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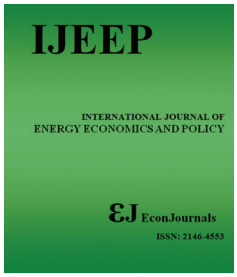

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Green Finance, Innovation, Agriculture Finance and Sustainable Economic Development: The Case of Indonesia's Provincial Carbon Emissions

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ABSTRACT

Indonesia is struggling with utmost pressure to restrict carbon emissions as it is included in those emerging economies who are recognized as highest carbon emitters. Nevertheless, the Indonesian government is showing remarkable effort to reduce the emissions and set a planned goal to achieve low carbon economy. However, the major reliance on fossil fuels to maintain economic growth is creating obstacles for country. To explore that what tools could be helpful in the scenario to support country's goal. The study intends to measure the role green finance, innovation, agriculture finance and sustainable economic development in gauging carbon intensity. The paper used two indicators to measure sustainable economic development; GDP per capita and renewable energy consumption. The panel data is used in the study which is extracted from 30 provinces of Indonesia in the time span of 2006-2020. The study used OLS fixed effect model and quantile regression technique to assess the relationship between explained variable and explanatory variables. Findings echo that with the increase in economic growth, carbon intensity also starts increasing. However, green finance, innovation, agriculture finance and renewable energy are significant tools to reduce the emissions. Furthermore, confirmation of findings was done through quantile regression analysis. The paper presents several implications as well on the basis of empirical evidence which are of great help for country.

Keywords: Green Finance, Innovation, Sustainable Economic Development, Renewable Energy Consumption, Economic Growth, Agriculture Finance
JEL Classifications: Q57, Q01, Q56, Q14, O31, O32, Q55

1. INTRODUCTION

In past few decades, climate changing effects are increasing the threat of well-beings. Factors such as GHG emissions, natural damage, pollution majorly contribute to environmental damage (Lan et al., 2022). As carbon emissions transmit greater environmental issues, thereby, it has become one of the important and leading discussion in contemporary times. Carbon emissions that are responsible for global warming and climate eclipse, thereby, concerns are raising to address these challenges especially in less established economies. To handle the awful situation, all of the economies are being confronted, as the increased global warming is due to major human operations on earth's surface that further leads to environmental destruction (Adebayo et al., 2022; Sadiq et al., 2022a). As it is predicted that situation will become worse with the passage of time, thereby economies individually

or collectively are working and findings effective way to address the issue and mitigate the growing emissions to some extent (Liu et al., 2022b; Sadiq et al., 2022b).

Osobajo et al. (2020) argued that economic growth is one of culprits as it causes disastrous effect on environment due to high trend emissions. Literature claims that economic practices that countries adopt in order to increase economic growth are responsible of high emissions. According to global prevailing expert, economic expansion relies on energy as it helps in increasing income generation and employment opportunities and accelerating productivity. Similarly, literature also suggest that there are two major factors that influence environmental greatly: energy use and economic growth. For instance, various studies established this argument that the main reason of environmental degradation is energy use and economic growth. There exist other studies as well which claims that non-renewable energy utilization increases carbon emissions which eventually challenges environmental quality. The proclamation is reinforced by various scholars as well in case of fossil fuel consumption, hence, articulating that GDP growth needs high energy consumption that leads to higher carbon emissions (Zhang et al., 2021). Similarly, Mercan and Karakaya (2015) also stated that carbon emissions are mostly churned out due to the consumption of energy that is being demanded for industries, transportation and households. Hence, it is quite clear that energy is an engine of any economy, and it beholds the power of high industrial production for achieving high economic growth. However, the grieving consequences due to the consumption of fossil fuel energy produces large amount of carbon emissions that has an adverse impact on environment (Sadiq et al., 2022c; Tan et al., 2021).

As stated earlier, the non-renewable energy consumptions have increased the growth of GHG emissions past few years. Fossil fuels can act as a powerful catalyst, thereby, treated as a crux of economic growth (Zhao et al., 2021). Scholars, therefore, gave join consensus that how climate change can be a threat to various facts such as environment, life and health. Carbon emissions in this regard are viewed as one of the main culprits of climate change because of this it is still considered a heated topic, hence, still in radar of researchers to address environmental disaster. It is predicted that GHG emissions will be doubled by 2035 from pre-industrial level if corrective measures are not taken timely (Farabi et al., 2019; Zhao et al., 2022). Ever since the evolutional phase of industries happened, the economies all around the globe have witnessed rapid growth. However, the growth does not come smooth, hence, piled up with various environmental issues such as global warming, sea-level rise that are mainly occurred due to economic development. These issues not only stick to environment but also leave this hanging threat on human heath while affecting social development. Developed economies in this regard, actively incorporated financial innovation in order to reduce environmental pollution and revealed the valuable experience and exposure which were helpful in the development of green financial systems. In this context, green finance concept has been emerged which increased the attention of scholars (Chen and Chen, 2021). By allocating financial resources rationally, green finance is aimed to provide guidance to industrial enterprises to utilize less energy without compromising on economic development but equally offers ecological benefits.

Many of the scholars also gave their consent that quality of environment can be enhanced when new economic policies and regulation are being implemented. However, there exists chances that it might hurt economic growth. Thereby, it is quite challenging to create a balance between them, which is only possible when emissions get reduced while making sure the availability of inexpensive energy resources (Jha and Bakhshi, 2019). Therefore, green finance offers sophisticated financial services, investment and funds that could integrate with environmental protections. Hence, it gives the edge to countries to fight against climate challenges. As environmental protection is a main driver of green finance and it involves environmentally friendly projects due to which injecting green finance in industrial sector is more favourable in comparison with renewable energy sector (Koomson and Danquah, 2021).

Furthermore, in recent times, academia witnessed this deepening effect of green financing and low carbon economy. The impact is greater and quite necessary to be observed for the betterment of environment. According to Aleksandrov et al. (2013), low carbon seems to be less problematic in the presence of green finance as it has been observed that it plays an important part in environmental quality. Scholars argued that green financing and low carbon emissions are closely related concepts. The reason is that it signifies the concept of environmental protection as a basic policy in financial sector, hence, all the financial decisions are being processed considering the environmental need (Lee, 2020). As it is already discussed that green finance and environmental destruction has been a talk of researchers, however, these one who already have done the digging suggested to explore the area further and add fresh evidences Therefore, role of green finance along with sustainable economic development in carbon emission is warranted to explore in detail to fill the existing gap.

Besides that, innovation is also considered an effective tool that helps to mitigate carbon challenges. It is an ability to provoke the thought process regarding any situation in novel ways with creative imaginations (Li et al., 2021). The creative skills unleash the subconsciousness due to which people are able to propose solution of complex situation in a surprising way. Scholars argued that creative economies look in to things from unique perspective. The reason being that when economies become creative that may find plausible solutions to address the challenges at broader level (Kubenka, 2020). As in recent times, when the world is facing chaotic situations such as popluation growth, industrialization, natural crisis, climate complexities, innovation is rather an effective way to address the challenges especially environmental one as it offers the solutions to get rid of polluting factors (Cerisola, 2019; Portolés & Šešić, 2017). As it is already discussed repeated times that technology usage, energy usage, production processess, all are the major contributor of harmfull emissions, thereby, in this tpyical scenario innovative skills are of best use to safeguard the environment. Hence, it is imperative to explore the role of innovation as well in reducing carbon emissions in Indonesian context.

The economy of Indonesia is mostly ruled by energy and agriculture sector. However, the sectors are known to be involved in dirty industrial activities. Commodities such as crude palm oil, electronic related equipment, rubber goods, oil and gas are most essential ones for Indonesian's export. If we look into the GDP growth, the export % of country is low in contrast with other developing economies. In 2019, the export was reached up to 206 US billion dollars (Kirikkaleli et al., 2021; Nasih et al., 2019). However, it is to be noted that all the emerging economic including Indonesia are putting great efforts to expand their economic growth, thereby, they are responsible for emitting higher percentage of emissions (Prastiyo and Hardyastuti, 2020). This implies that if these countries are witnessing remarkable economic growth, on the other hand they damaging the environment and if proper measures are not taken to make gain sustainability, the severe consequences the earth will face. The climate warning indeed pushed the country to set the goal regarding low-carbon economy. It is stated in literature that the country made a pact to reduce carbon emission up to 43% by 2020 and in parallel is expecting to increase its GDP growth up to 6% in next 25 years. However, if Indonesia slacks even in slightest manner, the dream of becoming low-carbon economy will be of no use. The present statistics shows that in order to maintain the economy, the country is dependent on fossil fuel (coal 59%, oil and gas 23% and electricity 6.2%). Simultaneously, the green energy the contribution of green energy is only 13% which is quite low (Kirikkaleli et al., 2021; Salman et al., 2019).

The aforementioned arguments in the light of justified evidences are enough to give the reason of further exploration as it will be helpful for policy makers to structure the policies which could help the country to reduce the carbon emissions. The study, thus, contributes to existing literature in several ways. Firstly, it purely focuses on Indonesia which is high carbon emitter, therefore, getting to know either green finance, innovation, agriculture finance and sustainable economic development are favourable for country's situation to reduce the emission. Since, the country is highly dependent of fossil fuel energy use, thereby, by taking renewable energy as a sustainable economic development indicator, the study, thus, adds fresh evidences that how renewable energy use could be helpful to for country to reduce the emissions and help country in maintain its economic growth.

The remaining part of the study is structured in 4 steps. The next step displays the synthesized literature related to chosen variables. It is necessary to do it because it helps in bridging the knowledge gap that what has done and what needs to be done, hence, highlighting the significance of study. Further, methodology part provides the glimpse of model construction and data resources. Empirical findings are then discussed and contrasted with prior studies in order to reveal that the results are consistent or contradicts the prior evidences. Finally, implications and limitation are discussed in last section which provides the concluding remarks.

2. LITERATURE REVIEW

2.1. Green Finance and Carbon Emissions

Difference from conventional financing method, green finance is normally called sustainable/environmental finance. The phenomenon emerged due to contradiction between energy consumption and green development in economic development process (Salazar, 1998). Green finance is a key driver as it helps economies to create balance between ecological environment and economic growth. With the constant development in the concept, scholars are able to propose three kinds of views regarding green finance. The first view is linked to the instrument level of financial application. This implies that it is viewed as an innovative financial tool offered by government and financial institutions in order to address the environmental problems. Through this tool various environmental issues can be resolved such as bringing improvement in environmental quality, decreasing pollution, extricating energy and equipping financial services for the sake of green development (Hamid et al., 2020). This view was proposed in early stage of green finance theory. Under this view, the researchers mainly emphasized on factors such as green insurance, green credit, green securities and green funds. Through these factors an indicator was developed for green finance development (Yu et al., 2022). The second viewed is tied to to-down strategic level. According to this view, green finance must show compliance with ESG standards (Ainou et al., 2022; Dyllick and Hockerts, 2002; Li et al., 2022; Khan and Ozturk, 2021). Moreover, it also should be integrated at governmental level in order to develop sustainable policies and modify financial services in order to green development (Umar et al., 2021). The last view is linked to bottom-up behavioural perspective. According to this view, when environmental protection laws are being improved and public awareness gets increased regarding environmental protection that's when economic growth enters in deep green phase. In this phase, green finance is transitioned by public and transfers capital flows towards green products and industries. This way, the whole financial system is transformed where green economy is being promoted (Umar et al., 2021).

Theoretically, it is proved that green finance helps in improving environmental quality via different measures but the question is whether green finance empirically as effective as it is proclaimed in Indonesian context in order to improve environmental quality? Thereby, it is necessary to assess the relationship and provides empirical evidences with fresh data set.

The synthesized literature also reveals that many of the scholars attempted to explain the phenomenon and formulated green finance framework. One set of literature expresses the current situation of green finance and focuses on the key similarities of climate finance and green finance. On the other hand, scarce literature shed light on finance and ecology (Agyekum et al., 2021). For example, Jinzhou (2011) stated green finance is a great path way to improve environmental quality. Cao et al. (2022) also stated green finance promotes innovation and increases technology investments. However, when it comes to green finance and its relationship with carbon emissions, it is still underexplored. Khan et al. (2022) evaluated green finance relationship with carbon emissions in the top 10 green finance economies. The scholars found green finance reduces carbon emissions and the impact varies in different quantiles. The variance occurred due market condition of different countries. Overcall, the study concluded that green finance is indeed an effective method to mitigate carbon emissions.

Guild (2020) also established the association of green finance with carbon emission in China context. The study discovered a significant association of green finance with carbon intensity. Zhang et al. (2022) also did some digging and investigated the role of green bond financing in carbon reduction, the results showed the significant relation, however, the study did not propose any policy for sustainable development. Wang et al. (2021) also added their contribution by providing a comprehensive view regarding the significance of green bond in the development of low-carbon society. The study offered some suggestions that are of equally important to achieve low carbon goal. The same suggestions were highlighted in the study of Zhong et al. (2022) which stressed that how much green bond is helpful in the promotion of environmental quality.

2.2. Innovation and Carbon Emissions

In present environment, organization are in continuous competition, hence, innovation is considered an essential part of business process. This helps economies to propagate big ideas, challenge the conventional ways and search innovative solution in the presence of plenty of opportunities. In this context, creative economies are fruitful to combat environmental issues as problem solving techniques, open mindedness and curiosity increase the horizon due to which they are able to think beyond (Ali et al., 2022; Bai et al., 2022). According to Mohsin et al. (2019), creative economies do not make themselves rely on conservative methods of production in a longer run. They are always in search of better ways, hence assess the old and current ways in continuous manner. This ability to think beyond helps them to address environmental challenges and in order to get rid of it, they find ways to improve the current process which are responsible of carbon emissions. Thereby, we can say that innovation is significant for environmental quality. As discussed, creative economies are efficient due to which they can handle the environmental issues by regularly regulating the tool which are culprits of climate complexities (Al-Ghazali and Afsar, 2021).

According to Ali et al. (2020), innovation can used as a significant tool to minimize carbon emissions and the authors explored the relationship in context of Malaysia. The authors covered the data from 1985 to 2016 and tested the relationship via ARDL method. The results of the study reveal the bidirectional causality between carbon emissions and technical innovation. Similarly, the study of Dauda et al. (2019) also explored the association by using CADF, FMOLS and DOLS techniques. The findings revealed the negative correlation between variable in G6 economies, however, it was opposite in case of MENA and BRCIS economies. According to Toebelmann and Wendler (2020), environmental innovation does not play significant role in carbon reduction in European countries in the timespan of 1992-2014. Similarly, the findings of Shaikh et al. (2018) also revealed the same results and found no significance between technological innovation and carbon emissions. The study of Yu and Du (2019) considered provincial data of China to check the association through STIRPAT. The analysis revealed that technological innovation increases carbon emissions.

To discuss it further, innovative economy possesses knowledge intensive properties and derives from individual talent and creativity, hence creating a positive and significant impact on building inclusive societies. Also, it appears to be critical to citizen's shared sense of cultural elements that helps in strengthening social cohesion (Chien, 2022a; Chien et al., 2022b). Discussing it with economic benefits, innovation plays a central role in sustainable development, hence, provides major contribution to SD agenda 2030 (Kamarudin et al., 2021; Khattak et al., 2021). In this regard, innovation offers an inclusive social development and motivates people to own their responsibilities as it promotes continuous progress and innovation towards sustainability (Liu et al., 2022a; Soini and Dessein, 2016). Discussing it further, creative initiatives and economic activity are somewhat paradoxical and mutually exclusive. It reflects on different approaches and policies that helps in gaining sustainability. Thereby, bridging the relationship of innovation and sustainable economic development is still an important view, even though it has overlooked by scholars (Streimikiene et al., 2019). The reason is adding more evidences provides a deeper insight which help policy makers to understand the background and extracts potential benefits of creative industries. Also, scholars admit that innovation is helpful in promoting inclusive social progress and sustainable growth.

2.3. Agriculture Finance and CO_2 Emissions

Scholars appreciated the significance of agriculture finance in order to mitigate carbon emissions. According to them, agriculture finance is linked to the provision of fund that is being used for agriculture-related activities. Financial institutions have the policy to facilitate farmers on flexible conditions and procedures so that the scope of agriculture can be expanded. Resultantly, agriculture financing could become a source of various positive outcomes such as protecting environment, increasing natural resources etc. Precisely, agriculture finance has the potential to help economies with limited resources. Along with it, it also guides future generation to stick with similar path, hence ensures sustainability in a longer run. Similarly, it is argued that in countries where individuals have easy access to finances and loans, they are capable enough to acquire quality seeds and advanced machineries to cultivate and harvest crops (Adegbite and Machethe, 2020; Paramati et al., 2018). This increases their productivity and make the agriculture growth consistent that ultimately leads to sustainability. The similar logic is also offered by Antwi-Agyei et al. (2018). According to authors, when farmers do not have funds scarcity due to easy access to loans, then they get enough time to think about environmental issue, hence adopting alternatives to reduce harmful emissions. For suppose, agriculture finance boots plantation which ultimately benefits environment by absorbing carbon emissions.

2.4. Economic Growth, Energy Consumption and CO_2 Emissions

Recently, various studies explored the association of energy consumption and economic growth with carbon emission. However, the exploration has been done in distinct ways, hence, creates an interesting debate (Aziz and Khan, 2022; Chien et al., 2022c; Chien, 2022d, Chishti et al., 2020). Scholars discuss that carbon intensity educates that how much carbon emissions are produced in one unit energy. The fact which cannot be denied that economic growth is dependent on energy-based sectors, hence, this

is not wrong to say that carbon intensity increases with the increase in economic growth. Prior studies explored the nexus among them and found some interesting insights. For example, Rahman et al. (2022) explored the relationship in developing economies covering the period from 1990 to 2018. By employing pool mean group technique, the results revealed in developing regions, carbon emissions are high due to significant economic growth. Study of Cheng et al. (2018) checked the relationship in European states, they found that relationship between constructs is heterogenous and asymmetric in nature. The results were also surprising as it was observed that economic growth helps in those regions to minimize carbon intensity where emissions were either medium or high. Vujović et al. (2018) also scrutinized the relationship and revealed the positive association. As the authors chose EU region, hence the results did show contradiction with Cheng study. Similarly, Li and Lin (2016) did the investigation in Chinese economy and found the negative relationship. The shreds of evidences revealed that energy intensity along with the impact of industrial development varied negatively in high growth trends. The study also shows that unclean energy provides benefit to carbon intensity, hence making the relationship with economic growth negative.

As economies are battling with higher emissions, they are putting great effort to find solutions and, in this regard, the economies consider renewable energy a viable solution. Scholars also attempted to find out potential benefit of renewable energy in the reduction of carbon emission (Chien et al., 2021; Haroon et al., 2021). For example, Rahman et al. (2022) explored the relationship in developing economies by using the data from 1990 to 2018 timespan. The evidences show that renewable energy helps these countries to reduce emission in a significant manner. Study of Zhang et al. (2022) conducted the study in top carbon emitter economies in order to find out that either the said energy can be of any help to reduce the emissions. The evidences show the remarkable significance in carbon reduction when renewable energy consumption has increased. Study conducted by Cheng and Yao (2021) checked the connection of these variable in Chinese economy. The results exhaled the negative association in long-run only. Whereas in short run, the variables did not show any connection. Shahzad et al. (2018) researched the similar context and revealed the renewable energy plays a major role in carbon reduction. Whereas the study of Waheed et al. (2018) which was conducted in Pakistani context showed the negative association between constructs in long and short both runs.

3. METHODOLOGY

The present study intends to examine the association of sustainable economic development, green finance, innovation and agriculture finance on carbon emissions in the context of Indonesian economy. Panel data was collected from 30 provinces of Indonesia. The paper used the data covering the period from 2006 to 2020 and it was extracted from WDI, EPS global statistical database, handbook of energy and economic statistics of Indonesia, statistical year book of Indonesia, Indonesian carbon emission database. The collected data was measured through various indicators such as carbon emissions are measured through carbon dioxide damages and is calculated by dividing emissions amount by GDP. Similarly, economic growth is measured through GDP per capita and renewable energy was measured through % of electricity produced from REW sources. Green finance is measured by green credit that is being provided by financial sector and innovation is measured through innovation index (0-100) and agriculture finance is measured by ration of agriculture loans to total loans. Furthermore, the simulation method is used in order to fill the missing values.

Following is the basic model of proposed framework in the form of linear.

$$CO_{2(i,t)} = f(GDP_{i,t}, REC_{i,t}, GF_{i,t}) \quad (1)$$

$$CO_{2(i,t)} = f(GDP_{i,t}, REC_{i,t}, INN_{i,t}) \quad (2)$$

$$CO_{2(i,t)} = f(GDP_{i,t}, REC_{i,t}, GF_{i,t}, AF_{i,t}) \quad (3)$$

$$CO_{2(i,t)} = f(GDP_{i,t}, REC_{i,t}, GF_{i,t}, INN_{i,t}, AF_{i,t}) \quad (4)$$

In above equations,

CO_2 represents carbon emissions which is the dependent variable of study. GDP is the GDP growth and REC represents renewable energy consumption. GF means green finance and INN represents innovation and AF means agriculture finance. Following equations are the empirical form of carbon emission function.

$$CO2_{i,t} = \alpha_{i,t} + \beta_1 GDP_{i,t} + \beta_2 REC_{i,t} + \beta_3 GF_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$CO2_{i,t} = \alpha_{i,t} + \beta_1 GDP_{i,t} + \beta_2 REC_{i,t} + \beta_3 INN_{i,t} + \varepsilon_{i,t} \quad (6)$$

$$CO2_{i,t} = \alpha_{i,t} + \beta_1 GDP_{i,t} + \beta_2 REC_{i,t} + \beta_3 AF_{i,t} + \varepsilon_{i,t} \quad (7)$$

$$CO2_{i,t} = \alpha_{i,t} + \beta_1 GDP_{i,t} + \beta_2 REC_{i,t} + \beta_3 GF_{i,t} + \beta_4 INN_{i,t} + \beta_5 AF_{i,t} \varepsilon_{i,t} \quad (8)$$

In order to avoid estimation issue, except carbon emission data, all variables' data has transformed in to natural log.

3.1. Estimation Strategy

The study used panel data which may contain unit root issues features. Thereby, initially, variables unit root properties were assessed through Levin-Chu (LLC) test that was proposed by Levin et al. (2002). Also, Harris-Tzavalis test was applied as well to assess the properties. Once we confirm variables integration properties, Kao cointegration method was employed in order to evaluate the long-run association. After that, when it is confirmed that no cointegration exists among constructs, pooled OLS method used with fixed effect technique. Quantile regression was also applied to assess that in which quantile variables have strong association.

3.2. GMM Technique (Generalized Method of Moments)

To scrutinize panel data regression, GMM technique was introduced by Hansen in the year 1982. It is argued that when no of moment conditions are larger or smaller then no of parameters, then HMM is appropriate. It is also argued that GMM is suitable in the case of endogenous variables. Along with it, GMM is also appropriate when there is a case of unobserved heterogeneity.

Prior literature indicates that scholars introduced GMM technique in order to make an estimation of panel data in such case where estimators are inconsistent across huge cross-sections and infinite time period (Ganda, 2019). Thereby, present study checked hypothesis with the help of GMM.

3.3. Panel Quantile Regression

The type of regression is used in the study in order examine the impact of chosen IVs on carbon emissions. It is necessary to evaluate the association in different quantiles. The major benefit of this method is that there is no requirement for normality of economic sequences in OLS. Along with it, extreme values impact can be measured through quantile regression which is not possible in OLS method. Following is the mathematical representation of quantile regression:

$$y_i = x_i^{'}\beta_\theta + \mu_{\theta i}, 0 < \theta < 1 \quad (9)$$

x represents vector of IV, explained variable is represented by y, theta is a quantile point, μ is the term of random distribution and β is parameter vector.

$$\min \sum_{y_i \geq x_i^{'}\beta} \theta \mid y_i - x_i^{'}\beta \mid + \sum_{y_i < x_i^{'}\beta} (1-0 \mid y_i - x_i^{'}\beta \mid) \quad (10)$$

Quantile regression also helps researchers to understand the association of variables beyond the means of data. It means that non normally distributed outcomes can also be understood via said method. It also helps to address the depression of data. Finally, robustness is done to explore the determinants of carbon emissions.

4. FINDINGS AND DISCUSSION

4.1. Descriptives

Table 1 dictates the descriptives of chosen constructs, hence showing the data normality. From table, it can be observed that highest mean value is of carbon emission whereas lowest average value is of innovation. From the data, it can also be seen that carbon emissions are most volatile and is opposite in case of economic growth.

4.2. Unit Root Test

As discussed, stationarity of data is essential in order to have proper analysis. Thereby, two type of unit root tests are used; LLC and Harris-Tzavalis. Results of unit root can be seen in Table 2. In LLC test, CO_2, REC and GF show stationarity at a level but EG and INN do not show stationarity. In first difference, however, all constructs show stationarity. Same results can be seen in later test as well.

4.3. Cointegration Test

As unit root test assured the stationarity, thereby, it is imperative to use cointegration method to scrutinize the integration between constructs. Five tests were considered which can be seen in Table 3. Table 3 illustrates that all constructs are significant at 1% in all test and models. This perpetuates that unit root null test is rejected which confirms that that unit root does not exist in data.

4.4. Long-Run Analysis

Table 4 illustrates long run-analysis results of 3 models which are being extracted through pooled OLS with fixed effect. Model 1 results indicate that GDP is positive at 10% significance and the coefficient value which is 0.841 shows that 1% of GDP varies carbon emissions with 0.841%. The findings are confined with Rahman et al. (2022) and other various studies. As literature review articulates that economic growth is highly dependent on energy development sectors that includes transportation too. In Indonesia, these sectors rely on fossil fuels to produce electricity which is to be used for energy usage. But the consumption of non-renewable sources increases the carbon emission trends. The results of present study echo that renewable energy consumption share negative connection with carbon emissions as the coefficient of REC is negative at 5%. This implicates that REC is a suitable resource of a country that helps in reduction of carbon emissions as from values it can be observed that the 1% increase of REC is responsible to decrease carbon intensity by 0.008%. The findings are similar to the evidences of Waheed et al. (2018) study. This negative trend can be explained in Indonesian context in such a way that government of Indonesia is already exerting great effort to bring diversification in economy by considering other sectors too and also making sure to increase the usage of renewable energy. Because of this, % of non-renewable consumption is comparatively lower now in energy mix. Thereby, overall reduction of carbon can be seen due to energy usage. The relationship of green finance and carbon emissions also appears to be negative at 10% significance level. As the beta coefficient is -0.103%, hence it indicates that 1% increase in green finance reduces carbon emissions by 0.103%. The result coincides with prior studies which dictate that green finance offers sophisticated financial services, investment and funds that could integrate with environmental protections. Hence, it gives the edge to countries to fight against climate challenges. As environmental protection is a main driver of green finance and it involves environmentally friendly projects due to which injecting green finance in industrial sector is more favourable in comparison with renewable energy sector (Hao et al., 2021; Saeed et al., 2021; Sandberg et al., 2019).

Model 2, which is an extension of model 1 due to the addition of innovation in the basic model which is based on REC and GDP. The model again shows GDP shares positive connection with

Table 1: Descriptives

Variables	Obs	Avg.value	SD	Minimum	Maximum
CO_2	359	182.109	1193.34	−5782.0	2478.0
GDP	359	9.123	1.086	7.109	11.154
REC	359	8.877	20.455	−3.121	76.146
GF	359	5.311	2.319	0.589	9.532
INN	359	2.643	1.877	−3.609	4.635
AF	359	3.512	4.127	2.019	5.764

Table 2: Panel root analysis

Variables	LLC test		Harris-Tzavalis test	
	Level	1st difference	Level	1st difference
CO_2	−5.743***	−8.5611***	−6.534***	−27.675***
GDP	−0.478	−3.564***	−1.578**	−29.456***
REC	−5.863***	−0.645*	−1.388*	−21.342***
GF	−1.897**	3.678*	3.789	−25.879***
INN	0.345	1.931**	0.906***	4.667***
AF	0.543	1.785**	0.798***	25.754***

Table 3: Cointegration test

Tests	Model 1		Model 2		Model 3		Model 4	
	t-stat	P-value	t-stat	P-value	t-stat	P-value	t-stat	P-value
Modified Dicky Fuller	−4.783***	0.00	−6.534***	0.00	−4.522***	0.00	−4.132***	0.00
Dicky- Fuller	−6.138***	0.00	−7.478***	0.00	−8.758***	0.00	−7.618***	0.00
Augmented Dickey Fuller	−3.853***	0.00	−4.878***	0.00	−4.904***	0.00	−3.604***	0.00
Unadjusted modified Dicky-fuller	−9.767***	0.00	6.969***	0.00	−6.856***	0.00	−7.876***	0.00
Unadjusted Dickey Fuller	−5.575***	0.00	9.226***	0.00	−9.015***	0.00	−8.011***	0.00

carbon emissions as its coefficient is positive at 10% significance level. This indicates that 1% increase in GDP brings increase of 0.886% in carbon emissions. Similarly, REC coefficient is again negative in this model as well at 10% significance level, hence, showing that 1% increase in REC reduces the carbon emissions by 0.137%. This means that the association between constructs is negative and significant. Now coming towards innovation, the coefficient value appears to be negative at 1%, hence implying that the relation is negative and significant in case of innovation and carbon emission. It means 1% increase in innovation declines carbon emissions by 0.164%. The results are consistent with Dauda et al. (2019), which also claimed the similar evidences.

Now talking about Model 4 which is also an extended version of model 1 by adding GF and INN. Findings show that GDP and carbon emissions in this case are negatively correlated at 10% significance level. But the magnitude is negligible in comparison with previous two models. As it can be seen in Table 4 that beta coefficient is 0.468, hence dictating that when GDP increases by 1%, the emissions increase by 0.468%. In case of REC, the relationship appears to be positive in this model, hence contradicts prior literature. This implies that when REC increases by 1% it increases the carbon emission in a longer run. As far as GF is concerned, the relationship is negative at 5% significance. It shows that carbon emissions get reduced by 0.556% when there is a 1% increase in green finance. INN also appears to share negative and significant relationship with carbon emissions in this model. It indicates carbon emissions reduces by 0.165% when INN increases by 1%. The results show compliance with Shaikh et al. (2018) study which asserts that innovation is essential to reduce carbon emissions as it improves environmental quality.

4.5. Quantile Regression

To offer more robust estimation, the study used quantile regression. Results can be seen in Table 5. Model 1 illustrates that GDP and carbon emissions are positively correlated at 5% significance. This implies carbon emissions are increased by 1.574% when there GDP increases by 1%. Surprisingly, REC coefficient is insignificant which shows no connection between them. This means renewable energy does not affect carbon emissions. The results contradict prior literature (Budzianowski, 2012; Zheng et al., 2021). The logical explanation for this evidence can be justified by stating that Indonesia is highly dependent on fossil fuel, hence for them renewable energy resources are irrelevant. In green finance case, the relationship is negative and significant at 5%. This indicates that when there is a 1% increase of GF, it reduces emissions by 0.060%. Model 2 also shows that positive and significant relationship of GDP with carbon emissions. However, again in this model REC and CO_2 are insignificant to each other. As innovation is added

Table 4: Long-run analysis

IVs	Model 1	Model 2	Model 3	Model 4
	β-coeff	β-coeff	β-coeff	β-coeff
GDP	0.841*	0.886*	0.569**	0.468**
REC	−0.008**	−0.137*	0.233*	0.833*
GF	−0.103*			−0.556**
INN		−0.164***		−0.165**
AF			−0.156**	−0.248**

DV: CO_2

Table 5: Quantile regression (fixed effect)

IVs	Model 1	Model 2	Model 3	Model 4
	β-coeff	β-coeff	β-coeff	β-coeff
GDP	1.574**	0.033**	0.013**	0.957**
REC	0.122	0.103	0.203	−0.420*
GF	−0.060**			−0.273**
INN		−0.893***		−1.384***
AF			−0.293***	−1.321**

DV: CO_2

in second model, it shows that INN is negatively correlated with carbon emissions at 1% significance level. Finally, the last model shows that GDP and carbon emission are positively correlated at 5%, means, 1% increase in GDP has the potential to increase CO_2 by 0.957%. Model 4 shows REC is negatively associated with CO_2 at 10%. Revealing this fact that REC when increases 1%, reduces CO_2 by 0.420%. Similar results are in case of green finance which indicates that when green finance increase 1%, it reduces carbon by 0.273%. Finally, INN and CO_2 are also negatively associated at 1%.

Result of Quantile regression at each quantile are illustrated in Table 6. From Table, it is quite obvious that GDP shows significance with CO_2 from Q50 to Q90. But the strongest impact can be observed in 50th quantiles at 1% significance, where coefficient value is 0.802%. Same is the case with renewable energy consumption, it gets significance from Q50 to Q90 and strongest impact can be seen in 90th quantile at 10%. Hence, we can conclude that renewable energy starts showing impact on CO_2 when reach to certain limit but it is also to be noted the strength of relationship of REC with CO_2 in these quantiles is quite low due to 10% significance. In case of green finance, it shows significance through all quantiles and the strongest impact can be observed in 75th quantile. Lastly, in case of innovation, the significance can be seen from Q25 to Q90. The high magnitude in innovation case can be observed in Q75 which is significant at 5%. The results show that high economic growth is tied to high carbon emissions, however the emissions can be controlled via green finance, innovation and renewable energy without interrupting the growth trend of economy.

Table 6: Quantile regression (each quantile)

IVs	Q10	Q25	Q50	Q75	Q90
GDP	0.071	1.152	0.802***	0.783**	0.799***
REC	0.301	0.137	−0.119*	−0.642*	−0.834*
GF	−0.643**	−0.568**	−0.750**	−0.870**	−0.440***
INN	−0.546	0.152*	−0.284*	−0.743**	−1.137***
AF	−0.146**	0.262*	−0.384**	−0.623**	−1.236***

DV: CO_2

Table 7: Robustness check with difference GMM and FGLS estimates

Variables	DGMM FGLS	
	Coefficient	Coefficient
GDP	1.633**	0.691***
REC	−1.097*	0.013
GF	−0.650*	−0.409*
INN	−0.273***	−0.327***
AF	−0.183***	−0.414***
Constant	–	0.874
Observation	359	359
f-stat	19.43	79.03
No of instruments	292	-
AR (1) Autocorrelation	0.091	No
AR (2)/Panels	0.121	Homoscedastic

We used difference GMM, approach with forwarding differenced instrument variables in empirical modelling. AR1 and AR2 are P-values for Arellano-Bond test for first order-serial auto-correlation and Arellano-bond test for second-order serial autocorrelation

4.6. Robustness Test

As discussed earlier, robustness test was conducted to gain confirmation of study's main findings. This was done through two tests namely DGMM and FGLS. In Table 7, we can see the findings of robustness tests. The values of DGMM test validate the empirical findings of our study. It is quite obvious that GDP is positive in this case where as all the remaining coefficients are negative which is expected already. In FGLS case, GDP, green finance and innovation all syncs with OLS estimations, however, results are difference in renewable energy. This implies the insignificant association of REC with carbon intensity. The findings of robustness indicate that there is no existence of autocorrelation issue and heterogeneity in proposed models. Thereby, errors terms are not correlated with instruments.

5. CONCLUSION

The prime purpose of the study is to explore the impact of sustainable economic development, green finance and innovation on carbon emission in Indonesian economy by using the provincial data from 2006 to 2020. As we can see that findings gauged from OLS regression indicate that while GDP is a culprit as it enhances carbon emission, however, renewable energy consumption, green finance and innovation are effective tools to reduce the intensity of carbon. Results of quantile regression also throw the suggestion that GDP which is an indicator of economic growth is responsible for high emission in case on Indonesia. However, with the evidences it is proved that renewable energy consumption, green finance and innovation appears to be perfect solution for Indonesia as it helps country to mitigate carbon challenges.

In the light of findings, the study is able to offer few implications that helpful for Indonesia. First, it sis advised that government institutions must motivate private industries to make greater investments in renewable energy resources. Practitioners are also advised to introduce green finance related strategies such as carbon-trading or green bonding to help country to achieve low-carbon economy. As in quantile regression, renewable energy did not show any significance with CO_2, thereby, it is suggested that government institutions offer capital subsidies on REC in order increase renewable consumption so that the country won't show much reliance on fossil fuels (Özcan and Yıldırım, 2018). Indonesia can also encourage the use of renewable energy via Feed in tariff. As the strategy provides greater output in lower price. Findings also back up this fact that effective green concepts when articulate in financial policies and agricultural policies, it helps in the removal of negative impact of economic activities that are causing severe harm to environment. Also, if personnel are innovative enough to propose creative ideas and solutions, it provides the meaningful contribution to handle the environment-related challenges.

Although the study spills greater theoretical and empirical significance, it still possesses few limitations which are needed to be considered by future researchers of the very same area. Firstly, the study chose green finance, agriculture finance, innovation, renewable energy consumption and economic growth to evaluate the combined effect of these factors on carbon emission. There indeed exists plentiful constructs such as green growth which are an effective tool to mitigate emissions. Also, besides carbon, methane is another deadly emission as literature claims, hence, it is suggested to explore these factors in order to increase the generalizability of study. Along with it, the study explored the outlined constructs in Indonesian context only, result may vary country to country, thus, encourage scholars to choose group of countries with extended time period in order to gain interesting and fruitful evidences.

REFERENCES

Adebayo, T.S., Oladipupo, S.D., Adeshola, I., Rjoub, H. (2022), Wavelet analysis of impact of renewable energy consumption and technological innovation on CO_2 emissions: Evidence from Portugal. Environmental Science and Pollution Research, 29(16), 23887-23904.

Adegbite, O.O., Machethe, C.L. (2020), Bridging the financial inclusion gender gap in smallholder agriculture in Nigeria: An untapped potential for sustainable development. World Development, 127, 104755.

Agyekum, E.B., Amjad, F., Mohsin, M., Ansah, M.N.S. (2021), A bird's eye view of Ghana's renewable energy sector environment: A multi-criteria decision-making approach. Utilities Policy, 70, 101219.

Ainou, F.Z., Ali, M., Sadiq, M. (2022), Green energy security assessment in Morocco: Green finance as a step toward sustainable energy transition. Environmental Science and Pollution Research, https://doi.org/10.1007/s11356-022-19153-7

Aleksandrov, N., Espinoza, R., Gyurkó, L. (2013), Optimal oil production and the world supply of oil. Journal of Economic Dynamics and Control, 37(7), 1248-1263.

Al-Ghazali, B.M., Afsar, B. (2021), Retracted: Green human resource management and employees' green creativity: The roles of green behavioral intention and individual green values. Corporate Social Responsibility and Environmental Management, 28(1), 536-536.

Ali, M., Ibrahim, M.H., Shah, M.E. (2022), Impact of non-intermediation activities of banks on economic growth and volatility: An evidence from OIC. The Singapore Economic Review, 67(1), 333-348.

Ali, W., Rahman, I.U., Zahid, M., Khan, M.A., Kumail, T. (2020), Do technology and structural changes favour environment in Malaysia: An ARDL-based evidence for environmental Kuznets curve. Environment Development and Sustainability, 22(8), 7927-7950.

Antwi-Agyei, P., Dougill, A.J., Agyekum, T.P., Stringer, L.C. (2018). Alignment between nationally determined contributions and the sustainable development goals for West Africa. Climate Policy, 18(10), 1296-1312.

Aziz, G., Khan, M.S. (2022), Empirical relationship between creativity and carbon intensity: A case of Saudi Arabia. Frontiers in Environmental Science, 145, 1-9.

Bai, X., Wang, K.T., Tran, T.K., Sadiq, M., Trung, L.M., Khudoykulov, K. (2022), Measuring China's green economic recovery and energy environment sustainability: Econometric analysis of sustainable development goals. Economic Analysis and Policy, 75, 768-779.

Budzianowski, W.M. (2012), Negative carbon intensity of renewable energy technologies involving biomass or carbon dioxide as inputs. Renewable and Sustainable Energy Reviews, 16(9), 6507-6521.

Cao, L. (2022), How green finance reduces CO_2 emissions for green economic recovery: Empirical evidence from E7 economies. Environmental Science and Pollution Research, 1-14. https://doi.org/10.1007/s11356-022-22365-6

Cerisola, S. (2019), A new perspective on the cultural heritage-development nexus: The role of creativity. Journal of Cultural Economics, 43(1), 21-56.

Cheng, Y., Zhang, N., Wang, Y., Yang, J., Kang, C., & Xia, Q. (2018). Modeling carbon emission flow in multiple energy systems. IEEE Transactions on Smart Grid, 10(4), 3562-3574.

Chen, X., Chen, Z. (2021), Can green finance development reduce carbon emissions? Empirical evidence from 30 Chinese provinces. Sustainability, 13(21), 12137.

Cheng, Y., Yao, X. (2021), Carbon intensity reduction assessment of renewable energy technology innovation in China: A panel data model with cross-section dependence and slope heterogeneity. Renewable and Sustainable Energy Reviews, 135, 110157.

Chien, F. (2022a), How renewable energy and non-renewable energy affect environmental excellence in N-11 economies? Renewable Energy, 196. 526-534.

Chien, F. (2022d), The mediating role of energy efficiency on the relationship between sharing economy benefits and sustainable development goals (Case of China). Journal of Innovation and Knowledge, https://doi.org/10.1016/j.jik.2022.100270

Chien, F., Chau, K.Y., Sadiq, M., Hsu, C.C. (2022c), The impact of economic and non-economic determinants on the natural resources commodity prices volatility in China. Resources Policy, 78, 102863.

Chien, F., Hsu, C.C., Sibghatullah, A., Hieu, V.M., Phan, T.T.H., Tien, N.H. (2021), The role of technological innovation and cleaner energy towards the environment in ASEAN countries: Proposing a policy for sustainable development goals. Economic Research Ekonomska Istraživanja, https://doi.org/10.1080/1331677X.2021.2016463

Chien, F., Zhang, Y., Sharif, A., Sadiq, M., Hieu, M.V. (2022b), Does air pollution affect the tourism industry in the USA? Evidence from the quantile autoregressive distributed lagged approach. Tourism Economics, https://doi.org/10.1177/13548166221097021

Chishti, M.Z., Ullah, S., Ozturk, I., Usman, A. (2020), Examining the asymmetric effects of globalization and tourism on pollution emissions in South Asia. Environmental Science and Pollution Research, 27(22), 27721-27737.

Dauda, L., Long, X., Mensah, C.N., Salman, M. (2019), The effects of economic growth and innovation on CO_2 emissions in different regions. Environmental Science and Pollution Research, 26(15), 15028-15038.

Dyllick, T., Hockerts, K. (2002), Beyond the business case for corporate sustainability. Business Strategy and the Environment, 11(2), 130-141.

Farabi, A., Abdullah, A., Setianto, R.H. (2019), Energy consumption, carbon emissions and economic growth in Indonesia and Malaysia, 9(3), 338-345.

Ganda, F. (2019), The impact of innovation and technology investments on carbon emissions in selected organisation for economic Co-operation and development countries. Journal of Cleaner Production, 217, 469-483.

Hamid, B.A., Azmi, W., Ali, M. (2020), Bank risk and financial development: Evidence from dual banking countries. Emerging Markets Finance and Trade, 56(2), 286-304.

Haroon, O., Ali, M., Khan, A., Khattak, M.A., Rizvi, S.A.R. (2021), Financial market risks during the COVID-19 Pandemic. Emerging Markets Finance and Trade, 57(8), 2407-2414.

Jha, B., Bakhshi, P. (2019), Green finance: Fostering sustainable development in India. International Journal of Recent Technology and Engineering, 8, 3798-3801.

Jinzhou, W. (2011), Discussion on the relationship between green technological innovation and system innovation. Energy Procedia, 5, 2352-2357.

Kamarudin, F., Anwar, N.A.M., Chien, F., Sadiq, M. (2021), Efficiency of microfinance institutions and economic freedom nexus: Empirical evidence from four selected ASIAN countries. Transformations in Business and Economics, 20(2b), 845-868.

Khan, M., Ozturk, I. (2021), Examining the direct and indirect effects of financial development on CO_2 emissions for 88 developing countries. Journal of Environmental Management, 293, 112812.

Khan, M.A., Riaz, H., Ahmed, M., Saeed, A. (2022), Does green finance really deliver what is expected? An empirical perspective. Borsa Istanbul Review, 22(3), 586-593.

Khattak, M.A., Ali, M., Rizvi, S.A.R. (2021), Predicting the European stock market during COVID-19: A machine learning approach. MethodsX, 8, 101198.

Kirikkaleli, D., Adebayo, T.S., Khan, Z., Ali, S. (2021), Does globalization matter for ecological footprint in Turkey? Evidence from dual adjustment approach. Environmental Science and Pollution Research, 28(11), 14009-14017.

Kirikkaleli, D., Shah, M.I., Adebayo, T.S., Altuntaş, M. (2022), Does political risk spur environmental issues in China? Environmental Science and Pollution Research, 29(3), 1-11.

Koomson, I., Danquah, M. (2021), Financial inclusion and energy poverty: Empirical evidence from Ghana. Energy Economics, 94, 105085.

Kubenka, M. (2020), The evaluation of methodology influence on the wacc value: The case of the czech republic. Transformations in Business and Economics, 19(3), 274-290.

Lan, J., Khan, S.U., Sadiq, M., Chien, F., Baloch, Z.A. (2022), Evaluating energy poverty and its effects using multi-dimensional based DEA-like mathematical composite indicator approach: Findings from Asia. Energy Policy, 165, 112933.

Lee, J.W. (2020), Green finance and sustainable development goals: The case of China. Journal of Asian Finance Economics and Business, 7(7), 577-586.

Levin, A., Lin, C.F., Chu, C.S.J. (2002), Unit root tests in panel data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1-24.

Li, K., Lin, B. (2016), China's strategy for carbon intensity mitigation pledge for 2020: Evidence from a threshold cointegration model combined with Monte-Carlo simulation methods. Journal of Cleaner Production, 118, 37-47.

Li, P., Zhang, Z.S., Zhang, Y., Zhang, J., Nunez, M., Shi, J. (2021), From implicit theories to creative achievements: The mediating role of creativity motivation in the relationship between stereotypes, growth mindset, and creative achievement. The Journal of Creative Behavior, 55(1), 199-214.

Li, X., Ozturk, I., Syed, Q.R., Hafeez, M., Sohail, S. (2022), Does green environmental policy promote renewable energy consumption in BRICST? Fresh insights from panel quantile regression. Economic Research-Ekonomska Istraživanja, 35, 1-17.

Liu, Z., Lan, J., Chien, F., Sadiq, M., Nawaz, M.A. (2022b), Role of tourism development in environmental degradation: A step towards emission reduction. Journal of Environmental Management, 303, 114078.

Liu, Z., Yin, T., Putra, A.R.S., Sadiq, M. (2022a), Public spending as a new determinate of sustainable development goal and green economic recovery: Policy perspective analysis in the Post-Covid ERA. Climate Change Economics, 2, 22400073.

Mercan, M., Karakaya, E. (2015), Energy consumption, economic growth and carbon emission: Dynamic panel cointegration analysis for selected OECD countries. Procedia Economics and Finance, 23, 587-592.

Mohsin, M., Abbas, Q., Zhang, J., Ikram, M., Iqbal, N. (2019), Integrated effect of energy consumption, economic development, and population growth on CO_2 based environmental degradation: A case of transport sector. Environmental Science and Pollution Research, 26(32), 32824-32835.

Nasih, M., Harymawan, I., Paramitasari, Y.I., Handayani, A. (2019), Carbon emissions, firm size, and corporate governance structure: Evidence from the mining and agricultural industries in Indonesia. Sustainability, 11(9), 2483.

Osobajo, O.A., Otitoju, A., Otitoju, M.A., Oke, A. (2020), The impact of energy consumption and economic growth on carbon dioxide emissions. Sustainability, 12(19), 7965.

Özcan, M., Yildirim, M. (2018), The impact of capital subsidy incentive on renewable energy deployment in long-term power generation expansion planning. Sakarya University Journal of Computer and Information Sciences, 1(3), 1-19.

Paramati, S.R., Apergis, N., Ummalla, M. (2018), Dynamics of renewable energy consumption and economic activities across the agriculture, industry, and service sectors: evidence in the perspective of sustainable development. Environmental Science and Pollution Research, 25(2), 1375-1387.

Prastiyo, S.E., Hardyastuti, S. (2020), How agriculture, manufacture, and urbanization induced carbon emission? The case of Indonesia. Environmental Science and Pollution Research, 27(33), 42092-42103.

Rahman, M.M., Sultana, N., Velayutham, E. (2022), Renewable energy, energy intensity and carbon reduction: Experience of large emerging economies. Renewable Energy, 184, 252-265.

Sadiq, M., Amayri, M.A., Paramaiah, C., Mai, N.H., Ngo, T.Q., Phan, T.T.H. (2022b), How green finance and financial development promote green economic growth: Deployment of clean energy sources in South Asia. Environmental Science and Pollution Research, 29(43), 65521-65534.

Sadiq, M., Ngo, T.Q., Pantamee, A.A., Khudoykulov, K., Ngan, T.T., Tan, L.L. (2022a), The role of environmental social and governance in achieving sustainable development goals: evidence from ASEAN countries. Economic Research Ekonomska Istraživanja, https://doi.org/10.1080/1331677X.2022.2072357.

Sadiq, M., Ou, J.P., Duong, K.D., Van, L., Ngo, T.Q., Bui, T.X. (2022c), The influence of economic factors on the sustainable energy consumption: Evidence from China. Economic Research-Ekonomska Istraživanja, https://doi.org/10.1080/1331677X.2022.2093244

Salazar, J. (1998), Environmental finance: Linking two world. In: A Workshop on Financial Innovations for Biodiversity Bratislava. Vol. 1. . p.2-18.

Salman, M., Long, X., Dauda, L., Mensah, C.N. (2019), The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. Journal of Cleaner Production, 241, 118331.

Shahzad, U., Sarwar, S., Amin, W., Qamar-uz-Zaman. (2018), The relationships among economic growth, renewable energy consumption, CO_2 emissions and agriculture production: empirical evidence for China and India. Global and Local Economic Review, 22(1), 41-68.

Shaikh, S.A., Taiyyeba, Z., Khan, K. (2018), The nexus between technological innovation and carbon dioxide emissions: Evidence from China. NICE Research Journal, 11(2), 181-193.

Soini, K., Dessein, J. (2016), Culture-sustainability relation: Towards a conceptual framework. Sustainability, 8(2), 167.

Streimikiene, D., Mikalauskiene, A., Kiausiene, I. (2019), The impact of value created by culture on approaching the sustainable development goals: Case of the Baltic States. Sustainability, 11(22), 6437.

Tan, L.P., Sadiq, M., Aldeehani, T.M., Ehsanullah, S., Mutira, P., Vu, H.M. (2021), How COVID-19 induced panic on stock price and green finance markets: Global economic recovery nexus from volatility dynamics. Environmental Science and Pollution Research, https://doi.org/10.1007/s11356-021-17774-y

Toebelmann, D., Wendler, T. (2020), The impact of environmental innovation on carbon dioxide emissions. Journal of Cleaner Production, 244, 118787.

Umar, M., Ji, X., Mirza, N., Naqvi, B. (2021), Carbon neutrality, bank lending, and credit risk: Evidence from the Eurozone. Journal of Environmental Management, 296, 113156.

Vujović, T., Petković, Z., Pavlović, M., Jović, S. (2018), Economic growth based in carbon dioxide emission intensity. Physica A Statistical Mechanics and its Applications, 506, 179-185.

Waheed, R., Chang, D., Sarwar, S., Chen, W. (2018), Forest, agriculture, renewable energy, and CO_2 emission. Journal of Cleaner Production, 172, 4231-4238.

Wang, X., Huang, J., Xiang, Z., Huang, J. (2021), Nexus between green finance, energy efficiency, and carbon emission: Covid-19 implications from BRICS countries. Frontiers in Energy Research, https://doi.org/10.3389/fenrg.2021.786659

Yu, B., Li, C., Mirza, N., Umar, M. (2022), Forecasting credit ratings of decarbonized firms: Comparative assessment of machine learning models. Technological Forecasting and Social Change, 174, 121255.

Yu, Y., Du, Y. (2019), Impact of technological innovation on CO_2 emissions and emissions trend prediction on "New Normal"economy in China. Atmospheric Pollution Research, 10(1), 152-161.

Zhang, A., Wang, S., Liu, B. (2022), How to control air pollution with economic means? Exploration of China's green finance policy. Journal of Cleaner Production, 353, 131664.

Zhang, L., Li, Z., Kirikkaleli, D., Adebayo, T.S., Adeshola, I., Akinsola, G.D. (2021), Modeling CO_2 emissions in Malaysia: An application of Maki cointegration and wavelet coherence tests. Environmental Science and Pollution Research, 28(20), 26030-26044.

Zhang, R., Sharma, R., Tan, Z., Kautish, P. (2022). Do export diversification and stock market development drive carbon intensity? The role of renewable energy solutions in top carbon emitter countries. Renewable Energy, 185, 1318-1328.

Zhao, L., Chau, K.Y., Tran, T.K., Sadiq, M., Xuyen, N.T.M., Phan, T.T.H. (2022), Enhancing green economic recovery through green bonds financing and energy efficiency investments. Economic Analysis and Policy, 76, 488-501.

Zhao, L., Zhang, Y., Sadiq, M., Hieu, V.M., Ngo, T.Q. (2021), Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era. Economic Change and Restructuring, https://doi.org/10.1007/s10644-021-09367-z

Zheng, H., Song, M., Shen, Z. (2021), The evolution of renewable energy and its impact on carbon reduction in China. Energy, 237, 121639.

Zhong, W., Zong, L., Yin, W., Ali, S. A., Mouneer, S., Haider, J. (2022), Assessing the Nexus between green economic recovery, green finance, and CO_2 emission: Role of supply chain performance and economic growth. Frontiers in Environmental Science, 2022, 869.