustainable water management, and green technology development. However, to maximise their potential, it is necessary to have policies that support and expand the GB market, as well as ensure transparency and accountability in the allocation of funds obtained. Governments need to consider the use of fiscal incentives to encourage the growth of the GB market, such as tax exemptions and investment incentives. It is also important to strengthen the policy and regulatory framework related to green bonds, including a clear assessment, as well as reporting and verification standards to ensure the integrity and sustainability of funded projects. Governments can also play an active role in facilitating dialogue and cooperation between industry players, financial institutions, and international institutions to increase understanding and knowledge of green bonds and accelerate growth and adoption on a global scale. Moreover, wider education and awareness campaigns can also be carried out to increase public understanding of the importance of sustainable investment and the role of green bonds in sustainable development. The relevance of further

efforts to address environmental challenges, correct inadequate infrastructure, and adopt consistent and effective policies. It is also crucial to raise public awareness about the importance of sustainable development and involve them actively in sustainable initiatives and programmes.

In order to address the challenges of sustainable development, the Philippines, Indonesia, and Thailand need to formulate appropriate policy measures. Increasing environmental awareness and education is an important priority in order to build public understanding of environmental impacts and the need for sustainable development. In addition, their governments need to strengthen pro-environment policies and provide fiscal incentives in order to support sustainable investment, creating a conducive environment for investors. Collaboration with the private sector is vital in increasing investment in sustainable projects and sustainable financial products. To increase investor confidence and the general public, it is necessary to prioritise transparency and availability of data on the use of green bond funds and their impact on sustainable development. Establishing international cooperation and learning from countries that have successfully developed sustainable financial markets, can accelerate transformation towards sustainable development. The Chinese government needs to speed up the transition from fossil energy sources to renewable energy, such as solar, wind, and hydropower, as well as implement policies that encourage energy efficiency in key sectors, such as industry, transportation, and buildings. These include stricter efficiency standards, tax incentives for green technologies, and public awareness campaigns on the importance of reducing energy consumption. There is a need for further implementation in an effort to reduce air and water pollution that damages the environment and public health. What is more, China has to play an active role in international cooperation to share experience, knowledge and resources to achieve the sustainable development goals globally.

The study has some limitations due to the limited data related to green bonds in emerging and developing Asian countries, as not all the countries have issued green bonds. It is expected that future studies will be able to cover a longer data period and use more samples.

References

- Adams, S., Adedoyin, F., Olaniran, E., & Bekun, F. V. (2020). Energy consumption, economic policy uncertainty and carbon emissions; causality evidence from resource rich economies. *Economic Analysis and Policy*, 68, 179–190. <https://doi.org/10.1016/j.eap.2020.09.012>
- Alamgir, M., & Cheng, M. C. (2023). Do Green Bonds Play a Role in Achieving Sustainability? *Sustainability (Switzerland)*, 15(13). <https://doi.org/10.3390/su151310177>
- Amran, A., Periasamy, V., & Zulkafli, A. H. (2014). Determinants of climate change disclosure by developed and emerging countries in asia pacific. *Sustainable Development*, 22(3), 188–204. <https://doi.org/10.1002/sd.539>
- Asian Development Bank. (2022). *Green Bond Market Survey for Thailand* (Issue June). <https://www.adb.org/publications/green-bond-market-survey-thailand>
- Atsu, F., & Adams, S. (2021). Energy consumption, finance, and climate change: Does policy uncertainty matter? *Economic Analysis and Policy*, 70, 490–501. <https://doi.org/10.1016/j.eap.2021.03.013>
- Babon-Ayeng, P., Oduro-Ofori, E., Owusu-Manu, D.-G., Edwards, D. J., Kissi, E., & Kukah, A. S. K. (2022). Socio-political factors underlying the adoption of green bond financing of infrastructure projects: the case of Ghana. *Journal of Capital Markets Studies*, 6(3), 304–319. <https://doi.org/10.1108/jcms-06-2022-0018>
- Banga, J. (2019). The green bond market: a potential source of climate finance for developing countries. *Journal of Sustainable Finance and Investment*, 9(1), 17–32. <https://doi.org/10.1080/20430795.2018.1498617>
- Bhutta, U. S., Tariq, A., Farrukh, M., Raza, A., & Iqbal, M. K. (2022). Green bonds for sustainable development: Review of literature on development and impact of green bonds. *Technological Forecasting and Social Change*, 175(August 2021), 121378. <https://doi.org/10.1016/j.techfore.2021.121378>
- Biermann, F., Kanie, N., & Kim, R. E. (2017). Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability*, 26–27, 26–31. <https://doi.org/10.1016/j.cosust.2017.01.010>
- Broadstock, D. C., & Cheng, L. T. W. (2019). Time-varying relation between black and green bond price benchmarks: Macroeconomic determinants for the first decade. *Finance Research Letters*, 29, 17–22. <https://doi.org/10.1016/j.frl.2019.02.006>
- Chang, Y. (2019). Green Finance in Singapore: Barriers and Solutions. *SSRN Electronic Journal*, 915. <https://doi.org/10.2139/ssrn.3326287>
- Chen, Z., Wang, J. N., Ma, G. X., & Zhang, Y. S. (2013). China tackles the health effects of air pollution. *The Lancet*, 382(9909), 1959–1960. [https://doi.org/10.1016/S0140-6736\(13\)62064-4](https://doi.org/10.1016/S0140-6736(13)62064-4)
- Cuiyun, C., & Chazhong, G. (2020). Green development assessment for countries along the belt and road. *Journal of Environmental Management*, 263(March 2019), 110344. <https://doi.org/10.1016/j.jenvman.2020.110344>

- Dafermos, Y., Nikolaidi, M., & Galanis, G. (2018). Climate Change, Financial Stability and Monetary Policy. *Ecological Economics*, 152, 219–234. <https://doi.org/10.1016/j.ecolecon.2018.05.011>
- Dai, H., Xie, X., Xie, Y., Liu, J., & Masui, T. (2016). Green growth: The economic impacts of large-scale renewable energy development in China. *Applied Energy*, 162, 435–449. <https://doi.org/10.1016/j.apenergy.2015.10.049>
- deHaan, E. (2020). Practical Guidance on Using and Interpreting Fixed Effects Models. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3699777>
- Diao, M. (2019). Towards sustainable urban transport in Singapore : Policy instruments and mobility trends. *Transport Policy*, 81(February 2018), 320–330. <https://doi.org/10.1016/j.tranpol.2018.05.005>
- Dorfleitner, G., Utz, S., & Zhang, R. (2022). The pricing of green bonds: external reviews and the shades of green. *Review of Managerial Science*, 16(3), 797–834. <https://doi.org/10.1007/s11846-021-00458-9>
- Elliott, C., & Zhang, L. Y. (2019). Diffusion and innovation for transition: transnational governance in China's green bond market development. *Journal of Environmental Policy and Planning*, 21(4), 391–406. <https://doi.org/10.1080/1523908X.2019.1623655>
- Elliott, L. (2017). Environmental regionalism : moving in from the policy margins. *The Pacific Review*, 2748(March). <https://doi.org/10.1080/09512748.2017.1303534>
- Ferrer, R., Shahzad, S. J. H., & Soriano, P. (2021). Are green bonds a different asset class? Evidence from time-frequency connectedness analysis. *Journal of Cleaner Production*, 292. <https://doi.org/10.1016/j.jclepro.2021.125988>
- Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, 142(2), 499–516. <https://doi.org/10.1016/j.jfineco.2021.01.010>
- Gianfrate, G., & Peri, M. (2019). The green advantage: Exploring the convenience of issuing green bonds. *Journal of Cleaner Production*, 219, 127–135. <https://doi.org/10.1016/j.jclepro.2019.02.022>
- Gibon, T., Popescu, I. Ş., Hitaj, C., Petucco, C., & Benetto, E. (2020). Shades of green: Life cycle assessment of renewable energy projects financed through green bonds. *Environmental Research Letters*, 15(10). <https://doi.org/10.1088/1748-9326/abaa0c>
- Greene, W. (2001). *Estimating Nonlinear Models with Panel Data*. 1–14.
- Gugushvili, A., Zelinska, O., Präg, P., & Bulczak, G. (2022). Does perceived social mobility affect health? Evidence from a fixed effects approach. *Social Science and Medicine*, 294(August 2021). <https://doi.org/10.1016/j.socscimed.2022.114705>
- Gujarati, D. (2003). *Ekonometri Dasar. Terjemahan: Sumarno Zain*. Erlangga.
- Hachenberg, B., & Schiereck, D. (2018). Are green bonds priced differently from conventional bonds? *Journal of Asset Management*, 19(6), 371–383. <https://doi.org/10.1057/s41260-018-0088-5>
- Hammoudeh, S., Ajmi, A. N., & Mokni, K. (2020). Relationship between green bonds and financial and environmental variables: A novel time-varying causality. *Energy Economics*, 92. <https://doi.org/10.1016/j.eneco.2020.104941>
- John, C., & Rapp, A. C. (2022). The Green Corporate Bond Issuance Premium. *International Finance Discussion Paper*, 2500(1346), 1–46. <https://doi.org/10.17016/ifdp.2022.1346>
- Kahn, M., Mohaddes, K., Ng, R., Pesaran, M., Raissi, M., & Yang, J.-C. (2019). Long-Term Macroeconomic Effects of Climate Change. *IMF Working Papers*, 19(19). <https://doi.org/10.5089/9781513514598.001>
- Kanamura, T. (2020). Are green bonds environmentally friendly and good performing assets? *Energy Economics*, 88. <https://doi.org/10.1016/j.eneco.2020.104767>
- Kang, J. (2018). Mobile payment in Fintech environment: trends, security challenges, and services. *Human-Centric Computing and Information Sciences*, 8(1). <https://doi.org/10.1186/s13673-018-0155-4>
- Kuchtyak, M., & Bruce, E. (2022). Sustainable bonds to hit record \$1.35 trillion in 2022. In *Moody's* (Issue January).
- Larcker, D. F., & Watts, E. M. (2020). Where's the greenium? *Journal of Accounting and Economics*, 69(2–3). <https://doi.org/10.1016/j.jacceco.2020.101312>
- Lee, C. C., & Lee, C. C. (2022). How does green finance affect green total factor productivity? Evidence from China. *Energy Economics*, 107. <https://doi.org/10.1016/j.eneco.2022.105863>
- Liu, F. H. M., & Lai, K. P. Y. (2021). Ecologies of green finance: Green sukuk and development of green Islamic finance in Malaysia. *Environment and Planning A*, 53(8), 1896–1914. <https://doi.org/10.1177/0308518X211038349>
- Liu, H., Fang, C., Miao, Y., Ma, H., Zhang, Q., & Zhou, Q. (2018). Spatio-temporal evolution of population and urbanization in the countries along the Belt and Road 1950–2050. *Journal of Geographical Sciences*, 28(7), 919–936. <https://doi.org/10.1007/s11442-018-1513-x>
- Liu, L., & Jensen, M. B. (2018). Green infrastructure for sustainable urban water management: Practices of five forerunner cities. *Cities*, 74(October 2017), 126–133. <https://doi.org/10.1016/j.cities.2017.11.013>
- Liu, M. (2022). The driving forces of green bond market volatility and the response of the market to the COVID-19 pandemic. *Economic Analysis and Policy*, 75, 288–309. <https://doi.org/10.1016/j.eap.2022.05.012>
- Liu, Y., Lei, J., & Zhang, Y. (2021). A study on the sustainable relationship among the green finance, environment regulation and green-total-factor productivity in China. *Sustainability (Switzerland)*, 13(21). <https://doi.org/10.3390/su132111926>

- Maltais, A., & Nykvist, B. (2021). Understanding the role of green bonds in advancing sustainability. *Journal of Sustainable Finance and Investment*, 11(3), 233–252. <https://doi.org/10.1080/20430795.2020.1724864>
- Mukarram, M. (2020). Impact of COVID-19 on the UN Sustainable Development Goals (SDGs). *Strategic Analysis*, 44(3), 253–258. <https://doi.org/10.1080/09700161.2020.1788363>
- Neves, S. A., Marques, A. C., & Patrício, M. (2020). Determinants of CO2 emissions in European Union countries: Does environmental regulation reduce environmental pollution? *Economic Analysis and Policy*, 68, 114–125. <https://doi.org/10.1016/j.eap.2020.09.005>
- Ng, T. H., & Tao, J. Y. (2016). Bond financing for renewable energy in Asia. *Energy Policy*, 95, 509–517. <https://doi.org/10.1016/j.enpol.2016.03.015>
- Nguyen, T. T. H., Naeem, M. A., Balli, F., Balli, H. O., & Vo, X. V. (2021). Time-frequency comovement among green bonds, stocks, commodities, clean energy, and conventional bonds. *Finance Research Letters*, 40. <https://doi.org/10.1016/j.frl.2020.101739>
- Ouyang, H., Guan, C., & Yu, B. (2023). Green finance, natural resources, and economic growth: Theory analysis and empirical research. *Resources Policy*, 83(3). <https://doi.org/10.1016/j.resourpol.2023.103604>
- Phan, D. H. B., Tran, V. T., Ming, T. C., & Le, A. (2022). Carbon risk and corporate investment: A cross-country evidence. *Finance Research Letters*, 46. <https://doi.org/10.1016/j.frl.2021.102376>
- Pratheepan, T., & Weerakon Banda, Y. K. (2016). The Determinants of Capital Structure: Evidence from Selected Listed Companies in Sri Lanka. *International Journal of Economics and Finance*, 8(2), 94. <https://doi.org/10.5539/ijef.v8n2p94>
- Rezai, A., Taylor, L., & Foley, D. (2018). Economic Growth, Income Distribution, and Climate Change. *Ecological Economics*, 146, 164–172. <https://doi.org/10.1016/j.ecolecon.2017.10.020>
- Robert, B., & Brown, E. B. (2013). *International Trade and Climate Change Policies* (1st Edition, Issue 1). <https://doi.org/10.4324/9781315071411>
- Sachs, J. D., Woo, W. T., Yoshino, N., & Taghizadeh-Hesary, F. (2017). ADBI Working Paper Series Why Is Green Finance Important? Asian Development Bank Institute. *Institute of Sciences*, 917. <https://www.adb.org/publications/why-green-finance-important>
- Salari, M., Javid, R. J., & Noghanibehambari, H. (2021). The nexus between CO2 emissions, energy consumption, and economic growth in the U.S. *Economic Analysis and Policy*, 69, 182–194. <https://doi.org/10.1016/j.eap.2020.12.007>
- Sartzetakis, E. S. (2020). Green bonds as an instrument to finance low carbon transition. *Economic Change and Restructuring*, 54, 755–779. <https://doi.org/10.1007/s10644-020-09266-9>
- Solangi, Y. A., Longsheng, C., & Shah, S. A. A. (2021). Assessing and overcoming the renewable energy barriers for sustainable development in Pakistan: An integrated AHP and fuzzy TOPSIS approach. *Renewable Energy*, 173, 209–222. <https://doi.org/10.1016/j.renene.2021.03.141>
- Sreenu, N., & Mishra, S. (2023). Jo ur of. *HELIYON*, e16301. <https://doi.org/10.1016/j.heliyon.2023.e16301>
- Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 61. <https://doi.org/10.1016/j.jcorpfin.2018.12.001>
- Tu, C. A., Rasoulnezhad, E., & Sarker, T. (2020). Investigating solutions for the development of a green bond market: Evidence from analytic hierarchy process. *Finance Research Letters*, 34(February), 101457. <https://doi.org/10.1016/j.frl.2020.101457>
- van der Waal, J. W. H., & Thijssens, T. (2020). Corporate involvement in Sustainable Development Goals: Exploring the territory. *Journal of Cleaner Production*, 252, 119625. <https://doi.org/10.1016/j.jclepro.2019.119625>
- Versal, N., & Sholoiko, A. (2022). Green bonds of supranational financial institutions: On the road to sustainable development. *Investment Management and Financial Innovations*, 19(1), 91–105. [https://doi.org/10.21511/imfi.19\(1\).2022.07](https://doi.org/10.21511/imfi.19(1).2022.07)
- Wang, E. Z., & Lee, C. C. (2022). The impact of clean energy consumption on economic growth in China: Is environmental regulation a curse or a blessing? *International Review of Economics and Finance*, 77, 39–58. <https://doi.org/10.1016/j.iref.2021.09.008>
- Wang, J., Chen, X., Li, X., Yu, J., & Zhong, R. (2020). The market reaction to green bond issuance: Evidence from China. *Pacific Basin Finance Journal*, 60(February), 101294. <https://doi.org/10.1016/j.pacfin.2020.101294>
- Weber, O., & Saravade, V. (2019). Green Bonds: Current Development and Their Future. In *Center for International Governance Innovation* (No. 210; Issue 210). [https://www.cigionline.org/sites/default/files/documents/Paper no.210_0.pdf](https://www.cigionline.org/sites/default/files/documents/Paper%20no.210_0.pdf)
- Wei, T., Wu, J., & Chen, S. (2021). Keeping Track of Greenhouse Gas Emission Reduction Progress and Targets in 167 Cities Worldwide. *Frontiers in Sustainable Cities*, 3(July), 1–13. <https://doi.org/10.3389/frsc.2021.696381>
- Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking and Finance*, 98, 39–60. <https://doi.org/10.1016/j.jbankfin.2018.10.012>
- Zhang, D., Chen, X. H., Lau, C. K. M., & Cai, Y. (2023). The causal relationship between green finance and geopolitical risk: Implications for environmental management. *Journal of Environmental Management*, 327(December 2022), 116949. <https://doi.org/10.1016/j.jenvman.2022.116949>