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Performance and sustainability of environment under entrepreneurial activities, urbanization and renewable energy policies: A dual study of Malaysian climate goal

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ABSTRACT

We studied Malaysia's ability to achieve its climate goal amidst high rate of entrepreneurial activities and influx of people from rural to urban cities (urbanization) due to massive and prospective economic activities in the cities. For this, we investigate the impact of urbanization, entrepreneurial activities, and economic growth on its environmental performance. Renewable energy and financial development were also incorporated in the analyses to see if they have mitigating effect on the country's carbon emissions. Malaysian data of 1992Q1 to 2017Q4 were adopted for this study, and we also adopted both linear (dynamic ordinary least square-DOLS) and non-linear (nonlinear autoregressive distributed lag-NARDL) scientific and analytical approaches for better and clear insight from our study. Granger causality is equally applied as a robust check to the findings from DOLS and NARDL through direct inference from the selected variables. Findings from NARDL exposed significant impacts of the selected variables on the carbon emissions. Specifically, entrepreneurial activities, urbanization, financial development and renewables are mitigating carbon emissions, while economic growth is increasing emissions. Findings from DOLS and granger causality support the findings from the NARDL with more light on the trend of impact from economic growth to the Malaysia environment through inverted U-Shape EKC hypothesis. From granger causality nexus is established among the variable of interest in this study. From the findings, policy to mitigate carbon emissions can be framed with renewables, urbanization, entrepreneurial activities and financial activities. Authorities can initiate subsidising policies that will enable both private and public players to invest in energy sector strictly for the purpose of expanding renewable energy source.

1. Introduction

Environmental degradation has long had a negative impact on economic performance, and attempts have been made around the world to mitigate its influence on economic growth. Currently, despite the fact that governments have given much attention to the issue of environmental pollution and climate change, the problem persists. The role of entrepreneurship in reaching such a goal has now become a topic of discussion. It is regarded as the most essential avenue for the development of sustainable products and services, as well as the development of new projects to address a wide range of environmental and social challenges. Several studies investigate the relationship between the resolution of global challenges and entrepreneurship as [1], and [2]. The Global Entrepreneurial Monitor (GEM) stated that entrepreneurial activities have the potential to help various countries reduce poverty and control environmental challenges by redistributing resources from previous economic projects to more efficient and successful ones through a country's large number of skilled entrepreneurs. This motivated the Malaysian government to conduct an urgent review of its entrepreneurship training and education program to increase economic performance and support employment growth. Moreover, the government introduced entrepreneurship education as an

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important component of the curriculum at Malaysian higher education institutions [3].

Environmental quality entails making rational decisions to limit negative environmental impact. Recently, Malaysia has switched to the manufacturing sector, but this has had a negative impact on the environment due to a rise in pollution, waste, and the rapid exploitation of natural resources. The green economy is described by the Organization for Economic Cooperation and Development (OECD) as a range of activities that uses cleaner technologies to create goods and services to assess, control, and prevent environmental damage and pollution.

Malaysia is one of the most urbanized nations in East Asia, as well as one of the world's most rapidly urbanizing regions. However, over the years, the urban population has expanded from 66% in 2004 to 74% in 2014. Subsequently, in 2020, 77% of the total population lived in the urban regions. This growth is expected to rise as people move from rural areas (agricultural base) to urban areas (industrial base) due to the economic performance, good health, and job opportunities. However, high urban population are capable of affecting the economy and environmental quality. This, however, can result in a slew of challenges, including increased unemployment, increased energy consumption, climate change, a health crisis.

The migration from rural to urban regions has resulted to higher energy demand and environmental degradation from economic activities, transportation, and residential consumption [4]. Most of the energy consumed are non-renewable energy (fossil fuels, coal) used in generating electricity and other economic activities which in turn pollute the environment. Several studies have explored the impacts of urbanization on CO_2 emissions, and found a positive link between urbanization and emissions through transportation, residential households, and industrial sector [5]

However, more energy sources are needed to enhance Malaysia's urbanization, industrial development, and productivity of factors of production (land, labour, and others). Many countries have encouraged the use of renewable energy (solar, biomass, mini-hydro and geothermal energy) sources to achieve more sustainable energy and lower carbon emissions. In the near future, renewable energy is predicted to be the most common source of energy. According to Malaysian Investment Development Authority (MIDA) (https://www.mida.gov.my/) (2021), solar energy projects are the most common renewable energy in Malaysia, owing to lower equipment production costs and easier green project financing. The government has extended the Green Investment Tax Allowance which is made to acquire green technology systems and the Green Income Tax Exemption for the use of green technology services until 2023, demonstrating its commitment to green consumption and to minimize emissions. According to Gill [6], renewable energy production has a significant negative influence on CO_2 emissions. As a result, Malaysia's high renewable energy use helps to minimize pollution. Malaysia agreed in the Paris Climate Agreement to cut greenhouse gas emissions by 45% by 2030. This aim entails to meet the growing demand for energy while also avoiding environmental damage caused by fossil-fuel-based energy generation [7].

Entrepreneurs are the driving forces behind the growth of businesses and the suppliers of entrepreneurship. Achieving green and sustainable development in entrepreneurship is a task and a requirement of the modern era. Therefore, entrepreneurship contributes to economic growth and clean environment. Entrepreneurship assists businesses in adapting to market changes such as green technological innovation and foreign investment to improve environmental sustainability. Malaysia offers a favorable environment for potential investors and entrepreneurial activities. It is placed 12th in the World Bank's Ease of Doing Business ranking, indicating that it is a country that is open to foreign investment and multinational corporations. Countries with large number of competent entrepreneurs have the ability to help diverse nations eliminate poverty and control current economic challenges by reallocating resources from past economic projects to more productive and effective ones (https://www.gemconsortium.org/). While entrepreneurship in Malaysia has many advantages, it also has certain downsides, such as environmental degradation, corruption, and social difficulties. Numerous studies have identified entrepreneurship as one of the major contributors of environmental pollution, [8,9]. However, few studies considered entrepreneurship to be one of the solutions to environmental degradation [10,11].

Following this background, this paper seeks to investigate the sustainable development of Malaysia amidst high rate of influx of people from rural to urban cities (urbanization) due to massive and prospective economic activities. Among these economic activities going on in the cities of Malaysia are the entrepreneurial activities which are capable of attracting rural people into cities. Malaysia has witnessed increase in urban population in the succession of 66, 74 and 77% in the 2004, 2014 and 2020 respectively (Statista, 2021)(https://www.statista.com/). This trend has placed the country (Malaysia) as one of the most urbanized in East Asia, as well as one of the world's most urbanizing regions. However, in as much as Malaysia is experiencing great urbanization, the country is posed to experience both the economic and environmental implication of the urbanization through the economic activities that are attached to urbanization. Some of the impactions are threat to environmental quality, climate change and health crises due to rise in pollutant emissions through increased utilization of fossil fuel energy sources both by the household and industries. Specifically, we researched the effect of entrepreneurship and urbanization on the environment in Malaysia.

The study investigates empirically the asymmetric and symmetric effects of urbanization and entrepreneurial activities on environmental sustainability, incorporating financial development, economic performance, and renewable energy from 1992Q1 to 2017Q4. To this end, environmental footprint has been used as the dependent variable in our estimation to indicate environmental sustainability in Malaysia. The novel part of our study is the incorporation and quantifying of the impact of entrepreneurial activities on Malaysian sustainable study. This is not common in the literature, and to our knowledge, few studies have adopted this instrument (entrepreneurial activities) in studying Malaysian environment. This study adds to the current literature in the following ways: a. measuring the Malaysian sustainable development with entrepreneurship, b. measuring the Malaysian sustainable development with urbanization on Malaysian environmental performance, c. measuring the ability of mitigating Malaysian carbon emissions and maintaining sustainable development with renewable energy and financial development. This empirical study differs from previous studies not just in terms of time span, but also in terms of technique and explanatory variables included in the study. Based on the researcher's knowledge of the earlier studies, this study is the first of its kind in Malaysia, covering the relationship between entrepreneurial activities, urbanization and ecological footprint. As a result, this study is driven to investigate the major causes that contribute to environmental deterioration in Malaysia in order to propose several policy guidance on how environmental quality can be improved to alleviate the environmental strain that the region is experiencing. The findings will also highlight crucial solutions that emerging economies can use to achieve environmental sustainability while simultaneously mitigating the negative environmental effects of entrepreneurial activities and urbanization.

The rest of the study entails section B Literature Review, section C Materials and method, section D Results and Discussions, and lastly section E Conclusions.

2. Literature review

The link between entrepreneurship, financial development, renewable energy, urbanization, and environmental degradation has attracted the interest of researchers and policymakers. Some research found a positive correlation between the factors, while others found a negative or neutral correlation. This study will look into some of the previous investigations in order to further the discussion, for example, the relationship between entrepreneurship, economic growth, financial development, renewable energy, urbanization, and environmental degradation respectively.

2.1. Entrepreneurship and environmental degradation

The link between entrepreneurship and the environment is an important topic that is currently attracting much attention. He et al. [12] stated that entrepreneurship enhances environmental quality. Omri [13], explored the role of sectoral outputs and entrepreneurship on environmental quality for 69 low-income, middle and high-income countries. Entrepreneurship contributes to environmental pollution more in the lower and middle-income countries. Similarly, Philip et al. [14] observed that entrepreneurial activities negatively impact environmental degradation, by increasing pollution. Gu and Zheng [15] used a panel regression model to examine the effects of entrepreneurship and economic growth on environmental degradation. Entrepreneurship has a direct effect on environmental pollution, but it also has a negative impact on the environment through environmental technological factors, scale effects, and structural consequences. Environmental regulation, on the other hand, lessens environmental challenges. Nakamura and Managi [16], explored the effect of entrepreneurship on environmental sustainability, indicating that entrepreneurial activities in high-income economies have low effects on environmental pollution compared to low-income economies which causes more environmental degradation. Youssef et al. [9] examined the role of entrepreneurship, innovation, and economic performance in achieving environmental sustainability in Africa, indicating that both formal and informal entrepreneurship contribute to environmental pollution. Informal enterprise, on the other hand, does greater environmental damage than official entrepreneurship. Riti et al. [17] used the Fully Modified Least Squares model (FMOLS) to show that entrepreneurship has a significant impact on environmental quality in Nigeria, as well as a positive relationship between entrepreneurship and CO_2 emissions due to the frequent use of fossil fuels, which emit a large amount of CO_2 emissions.

2.2. Economic growth and environmental degradation

Gill et al. [6] examine the influence of renewable energy and on the existence of EKC for carbon emission from 1970 to 2011 in Malaysia, and concluded that renewable energy has a significant negative effect on CO_2 emissions, implying that an increase in renewable energy reduces emissions. Etokakpan et al. [18] used a dataset from 1980 to 2014 to examine the linkages among globalization, CO_2 emissions, and economic growth in Malaysia. The authors used a co-integration test to establish the magnitude of the long-run equilibrium relationship. The empirical findings revealed that economic growth and globalization have a negative impact on environmental quality. From 1978 to 2018, Nurgazina et al. [19] used the ARDL approach to investigate the impact of economic growth, financial development, and energy use on environmental pollution in Malaysia. The study revealed that all variables have an impact on CO_2 emissions. Zhang et al. [20], using the Maki cointegration and wavelet coherence tests, confirmed that economic expansion had a favorable impact on CO_2 emissions. This entails that when Malaysia's economy expands, environmental degradation will rise. The asymmetric effects of FDI and growth on environmental deterioration were investigated by Ref. [21]. Their findings confirmed that Turkey's real GDP per capita has a positive impact on the environment.

2.3. Financial development and environmental degradation

The financial sector plays a critical role in maintaining financial intermediation and ensures that financial resources are used wisely for economic growth. However, greater financial development and economic growth could lead to environmental degradation. The relationship between financial development and environmental quality has also been studied in the literature. Applying the Autoregressive distributed lag (ARDL) approach from 1971 to 2014, Ibrahiem [22], examined the impact of technological innovation and financial development in Egypt. The findings show that financial development and economic growth lessen the quality of the environment whereas, technological innovation and energy resources enhance environmental quality. Using the generalized method of moments (GMM) technique, Alam et al. [23] stated that carbon emissions have no significant relationship with financial development in Malaysia. Shahbaz et al. [24] examine the influence of financial development on environmental degradation in Malaysia. The results indicate that financial development reduces environmental pollution while energy consumption and economic growth enhance CO_2 emissions. Ozturk and Acaravci [25] explored the nexus among financial development, trade, growth, energy consumption, and carbon emissions in Turkey. Financial development has no significant effect on carbon emissions in the long-run. Maji et al. [26] examine the influence of financial development on carbon emissions from different sectors in Malaysia. The outcome shows that financial development raises environmental pollution. Godil et al. [27] investigate the asymmetric influence of financial development on environmental quality. According to the ARDL results, financial development has a negative impact on ecological footprints. Ye et al. [28] applied ARDL approach to explore the influence of financial development on the environmental quality of Malaysia, concluded that financial development increases environmental degradation.

2.4. Renewable energy and environmental degradation

Zafar et al. [29] examine the role of renewable energy consumption and natural resources on environmental quality in Asian countries. The empirical results indicated that an increase in renewable energy improves environmental quality while an increase in natural resources enhances the level of CO_2 emissions. Riti et al. [17] examine whether renewable energy guarantees environmental quality in China in favor of economic growth. The findings indicate that renewable energy lessens environmental pollution while fossil fuel energy consumption enhances it. Moreover, Onifade et al. [30] observed that fossil fuel use has a positive impact on environmental degradation, while on the contrary observed negative impact of renewable energy use on carbon dioxide emission. Mehmood [31] examines the role of renewable energy and education on environmental pollution of G11 countries. The findings indicate that education and renewable energy lessen emissions while natural resources and foreign direct investment enhance CO_2 emissions. Similarly, Zafar et al. [32] also indicated that renewable energy and education enhance environmental quality, while increase in natural resource and foreign direct investment declines environmental quality.

2.5. Urbanization and environmental degradation

Bekhet and Othman [33], examined the impact of urbanization on environmental pollution in Malaysia, confirming that urbanization will be the solution to CO_2 emissions. Shahbaz et al. [34] applied the STIRPAT model to investigate the effects of urbanization on environmental degradation in Malaysia from 1970Q1 to 2011Q4, suggesting that urbanization influences CO_2 emissions. Khan et al. [35] explore how urbanization, natural resources, and value-added manufacturing affect environmental and economic growth. According to the findings, urbanization and value-added manufacturing worsen environmental quality. Natural resources promote environmental quality, but their preservation stifles economic development. Economic growth is boosted by urbanization. According to Pata [36], the study indicated that environmental degradation in Turkey is caused by urbanization, financial development, and energy usage. The findings of a study by Gasimli [37], utilizing time-series data for Sri Lanka from 1978 to 2014, found that the link between urbanization and environmental degradation is significantly negative, implying that urbanization does not cause environmental damage. According to Ahmed et al. [38] urbanization has a favorable impact on environmental degradation due to energy use in the industrial, residential, and transportation sectors. Urbanization contributes to environmental degradation by increasing garbage creation and infrastructural demand. Furthermore, Koyuncu et al. [39] explored the role of urbanization, income and energy on ecological footprint in Turkey, observing that any rise in urbanization has a negative impact on the environment.

Despite the conflicting theoretical and empirical approach on the links between entrepreneurship, financial development, renewable energy consumption, and environmental degradation, research into entrepreneurship and CO_2 emissions have eluded the literature, resulting in a knowledge gap that can be filled. This study will also contribute to the existing information on the environmental impact of entrepreneurship and financial development. This study can also help us comprehend the significance of using renewable energy to reduce emissions.

3. Data and methodology

Urbanization and entrepreneurial activities cause massive changes in terms of social, economic and environmental framework in a country. They also provide some opportunities to enhance the efficiency in the use of resources, to create more sustainable land use and to protect the biodiversity of natural ecosystems. Therefore, within the framework of SDGs, the asymmetric and symmetric effect of urbanization (URB) and entrepreneurial activities (ENT) on environmental sustainability have been investigated incorporating financial development (FD), economic performance (Y) and renewable energy (RE). To this end, ecological footprint (EFP) has been used as dependent variable in our estimation to indicate environmental sustainability in Malaysia. It was measured with global hectare (gha). Entrepreneurial activities were measured with the total number of newly registered businesses in Malaysia for investigated years. Urbanization was measured with urban population in the country as a percentage of total population. Domestic credit to private sector by banks was used to indicate financial development and measured as percentage of gross domestic product (GDP). Economic performance was indicated with real gross domestic product per capita (constant 2010 US$) and renewable energy was defined as the share of total final energy use.

The data was used from 1992Q1 to 2017Q4, in quarterly basis and obtained from World Bank World Development Indicators (WDI), except for entrepreneurial activities and ecological footprint data. The EFP data was obtained from global footprint network official website (https://www.footprintnetwork.org/) whilst, the entrepreneurial activities data was acquired from the official website of Companies Commission of Malaysia (www.ssm.com.my). The investigated variables and their sources are summarized in Table 1.

To investigate the asymmetric and symmetric association among variables the following model was produced.

$$\mathrm{EFP} = f(ENT, URB, FD, Y, RE) \tag{1}$$

Moreover, the variables were converted into their logarithmic forms in order to obtain robust results from the estimation, increase the homogeneity of variables and improve the normality in distribution. At the first phase, the augmented Dickey Fuller (ADF) [40] and Phillips Perron (PP) [41] unit root tests were utilized to check the applicability of our model. Afterwards, dual empirical analyses with both symmetric (dynamic ordinary least square-DOLS) and asymmetric (nonlinear autoregressive distributed lag-NARDL) approaches in short run and the long run periods were employed. The NARDL does not require the same order of integration and can decompose the positive and negative effects of explanatory variables on dependent variables. The general representation of these shocks is presented below:

$$\begin{aligned}\ln EFP_t = {} & \alpha_0 + \beta_1 \ln ENT_t^+ + \beta_2 \ln ENT_{T_t}^- + \beta_3 \ln URB_{B_t}^+ \\ & + \beta_4 \ln URB_{B_t}^- + \beta_5 \ln FD_{D_t}^+ + \beta_6 \ln FD_{D_t}^- + \beta_7 \ln Y_{Y_t}^+ + \beta_8 \ln Y_{Y_t}^- \\ & + \beta_9 \ln RE_{E_t}^+ + \beta_{10} \ln RE_{E_t}^- + \varepsilon_t\end{aligned} \tag{2}$$

where α_0 stands for intercepts, βs describes for the coefficients of positive and negative shocks of explanatory variables, and ε_t designates for the error term of estimations in time t. Besides this relationship in NARDL framework is presented in the equation below.

$$\begin{aligned}\Delta \ln EFP_t = {} & \eta_0 + \theta_1 \ln EFP_{t-1} + \beta_2 \ln ENT_t^+ + \beta_3 \ln ENT_{T_t}^- + \varphi_4 \ln URB_{B_t}^+ + \varphi_5 \ln URB_{B_t}^- + \varphi_6 \ln FD_{D_t}^+ + \varphi_7 \ln FD_{D_t}^- + \chi_8 \ln Y_{Y_t}^+ + \chi_9 \ln Y_{Y_t}^- \\ & \Theta_{10} \ln RE_t^+ + \Theta_{11} \ln RE_t^- + \sum_{j=1}^{n-1} (\gamma_1 \Delta \ln EFP_{t-1}) + \sum_{j=0}^{n_2} (\mu_j \Delta \ln ENT_{T_{t-j}}^+ + \mu_j \Delta \ln ENT_{T_{t-j}}^-) + \sum_{j=0}^{n_3} (\pi_j \Delta \ln URB_{B_{t-j}}^+ + \pi_j \Delta \ln URB_{B_{t-j}}^-) \\ & + \sum_{j=0}^{n_4} (\omega_j \Delta \ln FD_{D_{t-j}}^+ + \omega_j \Delta \ln FD_{D_{t-j}}^-) + \sum_{j=0}^{n_4} (\psi_j \Delta \ln Y_{Y_{t-j}}^+ + \psi_j \Delta \ln Y_{Y_{t-j}}^-) + \sum_{j=0}^{n_4} (\gamma_j \Delta \ln RE_{E_{t-j}}^+ + \gamma_j \Delta \ln RE_{E_{t-j}}^-) + \upsilon_t\end{aligned} \tag{3}$$

Furthermore, the short-term elasticities and error correction term (ECT) can be estimated by utilizing the following equation below:

Table 1
Description of investigated variables.

Variable	Measurement	Source
Ecological footprint (EFP)	Global hectare (gha)	(https://www.footprintnetwork.org/
Entrepreneurial activities (ENT)	Total number of newly registered businesses	Official website of Companies Commission of Malaysia (www.ssm.com.my)
Urbanization (URB)	Urban population in the country as a percentage of total population	WorldBank World Development Indicators (WDI)
Financial development (FD)	Domestic credit to private sector by banks, % of GDP	WorldBank World Development Indicators (WDI)
Economic performance (Y)	Real gross domestic product per capita (constant 2010 US$)	WorldBank World Development Indicators (WDI)
Renewable energy (RE)	Share of total final energy use	WorldBank World Development Indicators (WDI)

$$\Delta \ln EFP_t = \eta_0 + \sum_{j=1}^{n-1}(\gamma_1 \Delta \ln EFP_{t-1}) + \sum_{j=0}^{n_2}(\mu_j \Delta \ln ENT^{+}_{t-j} + \mu_j \Delta \ln ENT^{-}_{T_{t-j}}) + \sum_{j=0}^{n_3}(\pi_j \Delta \ln URB^{+}_{B_{t-j}} + \pi_j \Delta \ln URB^{-}_{B_{t-j}})$$
$$+ \sum_{j=0}^{n_4}(\omega_j \Delta \ln FD^{+}_{D_{t-j}} + \omega_j \Delta \ln FD^{-}_{D_{t-j}}) + \sum_{j=0}^{n_4}(\psi_j \Delta \ln Y^{+}_{Y_{t-j}} + \psi_j \Delta \ln Y^{-}_{Y_{t-j}}) + \sum_{j=0}^{n_2}(\gamma_j \Delta \ln RE^{+}_{E_{t-j}} + \gamma_j \Delta \ln RE^{-}_{E_{t-j}}) + \Theta ECT_{t-1} + \upsilon_t \quad (4)$$

Further the equation (2), the positive and negative shocks can be decomposed as follows:

$$\ln ENT_t = \ln ENT_0 + \ln ENT^{+}_t + \ln ENT^{-}_t \quad (5)$$

$$\ln URB_t = \ln URB_0 + \ln URB^{+}_t + \ln URB^{-}_t \quad (6)$$

$$\ln FD_t = \ln FD_0 + \ln FD^{+}_t + \ln FD^{-}_t \quad (7)$$

$$\ln Y_t = \ln Y_0 + \ln Y^{+}_t + \ln Y^{-}_t \quad (8)$$

$$\ln RE_t = \ln RE_0 + \ln RE^{+}_t + \ln RE^{-}_t \quad (9)$$

where $\ln ENT_0$, $\ln URB_0$, $\ln FD_0$, $\ln Y_0$, and $\ln RE_0$ signify the initial random value. Likewise, $\ln ENT^{+}_t + \ln ENT^{-}_t$, $\ln URB^{+}_t + \ln URB^{-}_t \ln FD^{+}_t + \ln FD^{-}_t \ln Y^{+}_t + \ln Y^{-}_t$ and$\ln RE^{+}_t + \ln RE^{-}_t$ accumulate positive and negative shocks, respectively and signify partial sum process in estimation. They can be also defined as follows:

$$\ln ENT^{+}_t = \sum_{j=1}^{t} \Delta \ln ENT^{+}_j = \sum_{j=1}^{t} \max(\Delta \ln ENT_j, 0), \ln ENT^{-}_t = \sum_{j=1}^{t}(\Delta \ln ENT_j, 0) + \varepsilon_t \quad (10)$$

$$\ln URB^{+}_t = \sum_{j=1}^{t} \Delta \ln URB^{+}_j = \sum_{j=1}^{t} \max(\Delta \ln URB_j, 0), \ln URB^{-}_t = \sum_{j=1}^{t}(\Delta \ln URB_j, 0) + \varepsilon_t \quad (11)$$

$$\ln FD^{+}_t = \sum_{j=1}^{t} \Delta \ln FD^{+}_j = \sum_{j=1}^{t} \max(\Delta \ln FD_j, 0), \ln FD^{-}_t = \sum_{j=1}^{t}(\Delta \ln FD_j, 0) + \varepsilon_t \quad (12)$$

$$\ln Y^{+}_t = \sum_{j=1}^{t} \Delta \ln Y^{+}_j = \sum_{j=1}^{t} \max(\Delta \ln Y_j, 0), \ln Y^{-}_t = \sum_{j=1}^{t}(\Delta \ln Y_j, 0) + \varepsilon_t \quad (13)$$

$$\ln RE^{+}_t = \sum_{j=1}^{t} \Delta \ln RE^{+}_j = \sum_{j=1}^{t} \max(\Delta \ln RE_j, 0), \ln RE^{-}_t = \sum_{j=1}^{t}(\Delta \ln RE_j, 0) + \varepsilon_t \quad (14)$$

Table 2
Stationarity test results.

Variables	*ADF*		*PP*	
	Level	Δ	Level	Δ
EFP	−1.475	−4.091**	−1.184	−5.119***
ENT	−0.6941	−3.104**	−2.377	−3.784***
FD	−2.598	−4.558***	−1.571	−4.340***
Y	0.111	−3.045**	−0.898	−4.743***
URB	−1.706	−3.385***	−2.036	−3.692***
RE	−2.012	−2.840**	−2.321	−4.202***

Note: (1) All variables were tested with only intercept. (2)***,** stands for the significance level at 1% and 5%, respectively.

The WALD test was used to examine the long run symmetric ($\gamma^+ = \gamma^-$) and asymmetric ($\gamma^+ \neq \gamma^-$) association. The effects of asymmetric cumulative dynamic multipliers on dependent variable of a unit change in positive and negative shocks of independent variables can be acquired as follows.

$$m_h^+ = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln ENT_{t-1}^+}, m_h^- = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln ENT_{t-1}^-},$$

$$m_h^+ = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln URB_{t-1}^+}, m_h^- = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln URB_{t-1}^-},$$

$$m_h^+ = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln FD_{t-1}^+}, m_h^- = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln FD_{t-1}^-}, \quad h = 0, 1, 2, 3.$$

$$m_h^+ = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln Y_{t-1}^+}, m_h^- = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln Y_{t-1}^-},$$

$$m_h^+ = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln RE_{t-1}^+}, m_h^- = \sum_{j=0}^{h} \frac{\delta \ln EFP_{t+j}}{\delta \ln RE_{t-1}^-}, \tag{15}$$

where $h \to \infty$, $m_h^+ \to \xi^+$ and $m_h^- \to \xi^-$, where ξ^+ andξ^- are accounted as $\xi^+ = -\beta^+/\rho$ and $\xi^- = -\beta^-/\rho$, respectively.

In addition, the consistency of the results was tested by using Dynamic Ordinary least squares model and stability and the consistency and goodness of fit of NARDL model were evaluated by utilizing CUSUM (cumulative sum of recursive residuals) and CUSUMsq (cumulative sum of recursive residuals squares) stability tests. Also, the required reliability tests were employed for our estimation. Lastly, the direction of causal relationships among all variables were investigated with Granger causality test.

4. Empirical findings and discussion

This section of the study provides the results obtained from employed methodologies. As mentioned in the previous section, to test the applicability of our methodologies and get robust results, ADF and PP unit root tests were utilized. The results of these tests are presented in Table 2 below. It can be said that all investigated variables are stationary at their first differenced form which indicates they are at integration order one I(1). Furthermore, in order to test the long run association among variables, NARDL bounds test was utilized. The results of this test given in Table 3 confirms the evidence of cointegration association among the variables. In other words, since the calculated F-statistic (3.6768) is greater than the upper critical bound of the test at 5% significance level, we can reject the null hypothesis of no long run steady state association among the variables and confirm the cointegration among them.

Table 3
Bound test results.

		1%		5%		10%	
K	Calculated F-stat	B_L	B_U	B_L	B_U	B_L	B_U
10	3.6768	2.84	4.10	2.33	3.46	2.07	3.16

Note: B_U: upper critical bound B_L: lower critical bound.
Source: Authors Computation.

Once the long run steady state association among the variables was identified, we proceed with employing NARDL method to obtain the magnitude and the direction of the relation among explanatory variables and environmental sustainability. Table 4 gives the details about the estimation result and prove that all explanatory variables used in the model are statistically significant and can be account as the determinant of environmental sustainability function.

The estimation outcomes of NARDL model revealed that the coefficient of ECT (−1) is negative and statistically significant at 1% significance level. This implies that, 55.7% of disequilibrium in environmental deterioration level in short run can be mended in the long run given the independent variables. Furthermore, the shocks on entrepreneurial activities accounted as statistically significant determinant of environmental sustainability in short run and long run. Remarkably, this indicates that a 1% rise in positive shocks on entrepreneurial activities deteriorates the environment by 0.037% in short run and contributes environmental sustainability by 0.066% in long run. The probable reason behind this can be prioritizing the entrepreneurial activities to the environment in the short run, adapting the environmental standards, increasing the awareness and the use of environmentally friendly technologies in the long run. On the other hand, a one percent increase in negative shocks on entrepreneurial activities in Malaysia increase its environment quality by 0.151% in the short run, on average and deteriorates the environment in the long run by 0.271%, on average. This implies that, increasing the bureaucracy and difficulty to reach the finance, unstable market conditions can discourage people to take the risk and increase their entrepreneurial activities. Therefore, this may lead to increase of the deterioration level of environment by inefficiently use of land and resources, doing traditional activities and emitting more greenhouse gasses. The finding from Ref. [12] aligns with finding of our study in the long run while the findings from Refs. [13,20] corresponds to our finding in the short run. The disparity in their findings give room for more research into the impact of entrepreneurial activities on environment.

Furthermore, there is a significant association among urbanization and environmental sustainability in Malaysia. This reveals that, keeping other things constant, a one percent increase in urbanization will lead to decrease of the deterioration level of environment by 0.416% in the short run and 0.747% in the long run, on the average. This shows that the long run magnitude of the effect of urbanization on environmental sustainability indicator is larger than the short run effect. This indicates that increase in urbanization can lead to having improved environmental sustainability, enhance the efficiency in the use of resources, create more sustainable land use and protect the biodiversity of natural ecosystems. Together with, a one percent rise in the negative shocks on urbanization will degrade the environment and reduce the sustainability level of environment by 0.379% and 0.680%, in the short run and long run, respectively. The results demonstrate that the long run effect of urbanization on environment is larger than in short run. Since the people at the first phase search for the comfortability and flexibility instead of prioritizing environmental sustainability, in the long run, the awareness of environment increases and the sustainability improved with the increase in urbanization level in country. Our finding aligns with the findings of

Table 4
Estimation output.

Short Run Coefficients				
Var	Coeff	Std. Error	t-Stat	P-value
D(LNENT+)	0.037**	0.032	2.141	0.0256
D(LNENT-)	−0.151**	0.065	−2.325	0.0224
D(LNFD+)	−0.130**	0.092	−3.399	0.0165
D(LNFD-)	0.420***	0.143	2.932	0.0043
D(LNY+)	0.386***	0.136	2.832	0.0057
D(LNY-)	1.034***	0.292	3.535	0.0007
D(LNURB+)	−0.416***	0.135	−3.078	0.0028
D(LNURB-)	0.379***	0.113	3.342	0.0012
D(LNREN+)	−0.210**	0.067	−3.125	0.0024
D(LNREN-)	0.034**	0.037	2.907	0.0365
ECT(-1)	−0.557***	0.120	−4.625	0.0000
Long Run Coefficients				
LNENT+	−0.066**	0.054	−3.219	0.0225
LNENT-	0.271***	0.101	2.667	0.0091
LNFD+	−0.233*	0.141	−1.652	0.1021
LNFD-	0.753***	0.161	4.660	0.0000
LNY+	0.694***	0.263	2.631	0.0101
LNY-	1.855***	0.342	5.416	0.0000
LNURB+	−0.747***	0.211	−3.534	0.0007
LNURB-	0.680***	0.126	5.387	0.0000
LNREN+	−0.377***	0.114	−3.304	0.0014
LNREN-	0.061**	0.067	2.906	0.0367
C	19.860***	3.759	5.282	0.0000

Note: ***,** and * stands for the significance levels at 1%, 5% and 10%, respectively.
Source: Authors Computation.

[33,34] for the case of Malaysia [37]; for Sri Lanka; while findings of [36] for Turkey [35]; for top 10 manufacturing countries and [38] for G7 countries.

On the other hand, the financial development has a statistically significant and incremental effect on the environmental sustainability. This finding points to the fact that, easy to access to the finance will cause an improvement in environment, hence people will be empowered to easily purchase the environment friendly technologies and use of modern technologies. In details, the asymmetric association of financial development and environmental sustainability indicates that a one percent increase in financial development will reduce the degradation level of environment by 0.130% and 0.233% in the short run and long run, respectively. However, a one percent increase in negative shocks on financial development will contribute to environmental deterioration by 0.420% and 0.753%, in the short run and long run, respectively. This shows that negative shocks on financial development have larger magnitude on environmental sustainability indicator. Thus, the more the financial stability and development in financial sector as well as easy to access to the finance the better the improvement in environment of the country. Finding from Shahbaz et al. [42] for the case of Malaysia supports our finding, while the findings from Ref. [28] for Malaysia and [27] for Turkey contradict our findings. The contradiction among the findings show that the topic is still open for research for ascertainment of the true position of financial development in mitigating pollutant emissions for Malaysia.

Furthermore, the positive and negative shocks on economic performance gives the same outcome in our estimation. In other words, an increase and decrease in economic performance will impede the preservation of environmental quality within investigated period. The magnitude of negative shocks is larger than the magnitude of positive shocks in both terms. This signalizes that Malaysia is at the first phase of environmental Kuznets curve process which was tested in DOLS estimation (see Table 5). In particular, one percent increase in positive and negative shocks on economic performance will lead to degrading the environmental sustainability level by 0.386% and 1.034%, on average in the short run. These values were accounted as 0.694% and 1.855% in the long run, on the average. A rise in economic performance triggers economic activities and increases the income Thus, this leads to increase in demand for energy consumption and reduces the importance of environment at the first stage. This also causes greater greenhouse gas emissions and environmental deterioration. Our finding corresponds with the findings of [18–21,43,44]. Therefore, government and policymakers should carefully design and generate the policies to push the economic activities to use modern technologies and act environmentally friendly.

Table 5
DOLS Estimation output.

Var	Coeff	Std. Error	t-Stat	P-value
LNENT	−0.114**	0.106	−3.076	0.0285
LNFD	−0.367***	0.079	−4.618	0.0000
LNREN	−0.292***	0.078	−3.729	0.0004
LNURB	−0.172**	0.725	−2.994	0.0037
LNY	1.501**	0.270	2.599	0.0112
LNY^2	−0.420**	0.171	−2.454	0.0164
C	−28.481**	13.848	−2.056	0.0432
R-squares:0.888			Adjusted R-squared	0.853

Note: *** and ** indicate 0.01 and 0.05 significance levels, respectively.
Source: Authors Computation.

Table 6
Diagnostic Test results.

Tests	Statistics	P-value
BG-LM test	1.143	0.218
BPG	5.175	0.003
RESET	1.211	0.228
ARCH	0.243	0.616
Jarque Berra Test	2.884	0.236

Source: Authors Computation.

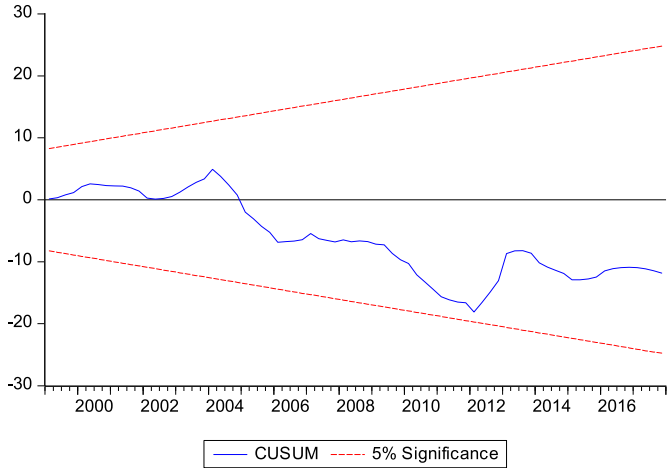

Fig. 1. Cusum test Result
Source: Authors computation.

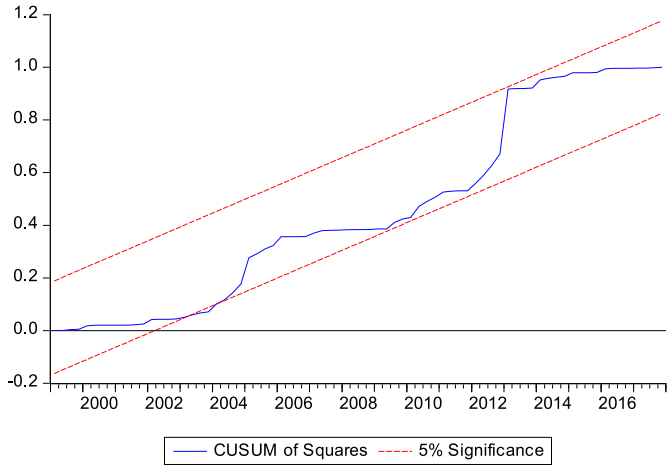

Fig. 2. Cusumsq test Result
Source: Authors computation.

Table 7
Granger causality test results.

Null Hypothesis:	F-Statistic	Prob.
LNFD ≠> LNEFP	2.00986	0.1594
LNEFP ≠> LNFD	1.96499	0.1641
LNREN ≠> LNEFP	**5.65231**	**0.0193**
LNEFP ≠> LNREN	1.52160	0.2203
LNURB ≠> LNEFP	**2.79227**	**0.0978**
LNEFP ≠> LNURB	0.97839	0.3250
LNY ≠> LNEFP	0.78872	0.3766
LNEFP ≠> LNY	4.2E-06	0.9984
LNENT ≠> LNEFP	0.80450	0.3719
LNEFP ≠> LNENT	1.65876	0.2007
LNREN ≠> LNFD	**3.13311**	**0.0798**
LNFD ≠> LNREN	0.04659	0.8295
LNURB ≠> LNREN	**5.71976**	**0.0186**
LNREN ≠> LNURB	1.60213	0.2085
LNY ≠> LNREN	**9.05717**	**0.0033**
LNREN ≠> LNY	0.01661	0.8977
LNENT ≠> LNREN	1.39432	0.2405
LNREN ≠> LNENT	0.27565	0.6007

Note: ≠> depicts for "does note granger cause".
Source: Authors computation.

Moreover, the use of renewable energy found significant contributor to environmental sustainability in both terms. This demonstrates that, a one percent increase in the use of renewable energy and increases its share in total energy use will deduct the environmental degradation level by 0.210% in the short run and 0.377% in the long run. However, a one percent rise in the negative shocks on renewable energy will degrade the environmental quality by 0.034% and 0.061% in the short run and long run, respectively. With this respect, although the investment on renewable energy sources needs significant budget, government should speed up the investment projects on renewable energy sources and lift the limitations on foreign/private investment to have environmental sustainability and better economic performance by reducing the energy-import dependency and money outflows. The findings from our study tallies with the findings from Ref. [29] for Asian countries [31], for the G11 countries and [17] for China.

To confirm the outcomes obtained from NARDL estimation, DOLS model has been utilized. The estimation output is given in Table 4. In this estimation, EKC hypothesis was also tested. Similar to NARDL results, all explanatory variables mentioned in equation (1) found significant determinant of environmental sustainability and except economic performance, one percent increase in explanatory variables deducts the environmental degradation level in Malaysia. In particular, one percent increase in entrepreneurial activities and urbanization in Malaysia will improve the environmental quality by 0.114% and 0.172%, on the average, respectively. Moreover, one percent increase in financial development will cause to improve environmental sustainability by 0.367% and this value was accounted as 0.292% for renewable energy consumption in Malaysia, on the average. However, the validity of EKC hypothesis was confirmed with DOLS estimation and demonstrates that one percent increase in economic performance will deteriorate the environment and damage the environmental sustainability by 1.501%, on the average, up to threshold level at the first phase, then, for every one percent increase in economic performance of Malaysia will decrease the deterioration level of environment and improve environmental sustainability by 0.420%, on the average.

Table 6 gives the outcomes for diagnostic tests. The results confirm the absence of heterogeneity and autocorrelation problems in our estimations. Moreover, Jarque Berra test implies that all investigated variables are normally distributed and Ramsey Reset test proves that the model is perfectly specified for estimations.

Also, the structural stability of the models was tested with CUSUM (Fig. 1) and CUSUMsq (Fig. 2) stability tests [45].These tests affirm the stability of estimated equations since the statistic is within the 5% significance level for both tests.

Finally, the granger causality test was employed to investigate the causal association among investigated variables. The outcome depicted in Table 7 and show feedback causal relationship of urbanization and entrepreneurial activities with financial development. Moreover, the unidirectional causal relationships run to environmental sustainability from renewable energy consumption and urbanization. Besides, another unidirectional causal relationship run from urbanization and economic performance to renewable energy consumption. Moreover, the outcome also reveals unidirectional relationships running from renewable energy use to financial development, from financial development to economic performance and from entrepreneurial activities to urbanization. Therefore, these results affirms that all investigated variables have causal relationships with each other, and they are significant determinant of environmental sustainability in Malaysia. Consequently, Malaysian government, policymakers and environmentalists should focus on not only one variable but the others as well to achieve the country's climate goal.

5. Conclusion and policy recommendation

This is a sustainable study of Malaysia amidst high rate of influx of people from rural to urban cities (urbanization) due to massive and prospective economic activities. Among these economic activities going on in the cities of Malaysia are the entrepreneurial activities which are capable of attracting rural people into cities. Malaysia has witnessed increase in urban population in the succession of 66, 74 and 77% in the 2004, 2014 and 2020 respectively. This trend has placed the country (Malaysia) as one of the most urbanized in East Asia, as well as one of the world's most urbanizing regions. However, in as much as Malaysia is experiencing great urbanization, the country is posed to experience both the economic and environmental implication of urbanization through the economic activities that are attached to urbanization. Some of the impactions are threats to environmental quality, climate change and health crises due to rise in pollutant emissions through increased utilization of fossil fuel energy sources both by the household and industries. Malaysia is among the countries that are conscious of maintaining its national determined contribution (NDC) towards achieving climate goal (i.e. maintaining equal to1.5 °C or less than 2 °C), and have made a pledge to the Paris Climate Agreement to cut its emissions by 45% by 2030.

Considering the Malaysia position in achieving its quota in climate goal before 2030 and with the trend of its economic activities which are centred in urbanization through entrepreneurial activities, we seek to investigate the impact of urbanization, entrepreneurial activities, and economic growth on its environmental performance. Renewable energy and financial development were also incorporated in the analyses to see if they have mitigating effect of carbon emissions of the country. We adopt both linear (dynamic ordinary least square-DOLS) and non-linear (nonlinear autoregressive distributed lag-NARDL) scientific and analytical approaches for better and clear insight from our study. Granger causality is equally applied as a robust check to the findings from DOLS and NARDL through direct inference from and among the variables. Findings from NARDL exposed significant impacts of the selected variables on the carbon emissions. Specifically, entrepreneurship is seen promoting environmental degradation in the short run through increase in carbon emissions, while enhancing the environmental quality in the long run through reduction of carbon emissions. Surprisingly, urbanization is seen impacting favourably on environmental quality in both periods through emissions reduction. Financial development and renewable energy are observed enhancing the environmental quality through their mitigating forces. On the contrary, economic growth is contributing to the environmental degradation in both periods. Findings from DOLS and granger causality support the findings from the NARDL with more light on the trend of impact from economic growth to the Malaysian environment through inverted U-Shape EKC hypothesis. A nexus is established among the variable of interest in this study. Hence, feedback causal relationship is established between urbanization and entrepreneurial activities with financial development, while unidirectional causal relationships run to environmental sustainability from renewable energy consumption and urbanization, from urbanization and economic performance to renewable energy consumption, from renewable energy use to financial development, from financial development to economic performance and from entrepreneurial activities to urbanization.

Findings from the above approaches revealed that the variables are significant determinants of environmental sustainability in Malaysia. Hence, policy recommendation is framed around the variables for better result towards the country's quest to achieve its climate goal of reducing carbon emission by 45% by 2030. Policy should be built towards moderating the economic activities in the urban cities to ensure the continuous positive impact of the urbanization in the Malaysian environment. Massive awareness and sensitization are needed from the side of the government to the masses (both household and industries) on the need for clean environment. Reducing private automobiles through initiatives like public transport and rail system is also advisable. The result shows progressive and positive impact of entrepreneurship in the Malaysian environment which means that the small owners are incorporating cleaner means of production and running of their businesses through innovation. This trend needs to be maintained through subsidies and encouragement of the small business owners from government. Credits and subsidies can be extended to the owners of the thriving business to empower their technological innovation research and development which will benefit them as well as benefit the entire cities. Also, from our finding, financial development and renewable energy are seen mitigating carbon emission. This shows that the financial and renewable sectors are already helping in moderating the carbon emissions in the country, and are capable of aiding in its climate goal. Expansion of renewable sector can be achieved through policies that will enhance financial flow from financial sector into the renewable sector through investments from private and public players. Government can initiate flexible policies that will enable both private and public players to secure loans and credits to fund their investments into energy sector strictly for the purpose of expanding renewable energy source.

Conclusively, this study is relevance and has implication to other emerging economies with similar features especially in the Asian regions. More studies can be done on this topic with other key drivers of carbon emission for Malaysia.

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Compliance with ethical standards

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CRediT authorship contribution statement

Edmund Ntom Udemba: wrote discussion and conclusion with abstract. In summary, Conceptualization, the idea, did, Supervision, Validation, Visualization, Project administration, Writing – review & editing. **Lucy Davou Philip:** wrote the intro-literature while, Writing – review & editing. **Firat Emir:** wrote the, Methodology, sourced the Data, did, Formal analysis, Investigation, with, Methodology, with, Software, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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