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Investigating the Environmental Kuznets Curves Through the Economic Globalization Lens: Evidence from Middle Income Countries

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ABSTRACT

This paper explores the implications of economic globalisation on the environment based on the revised KOF globalisation index for 76 middle-income nations from 1994 to 2014. The System Generalised Method of Moments (GMM) is adopted for a 7-year span panel data to examine the implications of economic globalisation on environmental sustainability based on the Environmental Kuznets Curve (EKC) hypothesis. Unlike prior studies, the economic globalisation index is examined from both the de facto and de jure perspective to determine its impact on climate change. The over-arching results indicate no evidence of the validity of the EKC hypothesis amongst the middle-income nations, with primary energy consumption as the major driving force of carbon emissions. Urbanisation and population growth are negatively correlated with carbon emissions. Based on our findings, it is imperative for policymakers in middle-income nations to identify potential trade barriers and investments restrictions that could thwart the emergence of green technology adoption to combat climate change.

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INTRODUCTION

With the accelerated growth in industrialisation and development, particularly amongst middle-income nations, issues on climate change remain a pressing concern amongst policymakers. Furthermore, as economic integration and trade freedom are becoming borderless, there has been a renewed interest to examine these trends that could potentially influence the environment. Comprehension of remedial efforts undertaken presently to mitigate climate change requires thorough reviews moving forward, as the processes of global change are increasingly systemic towards the environment. As such, middle-income nations should undertake collaborative efforts to address these environmental complexities and formulate coordinated policy responses towards combating climate change.

Based on existing environmental conditions, it is evident that middle income nations are likely to experience severe extreme temperatures compared to high-income nations, attributed to carbon emissions (Harrington et al., 2016). Furthermore, as most high latitude nations are middle income nations, volatile summer temperatures cause climatic effects arising from global warming (Mahlstein et al., 2011). Economic globalisation in the last two decades have validated the Pollution Haven Hypothesis whereby industries from developed nations are likely to shift their pollution-emitting industries particularly to middle income nations with lax environmental regulations (Wagner & Timmins, 2009). The rationale towards formulating this hypothesis (Copeland & Taylor, 2004, 2009) is attributed to the increased costs arising from implementing stringent environmental regulations for these businesses. These "free rider" nations have disproportionately contributed to greenhouse gas emissions (Rezza, 2013) that have exacerbated the environmental conditions amongst middle income nations.

Although the United Nations Framework Convention on Climate Change (UNFCCC) have recognised climate inequity between the developed and middle-income nations (Khan & Chowdhury, 2012), minimal economic globalisation efforts have been implemented towards combating climate change. Additional initiatives should be focused towards enhancing infrastructures and compensating loss and damage arising from climate change for middle-income nations as these nations are experiencing disproportionate adverse implications from global warming compared to high-income nations (Bednar-Friedl et al., 2012). With the signing of the Paris Agreement in 2015, it is evident, collective efforts via existing international climate agreements should be undertaken towards distribution of financial resources and expertise to assist middle-income nations combating climate change.

At present, literature on environmental impacts arising from economic globalisation are on individual nations (Arce et al., 2016) or cross-country comparisons which are pooled collectively (You & Lv, 2018) at varied stages of economic development. Although literature on individual nations pertaining to the impact of economic globalisation on environmental quality may be geared towards the development of policies for the respective nation, the results attained would be constrained by the limited observations that may fail to capture time-invariant factors that affects environmental quality (Ibrahim & Law, 2014). By focusing on middle-income nations, the risk of examining an immensely heterogenous global sample are minimised, particularly to address issues arising from spurious regressions and examining individual-specific effects within a pooled sample (Ibrahim, 2018).

According to a recent World Bank (2018) report, without cohesive climate and development actions, approximately 143 million people or 2.8 per cent of the population from the Sub-Saharan African, South Asia and Latin American regions could be forced to migrate within their own countries to avoid the impacts of climate change. The findings of the report also highlight that internal climate migration will likely rise through 2050, provided robust development actions be undertaken to reduce greenhouse gas emissions significantly amongst these middle-income nations over the next decade. By focusing the impact of economic globalisation on environmental quality for middle-income nations, it would be imperative to seek viable solutions to resolve these issues within these regions and implement policies to achieve sustainable development in the long-run.

Within the energy economics literature, numerous studies on the relationship between economic growth, energy consumption and carbon emission have been researched extensively by applying the Environmental Kuznets Curve (EKC) hypothesis (Özokcu & Özdemir, 2017; Su & Chen, 2018; Zaman et al., 2016). The EKC posits that during the initial stages of rising economic growth, environmental degradation increases concurrently, however, beyond a specific threshold level of economic growth, the environmental degeneration declines and brings welfare in the long-term (Grossman & Krueger, 1995).

The validity of the EKC model has been controversial particularly for middle-income and developing nations, attributed to the inconclusive results that may arise from the identification dilemma (Musolesi & Mazzanti, 2014). The hypothesis of the EKC holds true in specific studies (Alvarado et al., 2018; Azam & Khan, 2016; Hanif, 2018). However, opposing results were evident in India (Alam et al., 2016), Vietnam (Al-Mulali et al., 2015a) and other developing economies (Jha & Murthy, 2003; Lipford & Yandle, 2011; Ozturk & Al-Mulali, 2015; Rashid Gill et al., 2018). The non-existence of the EKC hypothesis also holds true for countries within the African region (Adu & Denkyirah, 2018; Lin et al., 2016) and does not provide a concrete foundation towards formulating environmental policies for these nations.

The three fundamental hypothesis that elucidates the globalisation-environment nexus is the Pollution Haven Hypothesis (PHH) (McGuire, 1982; Pethig, 1976; Siebert, 1977), Factor Endowment Hypothesis (FEH) and the Porter Hypothesis (Porter, 1991; Porter & Van der Linde, 1995). The PHH postulates that international trade (Copeland & Taylor, 2004, 2009; López et al., 2018; Zheng & Shi, 2017) and foreign direct investments (Rafindadi et al., 2018; Rezza, 2013; Sapkota & Bastola, 2017; Wagner & Timmins, 2009) contribute to the rise of carbon emission, as businesses are likely to establish its presence in jurisdictions with lax environmental regulations. The intuitive premise resides with the idea that environmental regulations increase the essential inputs on goods with pollution-intensive production which invariably reduces the comparative advantage in those products (Levinson, 2018).

Conversely, the FEH demonstrates that comparative advantage is motivated by factor endowments, factor intensities and environmental tax rates (Chen & Woodland, 2013). Copeland and Taylor (1997) have suggested that nations with higher economic growth and disposable income are likely to be subject to greater environmental taxes. As such, varying income levels and factor endowments (such as technology) would determine which nations would attain the comparative advantage towards the production of polluting goods and services. The FEH posits that higher-income nations are likely to export pollution-intensive goods that invariably increases production and affects environmental quality. On the contrary, environmental quality is not particularly affected in lower-income nations that is attributed to the contraction of producing pollution-intensive products, due to its lack of comparative advantage. As such, the effects of economic globalisation on environmental quality is dependent on the distribution of comparative advantages amongst nations across the globe. The comparative advantage arises based on the differences in pollution policy and factor endowments policy amongst these economies (Temurshoev, 2006). The Porter Hypothesis, alternatively, suggests that stringent regulations could potentially lead towards incremental innovation and creativity amongst industry players. Firms would be encouraged to formulate solutions that could stimulate commercial competitiveness within their organisations (Qiu et al., 2017; Ramanathan et al., 2017; Rubashkina et al., 2015).

The present paper contributes to the literature by examining both the de facto and de jure measures of economic globalisation and provides additional evidence on the pertinence of economic globalisation in the current EKC debate. Our central hypothesis is that segregating the de facto and de jure measures of economic globalisation are instrumental towards exerting a significant influence on the relationship between GDP, energy consumption and carbon emissions. To the author’s knowledge, presently, there are no studies that have incorporated the economic globalisation variables from the revised KOF Globalisation Index (2018) in an empirical EKC model.

The focus of this paper is on middle-income nations, as economic globalisation could play a pivotal role towards addressing concerns of climate change that plagues the welfare of these nations. Our findings further exacerbate the existing literature that determining the de facto and de jure measures separately are necessary to avoid biased conclusions in an EKC model. The rest of the empirical study is as follows. Section 2 highlights the literature review and the current contributions to this research area. The presentation of the theoretical framework of the model and data is in the following section. The estimated results and elaboration of discussions are in Section 4. Finally, Section 5 concludes this paper and policy recommendations are suggested to enhance the scope of climate change.

LITERATURE REVIEW

The debate surrounding the EKC model which was initially coined by (Grossman & Krueger, 1995, 1996) is discussed extensively by energy economists (Apergis et al., 2017; Bilgili et al., 2016; Riti et al., 2017) due to the inconclusive results arising from the hypothesis. Moomaw and Unruh (1997) highlighted that the EKC model represents the transitional process of nations from agrarian to industrial that have aggravated the damage in environmental quality attributed to the rise in production and consumption in economies. Furthermore, the study concluded that neither the U-shaped or N-shaped relationship between carbon emission and income provides a reliable indication of future patterns.

A broad range of literature has also discussed sectorial implications such as industrial and manufacturing (Wang et al., 2017; Zhou et al., 2018), residential (Pablo-Romero & Sánchez-Braza, 2017; Sinha & Bhattacharya, 2016, 2017; Zhang & Bai, 2018) and the transportation sector (Alshehry & Belloumi, 2017; Nassani et al., 2017; Pablo-Romero et al., 2017). Subsequent studies on EKC have also included the promotion of education towards achieving environmental objectives (Balaguer and Cantavella, 2018), the relevance of energy prices (Rodríguez, Pena-Boquete, and Pardo-Fernández, 2016) and the impact of political and economic freedom (Joshi and Beck, 2018) to combat climate change.

Recent literature has proposed the need to incorporate useful financial frameworks (Abbasi & Riaz, 2016; Bekhet et al., 2017; Salahuddin et al., 2018) to complement energy supply policies to mitigate the detrimental impact of climate change, particularly in middle-income nations. Financial stability is pertinent to develop a robust financial sector inclined to invest in environment-friendly technologies and infrastructure (Nasreen et al., 2017; Shahbaz, 2013) and further encourage businesses to adopt sustainable practices in their operations and production processes. Other multivariate frameworks which include urbanisation, population growth and renewable energy elucidate the implication of non-income factors (Olale et al., 2018; Shahbaz et al., 2013; Solarin et al., 2017; Xu, 2018; Zambrano-Monserrate et al., 2018) and its relevance to the EKC model upon controlling for these variables.

Economic globalisation which has been synonymous with international trade and foreign direct investment have been popular amongst energy economists due to its anthropogenic nature in recent years. Prior studies have utilised trade openness (Ben Jebli & Ben Youssef, 2015; Ben Jebli et al., 2016; Mutascu, 2018; Pal & Mitra, 2017; Shahzad et al., 2017) and international trade (Andersson, 2018; Arce et al., 2016; Fernández-Amador et al., 2016; Li et al., 2018) as proxies to measure the incidence of economic globalisation. However, elements such as trade partner diversification, trade regulations and tariffs are not captured within these variables and lead to a skewed perspective towards economic globalisation. A similar principle applies to the examination of foreign direct investments (Behera & Dash, 2017; Jiang et al., 2018; Sbia et al., 2014; Shahbaz et al., 2015; Zhang & Zhou, 2016) whereby the measurement excludes investment restrictions, capital account openness and portfolio investments within the financial liberalisation domain.

Present literature that have examined the impact of economic globalisation on carbon emission via the EKC hypothesis have demonstrated that as economies progress towards greater stages of economic growth, upon attaining specific thresholds of economic development, these economies would be attentive towards the detrimental impact of economic globalisation on environmental quality (Shahbaz et al., 2016; You & Lv, 2018). The dynamic relationships between economic globalisation, economic growth and carbon emissions can be investigated through three main elements of economic globalisation, i.e. the scale, technique and composition effect. Structural changes in an economy arising from international trade and foreign direct investments (proxies for economic globalisation) would affect the pollution levels in an economy (Shahbaz et al., 2018). From a scale effect perspective, environmental degradation would be attributed by economic globalisation policies that boost economic development and ignores its implications on the environment. The composition effect implies that precedence will be given to elevate economic growth by the presence of pollution-intensive industries. Conversely, if the economic globalisation policies are focused towards attaining sustainable economic development and environmental sustainability concurrently, it is evident that the technique effect of globalisation outweighs the scale and composition effect.

Concerning the study of climate change, the prevalent globalisation indices adopted are the KOF Index of Globalization (Dreher, 2006; Dreher & Gaston, 2008; Dreher et al., 2008) and the Maastricht Globalization Index (Figge & Martens, 2014). The existing studies on the implications of globalisation on the environment (Ding et al., 2018; Lim et al., 2015; Shahbaz et al., 2016) have combined both the de facto and de jure measures of economic globalisation as a single index. Consequently, the implications of globalisation would be distorted (Dreher et al., 2010; Martens et al., 2015) on issues arising from climate change.

Based on the current rationale highlighted in the above paragraphs, the segregation of de facto and de jure measures of economic globalisation could potentially attest to be valuable towards addressing issues surrounding climate change for middle-income nations. For middle-income nations, the question of whether the environmental quality will improve or decline with economic globalisation continues to play a prominent role in environmental research and policy. With the controversy surrounding the empirical evidence against and in favour of economic globalisation towards combating climate change, this study could potentially shed some light for policymakers in these countries.

METHODOLOGY FRAMEWORK

Methodology Framework and data

For the empirical estimation of this study, a panel of 76 middle-income countries (based on the World Bank classification of lower-middle income nations and upper-middle income nations) have been constructed from 1994 to 2014. For this study, a 7-year spanned data was adopted in our analysis to ensure the number of time periods are significantly less than the number of groups to conduct system GMM. The adoption of a 3-year average was to take account of the cumulative effects arising from economic globalisation and environmental quality (Petrikova, 2016) that is subject to business cycle fluctuations (Imam & Kpodar, 2016). The rationale of constructing three-year averages is to eliminate business cycle effects, to capture possible reverse causality (Poirson et al., 2004) and examine the long-run impact of economic globalisation on environmental quality. The deviation from the usual five-year averages is to stabilise the data by offsetting measurement errors that may arise during the 90s-era, attributed to the transitional era of the Soviet Union and other communist nations (Marelli & Signorelli, 2010), to attain additional sample size and ensure external validity of the results (Wamboye & Nyaronga, 2018).

The countries of interest were selected based on the availability of data. The key variables in the current study and the components of the economic globalisation are illustrated in Table 1 and Table 2. This empirical study employs panel data methodology to ameliorate the shortcomings of the normal time-series and cross-sectional data. Furthermore, this methodology is viewed to be effective, due to its ability to control heterogeneity and the serial correlation problems. For studies with short time-series data, it increases the degree of freedom (Baltagi, 2008; Baltagi & Pesaran, 2007).

Due to the vagaries of environmental quality, pollution measures are bound to be correlated over time. As such, it is essential to capture the dynamic element of the dependent variable (i.e. the carbon emissions per capita), in the empirical model of EKC. In line with this rationale, our empirical model includes the commonly adopted control variables to mitigate the potential for misspecification and biased estimations within the model. As highlighted in the plethora of studies (Apergis & Ozturk, 2015; Bo, 2011; Waslekar, 2014) relating to the EKC model, as opposed to national income, other pertinent variables also affect the environment, as indicated in Equation (1).

$$CO_2 = \text{f (GDP, GDP}^2\text{, PEC, Z)} \quad (1)$$

Where CO_2, GDP, GDP^2, PEC and Z represent environmental pollution, income, income squared, primary energy consumption and other non-income factors affecting the environment, respectively. Based on the existing literature, the empirical study extends the concept of the EKC hypothesis by incorporating various response variables which include, economic globalisation, population growth, urbanisation and democracy index as a proxy for institutional quality. This multivariate framework would further enhance the comprehension the manner non-income factors contribute to environmental degradation individually and the validity of the EKC hypothesis upon controlling for these variables.

To reduce potential bias and imprecision associated with a first-difference GMM estimator, Blundell and Bond (1998) developed the system GMM. The moment conditions for the differenced model and the levels model are combined in the system GMM. The equation in differences is instrumented by lagged values of the variables in level, while the equation in levels are instrumented by lagged values of the variables in differences (Bond, 2002). As a dynamic panel estimator, the system GMM includes a lagged endogenous variable amongst the exogenous variables to control the dynamics of adjustment.

Although the levels of the explanatory variables are essentially correlated with the country specific fixed effect, the differences are no t correlated. Alternative consistent estimators with lagged dependent variables, as proposed by Bruno (2005), are adopted if the explanatory variables are strictly exogenous. For all the model specifications in this study, the independent variables of interest are deemed to be endogenous, as it responds to the variations that arises in all the dependent variables within this framework, i.e. carbon emissions per capita.

Table 1 Definition of variables

Variables	Definition	Source
CO_2	Carbon dioxide emissions (metric tons per capita)	World Development Indicators (2017)
GDP	Gross Domestic Product per capita (Constant 2010 US$)	World Development Indicators (2017)
EG	Economic Globalisation (Overall Index)	KOF Globalisation Index (2018)
EGDF	Economic Globalisation (De Facto Index)	KOF Globalisation Index (2018)
EGDF	Economic Globalisation (De Jure Index)	KOF Globalisation Index (2018)
PECP	Primary energy consumption as a fraction of total population (metric ton of oil equivalent)	Enerdata Database
PGR	Annual population growth (in percentage)	World Development Indicators (2017)
UPTP	Urban population as a fraction of total population	World Development Indicators (2017)
DI	Sum of the Freedom House Political Rights and Civil Liberties Indices	Freedom House (2017)

Table 2 Components of Economic Globalisation

Variables	Weightage		Weightage
Economic Globalisation, de facto	**%**	**Economic Globalisation, de jure**	**%**
Trade Globalisation, de facto	50	**Trade globalisation, de jure**	50
Trade in goods	40.9	Trade regulations	32.5
Trade in services	45.0	Trade taxes	34.5
Trade partner diversification	14.1	Tariffs	33.0
Financial Globalisation, de facto	50	**Financial globalisation, de jure**	50
Foreign direct investment	27.5	Investment restrictions	21.7
Portfolio investment	13.3	Capital account openness 1	39.1
International debt	27.2	Capital account openness 2	39.2
International reserves	2.4		
International income payments	29.6		

Source: KOF Globalisation Index (2018)

To examine the validity of the EKC hypothesis, the linear model is transformed into a natural log form to produce consistent and efficient results, as well as induce stationarity in the variance-covariance matrix (Chang et al., 2001). This empirical study considers three models for evaluating the implications of economic globalisation on carbon emission as follows:

Model 1: Economic globalisation (overall index)

$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEG_{it} + \varepsilon_{it} \quad (2)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEG_{it} + \beta_{5i}lnPGR_{it} + \varepsilon_{it} \quad (3)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEG_{it} + \beta_{5i}DI_{it} + \varepsilon_{it} \quad (4)$$

where to measure economic development GDP and GDP^2 are Gross Domestic Product per capita (constant 2010 US$) and squared income per capita respectively, PECP represents total primary energy consumption that encompasses the balance of primary production, external trade, marine bunkers and stock changes, as a fraction of total population, EG represents the overall Economic Globalisation Index, PGR is the annual population growth, and DI is the sum of the Freedom House Political Rights and Civil Liberties Indices as a proxy for the aggregate democracy level. The assigned numerical value for both indices ranges on a scale of 1-7, where 1 indicates the highest degree of freedom and 7 the lowest degree of freedom. Existing literature (Farzanegan & Markwardt, 2018; Joshi & Beck, 2018) have adopted this index as a proxy for institutional quality concerning studies on climate change.

Model 2: Economic globalisation (de facto measurement index)

$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDF_{it} + \varepsilon_{it} \quad (5)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDF_{it} + \beta_{5i}lnUPTP_{it} + \varepsilon_{it} \quad (6)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^{2}_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDF_{it} + \beta_{5i}UPTP_{it} + \beta_{6i}DI_{it} + \varepsilon_{it} \quad (7)$$

where EGDF is the index that includes all the de facto measures of economic globalisation and UPTP represents the urban population as a fraction of total population.

Model 3: Economic globalisation (de jure measurement index)

$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^2_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDJ_{it} + \varepsilon_{it} \quad (8)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^2_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDJ_{it} + \beta_{5i}lnPGR_{it} + \varepsilon_{it} \quad (9)$$
$$lnCO_{2it} = \beta_{0i} + \beta_{1i}lnGDP_{it} + \beta_{2i}lnGDP^2_{it} + \beta_{3i}lnPECP_{it} + \beta_{4i}lnEGDJ_{it} + \beta_{5i}DI_{it} + \varepsilon_{it} \quad (10)$$

where EGDJ is the index that includes all the de jure measures of economic globalisation.

If the null hypothesis, $\beta_1 = \beta_2 = 0$ for all equations (2) – (10), it indicates that CO_2 is not related to GDP. Alternatively, $\beta_1 > 0$ and $\beta_2 = 0$ refers to a monotonically increasing relationship between CO_2 and GDP; and, $\beta_1 < 0$ and $\beta_2 = 0$ represents a monotonically decreasing relationship between CO_2 and GDP. Based on the notion of the EKC model, $\beta_1 < 0$ and $\beta_2 > 0$ expresses a U-shaped relationship between CO_2 and GDP and conversely $\beta_1 > 0$ and $\beta_2 < 0$ indicates an inverted U-shaped EKC relationship between CO_2 and GDP. The expected sign for β_3 in inconclusive, as a positive sign would suggest the continued use of heavily polluting carbon-emitting fossil fuel energies and a negative sign would indicate the adoption of renewable energy such as biomass, nuclear, wind and solar.

The coefficient for the population variables such as population growth and urban population is deemed to be inconclusive. The coefficients could be positive due to the additive effect whereby a rise in population or urbanisation would require vast expenditure by the government to improve on its existing infrastructure or the centralisation of industries (Wang et al., 2014; Zhao & Zhang, 2018). However, a negative coefficient would indicate that industry players and the policies advocated by the government are cost-effective towards addressing issues surrounding climate change (Abdallh & Abugamos, 2017; Lin & Omoju, 2017).

As this would be one of the first studies to examine economic globalisation by segregating both the de facto and de jure measures, the coefficients for these variables are dependent on the scale, technique and composition effects that arise from the impact of globalisation (You & Lv, 2018). From the scale effect perspective, foreign trade and investments, within the ceteris paribus condition, are likely to invest in carbon-emitting production facilities to boost economic growth in these nations. By merely focusing on the growth opportunities and ignoring the effect on the environment, refers to the composition effect. Conversely, with the deployment of new technologies and production methods that focuses on climate change issues, would lead towards the technique effect of globalisation. As such, if the scale effect dominates the technique effect, the coefficient would be positive for the overall economic globalisation index and the economic globalisation (de facto) measurement index and negative for the economic globalisation (de jure) measurement index. However, if the technique effect dominates the scale effect, the coefficient would produce opposing results to all the economic globalisation measurements (Ding et al., 2018; Shahbaz et al., 2016)

For this empirical study, the following plausible hypothesis is formulated to accept or reject the hypothesis in the panel of middle-income nations i.e.

H1: An inverted U-shaped relationship is evident between climate change and GDP per capita based on the overall economic globalisation perspective.
H2: An inverted U-shaped relationship is evident between climate change and GDP per capita based on the economic globalisation (de facto) perspective.
H3: An inverted U-shaped relationship is evident between climate change and GDP per capita based on the economic globalisation (de jure) perspective.

To examine these three models, with equations (2) – (10), the panel Generalised Method of Moments (GMM) technique has been adopted for this study. As the GMM method allow dynamics and utilises predetermined variables and/or lag terms for exogenous variables as IVs, the rationality of the IVs is verified through an inspection. (Halkos & Paizanos, 2013). There are two variations to the transformation methods, known as the first-difference transformation (one-step GMM) and the second-order transformation (two-step

GMM) adopted in varied panel data studies. However, the limitations of the one-step GMM propelled Arellano and Bover (1995) to recommend the adoption of the two-step GMM. If a variable's current value is missing or omitted, a first difference transformation (where a variable's previous value is deducted from its existing value) could potentially lead to a loss of observations (Roodman, 2009). As such, the second-order transformation applies "forward orthogonal deviations" by subtracting the average of all future variables of a particular variable, which averts unwarranted loss of data. This invariably allows a two-step GMM model to provide more efficient and consistent estimates for the coefficients within this area of study (Arellano & Bover, 1995).

Several studies on climate change have applied the GMM technique (Berk et al., 2018; Chaabouni & Saidi, 2017; Rehman Khan et al., 2018) as it provides a thorough theoretical and computational unified framework that estimates the linear and non-linear regressions with endogenous regressors and non-spherical disturbances. The primary empirical strategy for this study is on the system GMM methodology framework. The GMM framework is generally applied in the setting of semi-parametric models and belongs to many estimators, recognised as M-estimators. The estimators are identified by minimising the number of the functions of a criterion. The robust estimator does not require additional information about the precise distribution of the disturbances, as the number of estimates could potentially eliminate the correlation and the heterogeneity between the instruments' variables and disturbance (Al-mulali et al., 2015b).

In our equations (2) - (10), a few prominent variables may be endogenous, attributed to the results of reverse causation. The system GMM estimator is valuable for controlling country-specific effects, resolving omitted variable bias and preserving the cross-country dimension of the data when the first-differenced equation is estimated (Bhattacharya et al., 2017). With the adoption of the system GMM estimator, the endogeneity and reverse causality issues would be addressed.

To address issues of endogeneity, a variant of equation (1) of the GMM model would be stated as follows:

$$CO_{2it} = \beta_1 CO_{2i,t-1} + \beta'_{2i} Z_{it} + \upsilon_i + \mu_t + \varepsilon_{it} \qquad (11)$$

where CO_{2it} is the log of carbon emissions per capita, $CO_{2i,t-1}$ is the lagged dependent variable in the CO_2 Model and Z_{it} represents a vector of control variables as highlighted in preceding paragraphs above in the CO_2 regressions, respectively. The 'i' indicates the countries specification which represents the 76 middle-income nations and the 't' refers to the period spanning from 1994 – 2014. υ_i refers to unobserved fixed-effect term, μ_t represents the time effects, ε_{it} is the residual term in each model, and the βs are respective elasticities concerning carbon emissions. As indicated earlier, all variables, except for the democracy index are measured in logarithm for estimation purposes, and notations for fixed effects and the error terms are maintained across all models (Al-Mulali et al., 2016).

By rewriting equation (11) as a difference equation yields:

$$CO_{2it} - CO_{2i,t-1} = \beta_1 (CO_{2i,t-1} - CO_{2i,t-2}) + \beta'_{2i} (Z_{it} - Z_{i,t-1}) + (\varepsilon_{it} - \varepsilon_{i,t-1}) \qquad (12)$$

By differencing the above equation, unbiased estimates can be derived and unobserved country (υ_i) and time (μ_t) fixed effect can be eliminated, which could potentially lead to omitted variable bias. The underlying problem that arises from the Arellano-Bond difference GMM (Arellano & Bover, 1995) estimator is that the variance of the estimates may increase asymptotically under certain conditions that lead to bias estimates. These conditions arise when the dependent variable follows a random walk that causes the first lag to be an imperfect instrument for its difference. Furthermore, if the explanatory variables are persistent over time, the lagged levels would become weak instruments for their differences and result in considerable finite sample bias (Alonso-Borrego & Arellano, 1999).

To address the issue, Blundell and Bond (1998) developed additional moment conditions for an equation expressed in levels. The two-step system GMM estimator enabled a system containing both the original level equation and the transformed difference equation. The superior effect of the two-step system GMM estimator is demonstrated over the difference GMM equation. It is also evident that system-GMM estimators generate more instruments that remain good predictors for endogenous variables and leads to more reliable results compared to the difference-GMM estimator (Bond et al., 2001; Hauk & Wacziarg, 2009).

For this empirical study, regressions in STATA were conducted with the adoption of the two-step system GMM estimator, consistent with (Roodman, 2006) and are instrumented with GMM-style instruments in each of the models. The reliability of the models is dependent on complying with the Hansen J-test (Hansen, 1982) of over identifying restrictions and the AR(2) test which tests the null hypothesis that there is no second-order auto-correlation or that the error term is not serially correlated. These tests were conducted to examine the validity of the models. If the p values exceed 0.05, the null hypothesis cannot be rejected, attributed to the full set of orthogonality conditions which are valid. A similar principle applies for p-values the autocorrelation test, whereby the null hypothesis of no second-order serial correlation in the first-differenced terms are rejected (Roodman, 2009). Based on the recommendation by Baum et al. (2003), the statistics for the difference-in Hansen test on the validity of the subset of instruments associated with estimating the level equation in the system GMM regression is examined and reported in this study.

EMPIRICAL FINDINGS AND DISCUSSION

Descriptive statistics and correlation analysis

As a preliminary overview of the data, the descriptive statistics for all the variables of study are illustrated in Table 3. Table 4 indicates the correlations between the panel data variables of interest in this study. The correlation analysis illustrates a positive correlation between carbon emission and the respective economic globalisation indices. However, population growth and the democracy index are negatively correlated to carbon emission.

Table 3 Summary Statistics

Variables	N	Mean	Std. Dev.	Minimum	Maximum	Kurtosis	Skewness
LPECP	532	1.116	.224	.802	1.97	4.38	1.241
LGDP	532	7.933	.842	5.505	9.571	2.336	-.232
LGDP2	532	63.634	13.219	30.302	91.596	2.208	-.03
LCO2	532	1.051	.604	.073	2.757	2.489	.529
LPGR	532	1.991	.165	1.222	2.539	4.693	-.911
LUPTP	532	.409	.121	.122	.649	2.418	-.252
LEG	532	3.9	.245	2.896	4.403	4.431	-.924
LEGDF	532	3.952	.325	2.751	4.48	3.398	-.833
LEGDJ	532	3.79	.337	2.834	4.401	2.331	-.381
DI	532	7.655	3.118	2	14	1.911	.164

Table 4 Matrix of correlations

Variables	LPECP	LGDP	LGDP2	LCO2	LPGR	LUPTP	LEG	LEGDF	LEGDJ	DI
LPECP	1.000									
LGDP	0.698	1.000								
LGDP2	0.706	0.998	1.000							
LCO2	0.919	0.738	0.741	1.000						
LPGR	-0.374	-0.178	-0.175	-0.386	1.000					
LUPTP	0.537	0.720	0.718	0.590	-0.123	1.000				
LEG	0.077	0.262	0.248	0.113	-0.107	0.129	1.000			
LEGDF	0.012	0.088	0.076	0.016	0.022	-0.067	0.805	1.000		
LEGDJ	0.133	0.312	0.304	0.195	-0.232	0.266	0.689	0.144	1.000	
DI	-0.136	-0.391	-0.383	-0.184	0.182	-0.268	-0.311	-0.109	-0.383	1.000

Empirical Findings and Discussion

The two-step system GMM method was utilised to estimate the dynamic model of EKC in Equations (2) to (10). The estimation results for the overall index for economic globalisation, the economic globalisation index for the de facto measurement and the economic globalisation index for the de jure measurement are reported in Table 5, Table 6 and Table 7 respectively. The lag range of (2 – 5) was initially adopted for all equations (2) to (10), which indicates the 2^{nd} through the 5^{th} order lag terms of the endogenous variables are included as instruments within the transformed differenced equations. However, the first order lag terms are included in the level equation in the system GMM estimation framework. As the problem of over fitting generally arises in system GMM-equations, which is usually attributed to the usage of large sets of instruments, the restricted lag range of (2 – 4) was adopted for all the three models.

Based on the results in Table 5, the coefficients of the lagged dependent variable are positive and highly significant in all the three models and strengthens the view that carbon emissions are serially correlated and justifies studies on climate change from a dynamic EKC specification. Consistent with other literature on developing and middle-income nations (Adu & Denkyirah, 2018; Joshi & Beck, 2018) the results reveal that economic growth has a positive effect on carbon emission. It is evident that for middle-income countries, environmental pollution increases as it develops by producing goods and services that contribute to the GDP of the economy.

However, the non-significant relationship between economic growth and environmental degradation confirms the non-existence of EKC amongst the middle-income nations. The robustness of the model employed to determine the implications of the overall economic globalisation index on carbon emission is evident, as the strongly significant coefficients across the three models are within a similar range. Existing studies on international trade and foreign direct investments (Behera & Dash, 2017; Fernández-Amador et al., 2016; Sakai & Barrett, 2016) that have been adopted as proxies for economic globalisation have indicated similar findings on the effect of economic globalisation on climate change.

The results in Table 6 and Table 7 provide greater insight into the segregation of the economic globalisation index. From the measurement of the economic globalisation (de facto) measurement, with the inclusion of the urbanisation variable, it is evident that trade globalisation and financial globalisation amongst the middle-income nations could potentially encourage technology transfer and expertise to combat climate change. Furthermore, although the democracy index is not significant, with the inclusion of the variable, the results lend robust support to the existence of an inverted U-shaped EKC for carbon emissions amongst middle-income nations. However, the scale and composition effect of economic globalisation is illustrated by the results exhibited in Table 7. It is evident that with the imposition of trade regulations, trade taxes, tariffs and investment restrictions, environmental degradation is likely to increase as these nations would not be able to capitalise and leverage on technology transfers in their pursuit for sustainable economic growth.

Table 5 Analysis of results for Economic Globalization (Overall Index)

	Model 1	**Model 2**	**Model 3**
VARIABLES	LCO2	LCO2	LCO2
L.LCO2	0.279***	0.465***	0.301***
	(0.089)	(0.174)	(0.102)
LEG	0.212***	0.230**	0.225***
	(0.062)	(0.094)	(0.082)
LGDP	0.683	0.482	0.595
	(0.417)	(0.325)	(0.415)
LPECP	1.023***	0.988**	0.949*
	(0.350)	(0.454)	(0.522)
DI			0.005
			(0.011)
LPGR		-0.404**	
		(0.187)	
LGDP2	-0.047*	-0.026	-0.041
	(0.028)	(0.023)	(0.028)
CONSTANT	-3.945**	-1.046	-3.686*
	(1.711)	(1.631)	(1.951)
Observations	456.000	456.000	456.000
Number of code	76.000	76.000	76.000
No. of instruments	27.000	29.000	32.000
AR2 test (p-value)	0.395	0.688	0.473
Hansen test (p-value)	0.170	0.681	0.469
Diff-in-Hansen (p-value)	0.483	0.732	0.448

Notes: All variables are in logarithmic form. Robust standard errors are in parentheses. The significance of the estimates is denoted by *** $p < 0.01$, ** $p < 0.05$ and *$p < 0.1$. The Hansen J-test and Difference in-Hansen tests denote the over-identification test for restrictions and overfitting problems of attaining too many instruments in GMM estimations respectively. The results reported for both the Hansen J-test and the difference-in Hansen test are in p-values. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences in residuals.

Trade liberalisation and financial liberalisation is necessary amongst middle-income nations to ensure the climate mitigation effects of technology transfer could potentially play an instrumental role to facilitate carbon emission reductions. With early investments in environmental improvements and the deployment of clean technology in these countries may offset the costs of production and increase competitiveness in the long-term. For all models, the relationship between economic globalisation and carbon emissions is robust, irrespective of model specifications, except for one model which includes the urbanisation variable.

Based on the discussion in the preceding section, the reported results on the Hansen test and AR (2) in Table 5 – Table 7 indicates that the over identification restrictions are satisfied and the null hypothesis of no second-order correlation in the first-differenced terms cannot be rejected. By fulfilling these validity tests, the full set of instruments and variables estimates are deemed to be robust and unbiased. The reported statistics for the difference-in Hansen test in Table 5 – Table 7 further indicates that the estimations do not have issues on the overfitting problem of attaining too many instruments, as the null hypothesis cannot be rejected. Consistent with prior studies (Bekhet et al., 2017; Kivyiro & Arminen, 2014) the sign for primary energy consumption is positive and significant in all models.

From the perspective of population growth, a significant negative relationship (overall economic globalisation index) implies a subtractive effect would emerge as increased population growth results in the reduction in carbon emissions. With economic globalisation, government and businesses would be encouraged to deploy cost-effective carbon emission strategies and deploy green technology towards meeting the rising demands of the population in middle-income nations. Increased urbanisation has significant and negative signs, which implies that economic globalisation facilitates improved infrastructure and geared towards sustainable growth (Joshi & Beck, 2018). However, the relationship of the democracy index remains inconclusive due to the mixed results across all the models. The observed results of this study are broadly consistent with existing literature (Behera & Dash, 2017; Pablo-Romero & De Jesús, 2016; Salahuddin et al., 2018).

Table 6 Analysis of results for Economic Globalization (De Facto Measures)

VARIABLES	Model 1 LCO2	Model 2 LCO2	Model 3 LCO2
L.LCO2	0.757***	0.534***	0.478***
	(0.157)	(0.149)	(0.151)
LEGDF	-0.013	-0.101**	-0.168**
	(0.045)	(0.047)	(0.076)
LGDP	0.976***	0.721	1.315**
	(0.312)	(0.522)	(0.532)
LPECP	1.490***	1.044**	1.290**
	(0.470)	(0.451)	(0.521)
LUPTP		-1.285***	-2.094***
		(0.447)	(0.652)
DI			-0.014
			(0.015)
LGDP2	-0.072***	-0.034	-0.068**
	(0.020)	(0.034)	(0.035)
CONSTANT	-4.508***	-0.839	-5.323**
	(1.367)	(1.709)	(2.084)
Observations	456.000	456.000	456.000
Number of code	76.000	76.000	76.000
No. of instruments	15.000	41.000	33.000
AR2 test (p-value)	0.668	0.586	0.938
Hansen test (p-value)	0.291	0.111	0.382
Diff-in-Hansen test (p-value)	0.565	0.275	0.895

Notes: All variables are in logarithmic form. Robust standard errors are in parentheses. The significance of the estimates is denoted by *** $p < 0.01$, ** $p < 0.05$ and *$p < 0.1$. The Hansen J-test and Difference in-Hansen tests denote the over-identification test for restrictions and overfitting problems of attaining too many instruments in GMM estimations respectively. The results reported for both the Hansen J-test and the difference-in Hansen test are in p-values. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences in residuals.

Table 7 Analysis of results for Economic Globalization (De Jure Measures)

VARIABLES	Model 1 LCO2	Model 2 LCO2	Model 3 LCO2
L.LCO2	0.538***	0.424***	0.544***
	(0.155)	(0.135)	(0.147)
LEGDJ	0.125**	0.136**	0.123**
	(0.056)	(0.059)	(0.060)
LGDP	0.348	0.395	0.457
	(0.374)	(0.427)	(0.397)
LPECP	1.016*	1.268**	0.803**
	(0.536)	(0.506)	(0.384)
LPGR		-0.285	
		(0.268)	
DI			0.009
			(0.009)

Table 7 Cont.

LGDP2	-0.020	-0.018	-0.023
	(0.026)	(0.028)	(0.026)
CONSTANT	-2.588	-2.613	-3.051*
	(1.670)	(1.644)	(1.659)
Observations	456.000	456.000	456.000
Number of code	76.000	76.000	76.000
No. of instruments	36.000	43.000	43.000
AR2 p-value	0.489	0.898	0.375
Hansen p-value	0.113	0.301	0.216
Diff-in-Hansen p-value	0.350	0.486	0.363

Notes: All variables are in logarithmic form. Robust standard errors are in parentheses. The significance of the estimates is denoted by *** $p < 0.01$, ** $p < 0.05$ and *$p < 0.1$. The Hansen J-test and Difference in-Hansen tests denote the over-identification test for restrictions and overfitting problems of attaining too many instruments in GMM estimations respectively. The results reported for both the Hansen J-test and the difference-in Hansen test are in p-values. The AR (2) test is the Arellano-Bond test for the existence of the second-order autocorrelation in first differences in residuals.

CONCLUSIONS AND RECOMMENDATIONS

In recent decades, the failures of economic globalisation and its misguided backlash, particularly amongst emerging and middle-income nations have led to the development of policies that have affected climate change. With the intensification of international trade, climate losses are likely to amplify if there is a lack of adaptation measures undertaken by the relevant government and policy makers amongst middle-income nations (Beck, 2008). Our study aimed to investigate whether the Environment Kuznets Curve (EKC) exists amongst 76 middle-income nations from 1994 through 2014. While there is a large body of literature that addresses the implications of economic globalisation on the environment with the adoption of international trade and foreign direct investment as proxies, this paper provides an analysis by further segregating the impact of economic globalisation between the de facto and de jure measurements. We adopted the system GMM approach, due to its ability as reliable predictors of endogenous variables and provides more valid results compared to the difference-GMM estimator (Bond et al., 2001).

As advocated by recent literature (Figge & Martens, 2014; Gygli et al., 2018), to examine economic globalisation, it was pertinent to distinct the compelling differences between these two measurements towards comprehending its effect on the environment. To address this gap, our study incorporated these indexes, with other control variables such as primary energy consumption, population growth, urbanisation and democracy index to assess the EKC patterns exhibited within these regression models. The evidence in these models has been consistent on the non-existence of the EKC hypothesis and the relationship between economic globalisation and carbon emission amongst middle- income nations. However, the model which includes the economic globalisation (de facto) measurement and the urbanisation variable provided an opposing result. The findings provide greater insights for policymakers in middle-income nations to leverage on economic globalisation towards combating climate change.

One of the primary attributes of these results highlights the pertinence of international flows of clean technologies. It is imperative for technological knowledge to cross borders through international trade of capital goods and services, and foreign direct investments. Despite the mixed results on the economic globalisation (de facto) measures, the inclusion of urbanisation validates the rationale for economic globalisation amongst middle-income nations. To the author's knowledge, this would be the first study that examines the impact of economic globalisation on the environment by segregating the indexes between de facto and de jure measures. Based on the findings, it is necessary for policymakers in middle-income nations to identify potential trade barriers and investment restrictions that could thwart the emergence of green technology. Furthermore, by identifying these barriers and restrictions, the creation of new frontier job opportunities could propel these nations towards sustainable growth despite the rise in urbanisation and population growth.

In the current international landscape, several initiatives have been developed by the United Nations Framework Convention on Climate Change (UNFCC) via Article 10 of the Paris Agreement to encourage the diffusion of low-carbon technologies by spurring demand through ambitious emissions reduction objectives. Policymakers and the government in middle-income nations should develop ambitious climate change policies that could induce research and development activities in low-carbon technologies through these international initiatives (Lee et al., 2017). Furthermore, leveraging on the Green Climate Fund could play an instrumental role to materialise compensations through technology-related projects.

Policymakers should develop risk assessment framework and formulate trade or intellectual property laws to preserve their soil sovereignty and ensure the technique effect of economic globalisations dominates the scale effect. Furthermore, governments in middle-income nations should avoid precipitous decisions to spur economic growth without acknowledging its implication on the environment. Holistically, this study provides a pertinent dynamic panel data from the perspective of middle-income nations on the relationships between economic globalisation and carbon emissions. International institutions such as the United Nations and the World Bank should collaborate and coordinate their efforts towards pollution offshoring (Holladay et al., 2018) to reduce environmental degradation. Furthermore, policies executed amongst middle-income nations should be balanced between market-friendly policies to boost sustainable economic growth and policy-stringent initiatives to combat climate change.

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APPENDIX

Appendix 1 List of Middle-Income Countries

Albania	Croatia	Kyrgyz Republic	Peru
Algeria	Dominican Republic	Lao PDR	Philippines
Angola	Ecuador	Lebanon	Romania
Argentina	Egypt	Lesotho	Russia
Armenia	El Salvador	Macedonia	South Africa
Azerbaijan	Fiji Islands	Malaysia	Suriname
Bangladesh	Gabon	Mauritania	Swaziland
Belize	Georgia	Mauritius	Tajikistan
Bolivia	Ghana	Mexico	Thailand
Bosnia-Herzegovina	Guatemala	Moldova	Tunisia
Botswana	Guyana	Mongolia	Turkey
Brazil	Honduras	Morocco	Ukraine
Bulgaria	India	Myanmar	Venezuela
Cambodia	Indonesia	Namibia	Vietnam
Cameroon	Iran	Nicaragua	Yemen
Cape Verde	Ivory Coast	Nigeria	Zambia
China	Jamaica	Pakistan	
Colombia	Jordan	Panama	
Congo	Kazakhstan	Papua New Guinea	
Costa Rica	Kenya	Paraguay	