Energy efficiency financing and the role of green bond: policies for post-Covid period

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Abstract

Purpose – One of the major negative effects of the Coronavirus outbreak worldwide has been reduced investment in green energy projects and energy efficiency. The main purpose of this paper is to study the role of green bond proposed by the World Bank in 2008, as a reliable instrument to enhance the capital flow in energy efficiency financing and to develop green energy resources during and post the current challenging global time.

Design/methodology/approach – We model energy efficiency for 37 members of OECD through a panel data framework and quarterly data over 2007Q1–2020Q4.

Findings – The major results reveal the positive impacts of issued green bonds and regulatory quality index on energy efficiency, while any increase in inflation rate and urbanization decelerates the progress of raising energy efficiency.

Practical implications – As highlighted concluding remarks and policy implications, it can be expressed that the tool of green bond is a potential policy to drive-up energy efficiency financing and enhancing environmental quality during and post-COVID period. It is recommended to follow green bond policy with an efficient regulation framework and urbanization saving energy planning.

Originality/value – To the best of the authors' knowledge, although a few scholars have investigated the impacts of COVID-19 on green financing or examined the energy efficiency financing, the matter of modeling energy efficiency–green bond relationship has not been addressed by any academic study. The contributions of this paper to the existing literature are: (1) it is the first academic study to discover the relationship between energy efficiency and green bond in OECD countries, (2) since our empirical part provides estimation results based on quarterly data covering the year of 2019 and 2020, it may offer some new policy implications to enhance energy efficiency financing in and post-COVID period, (3) furthermore, we consider energy efficiency indicator (mix of industrial, residential, services and transport energy efficiency) as the dependent variable instead of using the simple energy intensity variable as a proxy for energy efficiency.

Keywords Energy efficiency, Green bond, OECD, Panel data

Paper type Research paper

1. Introduction

The COVID-19 pandemic has made unprecedented challenge for different aspects of global economy. The rapid spread of this disease has pushed governments to take prompt lockdown, quarantine and restrictions on travel and trade which have brought serious concerns for economic life of countries. Maliszewska *et al.* (2020) estimated that the pandemic has shrunk the size of economies worldwide. According to their findings, due to the outbreak of coronavirus, the GDP of China, Europe, India, Singapore and total world decreased by nearly 3.6%, 1.8%, 2.4%, 2% and 2.09%, respectively (Table 1) lowering the financial power of public and private sectors.

The negative and unpredicted consequences of pandemic on economic markets such as capital market in the form of more confusion, lowering financial well-being and increase of uncertainty among investors (Chu and Fang, 2021; Samadi *et al.*, 2021) have highlighted the greater need for investment in energy efficiency and enhancement of green projects.

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Barrafrem *et al.* (2020) explain that the risk expectation has increased due to the uncertainty from the COVID-19 globally. The pandemic and its consequences make the future for households and corporate investors grey and vague causing further lack of capital for project financing. Yi *et al.* (2021) argued that the pandemic has lowered the capital flow in projects that are in related to environmental pollution as one of the most important goals of sustainable development highlighted by the UN General Assembly. Hak *et al.* (2016) believed that reaching the goals of sustainable development such as combating environmental pollution is essential for all countries in the world. Thus, the study of how countries can support green projects during and post-COVID period is vital.

In addition, energy efficiency is a highlighted variable as a useful tool to reduce CO_2 emissions (Pardo *et al.*, 2011; Chen *et al.*, 2012; Chen *et al.*, 2012; Kalpakov 2020). Over the last decades, fossil fuels as a primary energy sources have been consumed increasingly causing climate change, environmental pollution and threat of energy poverty in some countries. Zou *et al.* (2016) expressed that countries do not have any solution except following some policies such as expanding green projects and increasing energy efficiency to make an energy revolution from fossil fuels to green energy era. The increasing average atmospheric temperature caused by greenhouse gases such as carbon dioxide is a major concern and danger for the current era and future of humanity. Rasoulinezhad *et al.* (2020) proved that mortality from cardiovascular disease, cancer, diabetes and chronic respiratory disease are affected by CO_2 emissions. Furthermore, Aung *et al.* (2017) as well as Chao and Feng (2018) expressed that the ongoing trend of CO_2 emissions highlights the risk of natural ecosystems and the social economy, thus being a major threat for our globe. Hence, countries and international organizations have tried to find and propose different policies, instrument and plans (Lu *et al.*, 2020) in order to lower carbon dioxide emissions, raise energy efficiency and improve the progress of green projects.

The major role of energy efficiency in reducing carbon dioxide emissions has been debated by a vast number of scholars (e.g. see Kelly, 2006; Blesl *et al.*, 2007; Kamal *et al.*, 2019; Sun *et al.*, 2021). The global spread of pandemic outbreak and increased economic policy uncertainty (Chu and Fang, 2021; Jiang *et al.*, 2021) have lowered the capital flow in projects in related to increase of energy efficiency and the lack of finance in these projects has been highlighted more by the coronavirus shock.

Therefore, there is a vital need for any policies and tools to absorb capital in these projects in and post-COVID period.

It is widely accepted that green bond tool provided by World Bank in the "Strategic Framework on Development and Climate Change" in 2008 is an appropriate way to accelerate the flow of capital into energy projects, especially into those that are necessary for the environment. Reboredo (2018) proved that green bond can solve the problem of lack of capital in green investment which helps countries improve the projects related to renewable energy resources and energy efficiency, thus lowering carbon dioxide emissions. Wang *et al.* (2020) addressed the importance of development of green bond market to ease green financing support in countries and regions. Jakubik and Uguz (2020) argued that green bond as a key green policy can be used by governments to attract private investors to participate in projects in

Table 1.
Impacts of COVID on GDP in 2020

China	−3.69
Europe	−1.85
India	−2.41
Singapore	−2.08
Total World	−2.09

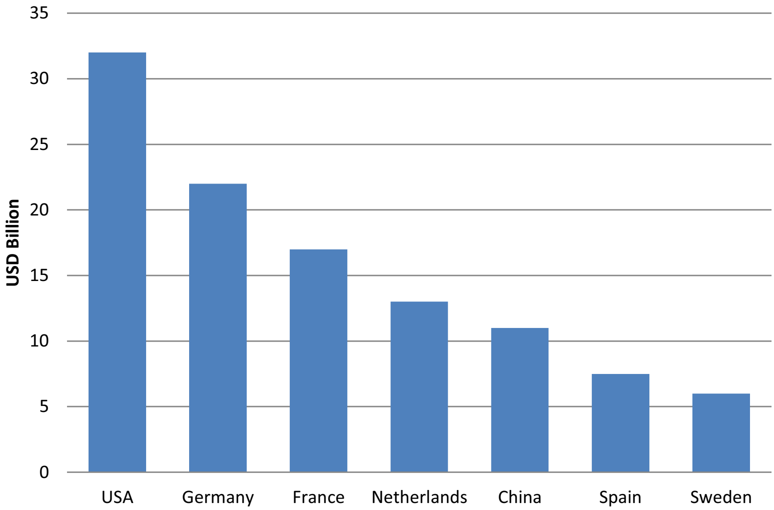
Source(s): Authors' compilation from Maliszewska *et al.* (2020)

order to lower carbon dioxide emissions. Flammer (2021) believes in the efficiency of green bonds to finance climate-friendly projects in the era of capital shortage in green projects. The process of working green bonds in financing green projects is similar to conventional bonds with a defined interest rate determined by a bond issuer and a more transparency on the use of funds, meaning that bondholders (investors) can be certain that their capital is used to finance green projects. According to the Climate Bond Initiative report (2020) (Figure 1), top issuers of green bonds in 2020 were USA, Germany, France, Netherlands, China, Spain and Sweden where over 30% of green bonds are used for energy financing.

The negative impact of COVID-19 on energy efficiency financing and the potential power of green bond to solve this problem motivated the authors to conduct this academic research. To the best of authors' knowledge, although a few scholars such as Mukanjari and Sterner (2020) and Yi *et al.* (2021) investigated the impacts of COVID-19 on green financing or Catttaneo (2019) and Forrester and Reames (2020) studied the energy efficiency financing, the matter of modeling energy efficiency–green bond relationship has not been addressed by any academic study. Accordingly, this literature gap is filled in by this research and can provide various practical policy implications for scholars as well as policymakers in different countries.

This paper contributed to the literature through different aspects: First, it is the first academic study to discover the relationship between energy efficiency and green bond in OECD countries which are pioneer in issuing green bonds (Inderst *et al.*, 2012) and have been damaged by the negative consequences of the pandemic. Further, since our empirical part provides estimation results based on quarterly data covering the year of 2019 and 2020, it may bring some policy implications to enhance energy efficiency financing in and post-COVID period. Furthermore, we consider energy efficiency indicator (mix of industrial, residential, services and transport energy efficiency) as the dependent variable instead of using the simple energy intensity variable as a proxy for energy efficiency.

Our major findings reveal that the issued green bond has shown a positive impact on energy efficiency index. This highlights the significant role of green bonds on enhancement of financing energy efficiency projects in OECD countries. This is in line with the argument of



Source(s): Authors' compilation based on Climate Bonds Initiative report (2020)

Figure 1.
Top green bonds issuers in 2020

Mclnerney and Bunn (2019) who emphasized the major role of green bonds on green projects which would lead to a higher energy efficiency in countries. It proves that the tool of green bond is a potential policy to drive-up energy efficiency in the panel countries thereby enhancing environmental quality during and post-COVID period.

The rest of this paper is organized as follows: Section 2 briefly reviews the literature to clarify the existing literature gap that the paper seeks to fill in. The next section provides data and methodology to justify the way the paper wants to apply to represent empirical findings. Section 4 includes the findings of preliminary tests, estimated coefficients and causality relationship between variables. Section 5 offer concluding remarks and addresses policy implications.

2. Literature review

The related literature to the issue of energy efficiency, carbon emissions and the role of green bond in energy efficiency financing is explained in this section. The role of green bond on green project financing has attracted the attention of a vast number of scholars. Ng and Tao (2016) highlighted the challenge of lack of enough financing in green projects which is a major obstacle of countries to combat carbon dioxide emissions. In other studies, Ruiz *et al.* (2016) and Clark *et al.* (2018) declared that private participation in financing green projects should be increased. Yoshino *et al.* (2019) explained that the return on investment of green projects is lower than that of fossil fuel projects, thereby creating financial gaps between renewable and fossil fuel investments. Sikora (2020) mentioned that financial challenge reduces the speed of progress of green economy worldwide. Hammoudeh *et al.* (2020) declared that green bond instrument can help governments increase the participation of private sectors in developing green projects which can reduce carbon dioxide emissions. Hanif *et al.* (2019) found out the positive impact of green bond issuing on financing renewable energy projects which combating the air pollution caused by the carbon dioxide. Dafermos *et al.* (2018) studied the relationship between climate change and financial stability in which the results depicted the major role of green bonds in enhancement of innovative green projects and lowering air pollution level. Mclnerney and Bunn (2019) argued that green bond is a remarkable instrument to improve the progress of low carbon transition through two ways of boosting energy efficiency and enhancing contribution of green energy recourses across the entire energy consumption basket of countries. Reboredo and Ugolini (2020) expressed that green bond can increase the return on investment (ROI) of green projects for private investors which makes the projects more feasible for investors. Paranque and Revelli (2019) revealed that green bonds are useful for green financing as well as for our future globe and humanity. Cao *et al.* (2021) highlighted the green bond as a key element to improve green projects through a larger participation of private sector ensuring the existence of enough capital in green energy investments. MacAskill *et al.* (2021) mentioned that despite the efficiency of green bonds in green financing, bond characteristics should be addressed by regulators and banks to attract private investors. In line with this argument, Febi *et al.* (2018) showed that liquidity risk is an influential factor on the success of green bonds, or Pineiro-Chousa *et al.* (2021) addressed the role of investor sentiment in this matter. With regards to energy efficiency financing, it has generally been expressed that energy efficiency financing is a challenge for countries due to the lack of capital. In particular, the shock of COVID-19 has harshly damaged the green financing. Rowan and Galanakis (2020) argued that COVID-19 pandemic reduced the capital in order to invest in green projects. In line with this argument, Vale *et al.* (2021) highlighted the serious challenge of green investment during and post-COVID period. They believe that in the post-COVID period, the governments will have to focus more on the issue of green investment which needs more attraction to absorb capital. As a pioneer study, Benjamin (1984) addressed the problem of energy efficiency financing and introduced share saving method to increase capital without initial investment with limited risk. Azhgaliyeva *et al.* (2012) expressed that green bonds can be proposed as an efficiency tool to help increase energy efficiency of countries. This financing tool can motivate private investors (Alonso-Conde and Rojo-Suarez, 2020) to bring their free capital to the market of green projects. In addition, the IDB (2017) has developed the Energy Efficiency Green Bond Program in Mexico to boost up financing mechanism for energy efficiency projects through the green bonds. The primary results of this program showed the success of using this financing tool to absorb adequate capital to the energy efficiency projects.

Considering the existing literature, we intend to explore how green bond can affect the energy efficiency in OECD countries to find out some policy implications for the post-COVID period. It is the exact literature gap that the paper wants to fill in.

3. Data and methodology

Developing energy efficiency projects through new financing tools such as green bonds is important for our global environment. Green bonds can make favorable circumstances for private investors who intent in projects with low risk and high rate of return. In other words, it can be expressed that the utility function of an investor for participation in green projects is related to the risk and rate of return of project (Yoshino *et al.*, 2019; Zhang *et al.*, 2021). In other words, the utility function of a potential investor for energy efficiency project can be written as follows:

$$U_t = U(r_t, \sigma_t) = r_t - \beta\sigma_t^2 + X_t \tag{1}$$

In the above utility function, r_t and σ_t denote the rate of return and the risk of an energy efficiency project, while β and X_t are the weight for the risk of the project and all the remaining factors (such as the COVID-19, political tension, financial openness, etc.) affecting the utility of investor at time t.

It is clear that the risk and rate of return are dependent on X_t which can have indirect effects on the two major important factors influencing the investor's decision to participate in an energy efficiency project. The challenge of COVID-19 boosts up the concerns of green projects meaning a larger β (a higher concern of investor about risk of project). However, the proposed tool of green bonds can make a lower risk of project for private investors (Markus and Adriana, 2018). If we assume that the private investor tries to make a dual-distribution on investments using bank deposit (α_t) with interest rate of r_t^D and investment in green bonds $(1-\alpha_t)$ with r_t^H as the rate of return of green bonds, then:

$$r_t = \alpha_t \cdot r_t^D + (1-\alpha_t) \cdot \; r_t^H \tag{2}$$

In Eq (2), r_t represents total risk of a private investor. Replacing Eq. (2) in the first equation generates Eq. (3) as follows:

$$U_t = U(r_t, \sigma_t) = \alpha_t \cdot r_t^D + (1-\alpha_t) \cdot \; r_t^H - \beta\sigma_t^2 + X_t \tag{3}$$

If we consider COVID-19 as an exogenous shock to an economy with X_t, a good regulation (such as monetary and fiscal policies to ensure the low risk of investment in bank deposit and green bonds) is an important factor (Aven, 2016) to maintain the utility of investor at a favorable level. The threat of CO_2 emissions is an acceleration point for governments to implement efficient monetary and fiscal policies to increase investments in green projects. Furthermore, COVID-19 has indirect impact of general level of price of commodities as addressed by some scholars such as Devpura (2021). Thus, it can be mentioned that the inflation rate generated by the consequences of the COVID-19 can be a major factor to determine the risk and utility of investor to participate in an energy efficiency project. Another indirect impact of the pandemic can be recognized on the urban population

(Sharifi and Khavarian-Garmsir, 2020; Ulloa *et al.*, 2021) in cities which are the major energy consumers. Hence, the urbanization growth rate impacted by the pandemic can be an influential factor in determining the risk of energy efficiency project and utility value of a private investor.

In this paper, to explore the relationship between green bond and energy efficiency for 37 members of OECD (see Appendix), we carry out a panel data estimation technique. Regarding dependent variable (energy efficiency), beside our theoretical approach of utility function of an investor, some scholars such as Sener and Karakas (2019) have addressed energy intensity (defined as total energy consumption to total GDP) as a proxy for energy efficiency. However, based on Quadrelli (2015), energy intensity cannot enough to show energy efficiency of a country. Thus, we use a simple average of energy efficiency indicators of households, industry, transport and services prepared by IEA (Energy Efficiency indicators database) to have a more comprehensive indicator for energy efficiency. Further, to select independent variables, we follow earlier studies such as (Thoumy and Vachon, 2012; Liu *et al.*, 2017; Jin and Yu, 2018; Bakirtas and Akpolat, 2018; Ng, 2018; Sener and Karakas, 2019; Yiran *et al.*, 2020; Tolliver *et al.*, 2020) where our econometric equations are structured as Eq. (4):

$$\mathrm{TEE}_{i,t} = \alpha_0 + \alpha_1 \mathrm{RQ}_{i,t} + \alpha_2 \mathrm{GB}_{i,t} + \alpha_3 \mathrm{INF}_{i,t} + \alpha_4 \mathrm{URB}_{i,t} + \alpha_2 \mathrm{CO}_{i,t} + \varepsilon_{it} \tag{4}$$

where TEE denotes energy efficiency indicator. RQ is regulatory quality based on regulatory quality index of the World Bank WGI, while GB, INF, URB and CO represent volume of issued green bond, inflation rate, urbanization and carbon dioxide emissions in country i at time t, respectively. The data for volume of green bonds are gathered from Climate Bonds Initiative, while other variables are collected from World Bank database (Quarterly Public Sector Debt (QPSD) database), BP statistical review of world energy 2020 and OECD database. All the quarterly data cover 2007–2020 based on the existence of data. Table 2 represents information about the variables of our model:

To ensure the reliability of empirical panel estimation results, some preliminary tests should be carried out. As the first test, we check whether there exists cross-sectional dependence through Breusch–Pagan LM test and Pesaran CD test. Next, we investigate stationarity among variables by performing a panel unit root test known as Cross-sectionally augmented IPS test (CIPS) using the following statistic (Eq. (5)):

$$\mathrm{CIPS}\ (N,\ T) = N^{-1} \sum_{i=1}^{N} t_i(N,\ T) \tag{5}$$

If the variables are first-difference stationary, we can test cointegration relationship between them. To the end, we use Westerlund (2007)'s four-panel cointegration test as follows (Eq. (6)–(9)):

Variable	Symbol	Unit
Energy efficiency index	TEE	Percent
Green bond	GB	US$
Inflation rate	INF	Percent
Regulatory quality index	RQ	2.5>RQ>−2.5
CO_2 emissions per capita	CO	Metric tones per capita
Urbanization	URB	Percent

Source(s): Authors

Table 2.
Information about variables of model

$$P_r = \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \tag{6}$$

$$P_\alpha = T\hat{\alpha} \tag{7}$$

$$G_r = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \tag{8}$$

$$G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \tag{9}$$

where $\hat{\alpha}_i$ shows the estimated value of the error correction parameter, while $SE(\hat{\alpha}_i)$ represents standard error of $\hat{\alpha}_i$. In addition, $\hat{\alpha}_i(1)$ denotes $1-\sum_{j=1}^{p_i}\hat{\alpha}_{ij}$. If the Westerlund's findings reveal the rejection of null hypotheses, it means that green bond and energy efficiency are cointegrated. To estimate the coefficients, we carry out a CUP-FM estimator (Bai and Kao, 2006) which considers cross-sectional dependence in panel data framework and does the estimation based on the long-run covariance matrix and loadings recursively. After running the panel estimation, the Dumitrescu and Hurlin (2012)'s panel causality test is considered to discover the direct of relationship between green bond and energy efficiency.

4. Empirical estimation results

As mentioned above, some preliminary tests are applied to find an appropriate estimation technique and ensure the reliability of empirical findings. Table 3 reports the results of cross-sectional dependence tests (i.e. Breusch–Pagan LM test and Pesaran CD test.). According to the results, we can reject the H0 (no cross-sectional dependence).

Due to the existence of cross-sectional dependence between series, it is necessary to apply a panel unit root test allowing for cross-sectional dependence. To this end, the CIPS test is carried out and its results are reported in Table 4.

In the next stage, the long-run relationship between variables is explored by performing the Westerlund (2007) panel cointegration test. The findings, as shown in Table 5, indicate the rejection of H0 meaning that there exists cointegration in our panel.

Due to the existence of cross-sectional dependence, the CUP-FM estimator proposed by Bai and Kao (2006) is employed to explore the coefficients of independent variables. The estimation results are reported in Table 6.

According to the estimated coefficients, shown in Tables 6 and 1% increase in regulatory quality index of OECD members raises the energy efficiency index by nearly 0.53%. A better quality of regulatory can make a better group of standards related to energy in countries and can solve the barriers to carry out energy efficiency projects leading to a higher energy efficiency level. This finding is in line with Wang *et al.* (2004), Kaller *et al.* (2018), Alam *et al.* (2019) and Apergis and Garcia (2019) who proved the positive impact of regulatory quality on energy efficiency. The issued green bond shows positive impact on energy efficiency index which highlights the significant role of green bonds on enhancement of financing energy efficiency projects in OECD countries. This is in line with the argument of Mclnerney and Bunn (2019) who emphasized the major role of green bonds

Breusch-Pagan LM test	Pesaran CD test
366.219 (0.00)	25.118 (0.00)

Source(s): Authors' compilation

Table 3. Cross-sectional dependence test

Variable	CIPS stat.
Energy efficiency	−1.382
D(energy efficiency)	−3.771
Regulatory quality Index	−2.013
D(Regulatory quality Index)	−5.684
Issued green bond	−2.058
D(Issued green bond)	−5.829
Inflation rate	−1.414
D(Inflation rate)	−3.181
Urbanization	−1.139
D(Urbanization)	−3.177
CO_2 emissions per capita	−2.039
D(CO_2 emissions per capita)	−5.593

Note(s): 1. *D* denotes the first difference of variable. 2. The critical values for variables are −2.10, −2.22, and −2.50 at 10%, 5% and 1% levels of significance
Source(s): Authors' compilation

Table 4.
CIPS unit root test

Tests	Statistics (*p*-values)
P_r	−10.505 (0.00)
P_α	−14.118 (0.00)
G_r	−3.491 (0.00)
G_α	−21.142 (0.00)

Source(s): Authors' compilation

Table 5.
Westerlund's panel cointegration test

Variable	Coefficient (*t*-stat)
Regulatory quality index	0.53 (8.747)
Issued green bond	0.95 (9.014)
Inflation rate	−0.18 (−8.400)
Urbanization	−0.03 (8.124)
CO_2 emissions per capita	0.24 (9.683)

Source(s): Authors' compilation

Table 6.
Empirical estimation results

on green projects which increase the participation of private investors (Tang and Zhang 2020) leading to a higher energy efficiency in countries. In contrast, Pineiro-Chousa *et al.* (2021) and Let *et al.* (2021) expressed that due to the inconsistent definitions and standards, the green bond markets are not efficient now and there is a dire need for making a unique standard, mechanism and definition for green bond markets. Thus, it cannot become an efficient instrument to enhance green projects now.

The inflation rate had negative and statistically significant coefficient meaning that 1% increase in general price of commodities decreases energy efficiency index by about 0.18%. It is widely believed that inflation in prices of commodities (or in energy) may lead to reduced energy consumption (e.g. see He *et al.*, 2016; Amin *et al.*, 2020) while also boosting up the cost of energy efficiency projects (labor wages, machinery *p* hire rate and materials prices increase) which requires a higher level of financing.

Regarding urbanization, it has a negative impact on energy efficiency declaring inappropriate urban energy policies (e.g. construction of infrastructure and urban dimension) and behavioral effects (e.g. inattentiveness to energy saving) in OECD members. The finding of negative impact of urbanization on energy efficiency is in line with Sheng *et al.* (2017) who reported this negative relationship for 78 countries over 1996–2012. Furthermore, Asarpota and Nadin (2020) found out a direct relationship between urban dimension and energy efficiency level which reveals the important role of urbanization growth rate to accelerate/postpone energy efficiency projects.

Finally, we found a positive relationship between CO_2 emissions per capita and energy efficiency meaning that 1% increase in carbon dioxide emissions per capita increases energy efficiency by approximately 0.24%. The main reason is that by increasing CO_2 emissions (air pollution), OECD members would try to issue various policies to boost energy efficiency to combat air pollution. This finding is in line with Flavio *et al.* (2020) who expressed that larger CO_2 emissions become a more significant motivation for governments to make policies to improve green and energy efficiency projects.

At the final stage, we investigated the causal direction between green bonds and energy efficiency by applying Dumitrescu and Hurlin (2012)'s panel causality test. The results are represented in Table 7.

The results of panel causality test revealed that there exists a uni-directional relationship running from green bond to energy efficiency highlighting the impact that a higher energy efficiency level in OECD does not make increase in issued green bonds in these countries. In line with Tu *et al.* (2020), the factors for the development of green bond market such as efficient legal framework should be addressed by countries. In line with Sartzetakis (2020), green bonds are generally considered as a temporary tool to boost green projects, while governments and central banks should determine green bonds as a permanent financing tool which is beneficial for private investors, households and our globe.

5. Robustness check

In order to check the robustness of our empirical results (Table 6) and validate our method of estimation, we repeat the estimation of coefficients of variables for a sub-sample of 25 OECD European countries that are mostly among the major green bonds issuers in 2020. The estimation process follows the exact same steps as those described in Section 3. The results, outlined in Table 8, confirm those obtained in the case of all OECD member countries, reflecting the validity and reliability of our empirical findings.

Null hypotheses	
Green bond does not homogeneously cause energy efficiency	Energy efficiency does not homogeneously cause green bond
2.707 (0.07)	0.303 (0.62)

Note(s): Numbers in () show *p*-values
Source(s): Authors' compilation

Table 7. Causality direction

Variable	Coefficient (*t*-stat)
Regulatory quality Index	0.23 (9.110)
Issued green bond	0.64 (9.319)
Inflation rate	−0.10 (−8.101)
Urbanization	−0.16 (8.694)
CO_2 emissions per capita	0.19 (9.069)

Source(s): Authors' compilation

Table 8. Robustness check

6. Conclusions and policy implications

The unpredictable impacts of COVID-19 on different economic aspects have made the future of global economy more unclear. Due to the threat of climate change and environmental pollution as well as the reduction of global economic size under the pandemic, the increase of energy efficiency financing and green financing are among the issues that have attracted the attention of scholars and policymakers. Governments are seeking for useful policies or tools in order to absorb capital into green and energy efficiency projects. The green bond tool provided by World Bank in the "Strategic Framework on Development and Climate Change" in 2008 is addressed as an appropriate way to accelerate the flow of capital into green projects.

From the backdrop of the aforementioned situation (lack of capital in green projects due to the pandemic, necessity to increase energy efficiency financing and tool of green bonds), this paper studied and measured the impact of the linkage between energy efficiency index and green bond in 37 OECD countries. By utilizing the quarterly data of variables (dependent and independent ones) over the period of 2007–2020, a significant cointegration linkage between the series was outlined by the Westerlund's panel cointegration test. In a similar insight, the CUP-FM estimator proposed by Bai and Kao (2006) opined that the impacts of independent variables on energy efficiency index of OECD were statistically significant with the impact of green bond observe to be positive and 0.95% meaning that 1% increase in issued green bonds would raise energy efficiency index of OECD by about 0.95%. Thus, it proves that the tool of green bond is a potential policy to drive-up energy efficiency in the panel countries thereby enhancing environmental quality during and post-COVID period. By carrying out the robust check of Dumitrescu and Hurlin (2012)'s panel causality test, uni-directional causality linkage from green bond to energy efficiency index is observed for the examined panel of countries. It can be concluded that green bond is a major tool that enjoys the capacity toward absorbing private investment and participation in energy efficiency financing in OECD. It leads to a higher level of energy efficiency and reducing greenhouse emissions in the environment. Note, however, there is no causal relationship from energy efficiency to the volume of issued green bonds in OECD countries which is highly recommended to be addressed by the policymakers in the investigated countries. A rational bi-directional relationship between these two variables may be established to strike a balance in issuing green bond and development of green bond markets in these countries. Additionally, empirical results suggested that urbanization has a negative impact on energy efficiency level. This point should be addressed by policymakers in OECD countries because growth in population living in urban should be followed by an appropriate energy infrastructure and culture of energy saving by households. Furthermore, as the results revealed the significant impact of regulatory quality index on energy efficiency level, the countries can draw attention to a better regulation framework in and post-COVID period to enhance energy efficiency leading to a better environment and climate. Development of some successful tools such as the CO_2 Performance Ladder in Netherland (Rietbergen *et al.*, 2017; Hossain *et al.*, 2021) is highly recommended for other countries for the post-COVID era. These tools can help non-industrial sector to have better energy efficiency and accelerate the progress of energy efficiency projects worldwide.

Although the indication from our paper recommends fruitful policies related to improvement of green bond markets to energy efficiency financing during and post-COVID period for OECD and other nations, it is clearly an adequate reason to future study the green financing in post-COVID by addressing the impacts of issued green bonds on energy transition by disaggregate or sector analysis. Moreover, consideration of other control variables such as the carbon tax and innovative green subsidies is highly suggested for further studies.

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Further reading

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Appendix

Table A1.
OECD countries

OECD countries
Austria, Australia, Belgium, Canada, Chile, Colombia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, The United States

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