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Article

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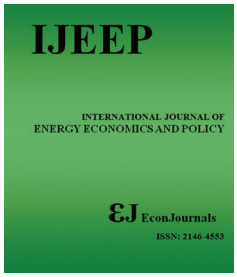

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The Nexus between Technological Advancement and CO_2 Emissions in Malaysia

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ABSTRACT

The key obstacles to attaining the prevailing goal of viable development are environmental degradation and climate change. Copious efforts have been made in this field, but still, the policy embraced and the empirical connection among the factors of carbon dioxide emissions are not evident. The connection between the variables of the analysis is subject to a theoretical and statistical inconsistency in the research. Through this research work, the association between carbon dioxide emissions and its determinants such as economic growth, energy use, financial development and technical progress is examined in Malaysia for the period from 1985 to 2019. The auto-regressive distributed lag method is employed to estimate long-run parameters. The results indicate that during the research period TI has an inverse but negligible impact on pollution in Malaysia. The analysis further shows that higher growth of economy increases long-term environmental efficiency and is consistent with the Kuznets environmental hypothesis. Also, the findings show that financial sector development would minimize emissions of carbon dioxide, thereby enhancing environmental quality in Malaysia. The short-term findings do not validate the EKC hypothesis. The Granger causality results reveal a two-way causality ranging from the growth of the economy to carbon dioxide emissions and TI to carbon dioxide emissions.

Keywords: CO_2 Emissions, Technological Growth, GDP, Malaysia
JEL Classifications: O3, Q3

1. INTRODUCTION

The main purpose of global government policies is pursuing greater and more viable economic growth. However, greater materials and energy input would need to be used to increase industrial activities that pollute the atmosphere and would have adverse effects on the health of people as well as a productivity because a large number of waste byproducts are generated in the procedure. These actions thus increase greenhouse gas (GHG) concentrations and contribute to climate change and global warming. The rise in the average world ocean and air temperatures, increase in the sea level, the melting of snow and ice glaciers as well as the depletion of various species around the world demonstrate the rising GHG concentration that causes global warming and climate change. It is claimed that in 2100 the world's average temperature may increase by 1.2–6.5°C (Bernstein et al., 2007) and sea level may rise about 16.5-53.8 cm and it may jeopardize the life of half of the world's coastal population (Lau and Kim, 2010; Serrano-López, 2020; CC, 2020).

Climate change is said to be one of the biggest challenges to achieve viable development (De, 2013). As a consequence of the degradation of environmental quality in the sense of economic and other activities, climate change and global warming are becoming a high priority for humans in regulating both emissions and global warming. Efforts are being made to decrease the catastrophic impact of global warming by intergovernmental negotiations and bindings. The Kyoto Protocol written in 1997 by the UN Climate Change structure aims to decrease the GHG emitted causing climate change has become one of the key agreements.

The dream of becoming an advanced high-income state is the primary target of Malaysia, with the country following a free

economy export-oriented program. The economic growth of this country has been one of the main factors and progress indicators for national growth and development. The development of the country, infrastructure growth and supplementary basic structure is driven by the growth of the economy. Malaysia, including one of South Asia's rapidly growing economies, relies on fossil fuel, such as oil, gas and coal to maintain its fast economic growth. As a result of construction activities and fossil fuel usage, the country's rapid growth has caused a significant amount of GHG pollution from the atmosphere and has made it more serious with that deforestation to establish more infrastructure buildings and agricultural land. In September 2004 Kyoto protocol was confirmed and since 1974, the Malaysian Environmental Authorities (Ministry of Natural Resources and Environment Malaysia, 2010) has initiated and implemented 35 sets of orders and rules. Irrespective of the government's attempts, air quality has worsened since the 1970s, and the per capita emission of carbon dioxide rose about 1.6 in 1974 and about 7.8 metric tons in 2010. The nation has revealed impressive achievements in economic development grounds since there has been an increase in per income per capita from 200 US$ in 1957 to 10,687 US$ in 2013. Furthermore, in 2010 energy usage has risen to 72645.419 kilo-tons of oil equivalents from 6965.782 in 1974, as shown by 2014 world development indicators.

Follow up the importance of financial growth, if a country would have an efficient and sustainable financial sector, it is said that it will assure, improvement in the investment processes, the financial risks reduction, and also the accumulation of capital etc., which could in effect encourage additional foreign direct investment (FDI) and therefore improve the TI as well as enhance the quality of the environment. It is asserted that fiscal progress is vital to allocate funds to prolific activities furthermore to mobilize savings that improve domestic production and contribute to the growth of the economy. It is speculated that FDI and new environmentally friendly technologies would be encouraged by financial sector development (Birdsall and Wheeler, 1993; Frankel and Rose, 2002). Also, it has been inferred that energy usage could be influenced by financial sector improvement (Islam et al., 2013; Sadorsky, 2010), as well as the emission of CO2 (Alam et al., 2015; Tamazian et al., 2009).

Environmental degradation has become one of the biggest problems in today's world. Several scholars talked about the issue, but perhaps the findings are inconsistent and the issue still exists. Based on the above-mentioned literature and empirical analysis, the main aim of this research is to examine the effect of TI on Malaysia's environmental quality. The study of the connection between TI and carbon dioxide emissions is considered as the fourth IPPC assessment report (Metz et al., 2007) stated that rise in the world's average temperature must not surpass 2°C, and this global average change in temperature could only be kept below 2°C if alternatives to energy technologies are present at an affordable price (Tol, 2007). The paper centred on Malaysia as the state is highly sensitive to weather changes because if the global temperature rises, it will cause extreme floods occurring in the coastlines of Malaysia as well as drought and drinkable water scarcity in some other areas of the country. The research employed yearly data of time series from 1985 to 2019 for Malaysia. The pragmatic research is not only dissimilar from the prior research but also varies from the methods and the explanatory variables used in the analysis. This research is the first of its kind to examine the connection between TI and environment, focusing on the investigator's knowledge of previous studies. This research is even different from the latest (Sohag et al., 2015) study in Malaysia, in which it concentrated on the link between IT and energy usage. In the scenario of Malaysia, the study adds to the TI's information and literature, as well as the effect it has on environmental degradation. The research centred as well on the accuracy of the EKC among the growth of the economy and environmental contamination. Besides, the research is also focused on the effects of the financial development of carbon dioxide emissions.

This analysis is structured as follows. Part 2 is linked to the review of the related literature. Section 3 deals with details, methods and the process of estimating the analysis. Part 4 deals with the statistical findings. Finally, Section 5 contains the findings and suggestions.

2. REVIEW OF RELATED STUDIES

Both politicians and academics have been mystified by the connection between growth of the economy, financial development, trade openness and carbon dioxide emissions. The positive connection among these variables is provided by certain research scientists, while others endorse the inverse or neutral association. This research discusses some of the previous studies to advance the debate.

2.1. Growth of the Economy and Carbon Dioxide Emissions

Every economy's main purpose is to increase economic growth so that it can eventually emerge in developed global economies and this provides an extraordinary and critical environmental response to the growth of the economy, as economic growth influences the natural environment. Growth is recognized at the charge of the quality of the environment, but developed economies have also demonstrated the capacity to adopt environmental-friendly technologies that might boost their livelihoods in turn. As stated by the hypothesis of the EKC, quality of the environment is first exacerbated by the growth of the state; however, the economic growth level, after gaining appropriate growth up to a threshold, will boost environmental quality and there is a situation in which the increasing relations among quality of the environment, income per capita and inequality of income hold the inverse U shape. This research became the first to suggest and endorse this hypothesis (Grossman et al., 1991) but since today the literature of this relation is conflicting. Two distinct EKC specifications have been used to examine the existence of the EKC in a panel of ten MENA countries for 1990 to 2010 in the latest research (Farhani et al., 2014). The analysis inferred an inverse U shape relation linking income and descent of the environment, whereas, in favour of the second-order of the EKC, the analysis established an inverse U shape connection among human resource development and sustainability, known as updated EKC. The EKC Hypothesis Connection among growth and environmental contamination also verified by some of the latest work (Al-Mulali et al., 2015; Apergis

and Ozturk, 2015; Jebli et al., 2016; Onafowora and Owoye, 2014; Shahbaz et al., 2014).

In comparison, a monotonous curve between growth and carbon dioxide emissions is claimed (Douglas and Selden, 1995). The latest research by Begum et al. (2015) examined Malay's economic growth, energy usage, growth of population and carbon dioxide emissions data from 1980 to 2009 time period and found that the relationship between carbon dioxide emissions and economic growth in Malaysia is not inverted. Furthermore, some h researches have also found that there is no inverted U-shaped connection between the growth of the economy and environmental pollution (Al-Mulali et al., 2014; Harris et al., 2009; Halkos and Tzeremes, 2009; Mills and Waite, 2009), and some other. Also, some preceding studies have found that the relationship curve between the growth of the economy and emission of carbon dioxide is N-shape and denies the EKC hypothesis (Friedl and Getzner, 2003; Zarzoso and Bengochea-Morancho, 2004). A Richmond and Kaufmann (2002) study reveals more clearly that the growth of the economy does not interrelate with emissions of carbon dioxide. The analysis, therefore, hypothesizes that the presence of the EKC is validated by summing up the above-mentioned inconclusive and contentious literature.

2.2. Financial Development and Emissions of Carbon Dioxide

One of the growing issues in the latest studies is the connection between financial development and environmental changes. A central factor in attaining economic growth seems to be the participation of developed financial sectors in an economy. The growth could be driven by established financial markets when they are capable of attracting FDIs, and larger investment in study and improvement (Frankel and Romer, 1999), as well as the dimensions of the atmosphere, can, therefore, be influenced. There are also arguments that the utilization of modern environmentally friendly technologies could be encouraged by financial developments which could keep the atmosphere safe, support cleaner production and thus contribute to a rise in regional development sustainability (Birdsall and Wheeler, 1993; Frankel and Rose, 2002). Similarly, energy usage in an economy is anticipated to be directly affected by the advancement of the financial sector (Islam et al., 2013; Sadorsky, 2010) also therefore to influence the emissions of carbon dioxide patterns (Tamazian et al., 2009). Moreover, a similar range of study results asserted that borrowing costs could be reduced and investment behaviour inspired by the financial sector developed (Shahbaz, 2009). However, the financial development could increase the energy sector efficiency which might decrease the emissions of energy (Tamazian et al., 2009) (Tamazian and Rao, 2010). It is indeed sad that the financial advancement of construction projects will support all tires (levels) of government and might even contribute to technological innovation (King and Levine, 1993), which can substantially decrease pollution through effectiveness in energy consumption, and advancing technology (Kumbaroğlu et al., 2008).

On the other hand, the advanced financial sector increases the emission of carbon dioxide by promoting manufacturing activity in the economic systems, besides the establishing role of financial development by evoking energy use and reducing emissions activities. It is also stated that financial development encourages FDI, raise energy usage through investment in innovative ventures, improve capital markets, lend to residents and purchase new facilities, thus growing customer capacity to purchase vehicles contributing to Carbon dioxide emissions (Sadorsky, 2010; Zhang, 2010). Furthermore (Tamazian and Rao, 2010) claimed that the emission of carbon dioxide was driven by financial progress during the transitional period. Moreover, an (Ozturk and Acaravci, 2012) study in Turkey found recently that financial development would not impact emissions of carbon dioxide significantly. Looking at the consideration earlier in this thread, it could be written that the involvement of financial development may profoundly impact the environmental performance (Omri et al., 2015; Ziaei, 2015).

2.3. Technical Growth and Carbon Dioxide Emission

Schumpeter's (1942) philosophy, as quoted in Fields (2004), which defined that the unique and improved technologies come into the market in 3 phases: invention, innovation and dissemination, is theoretically behind the technological change. He claimed that the R and D method had been employed to conduct the process of technology discovery and advancement. Consequently, the diffusion process is carried out when a productive invention is implemented for the required purposes by individuals and organizations and is commonly used in applications concerned. The combined effect of all three is called the method of changes in technology, whether economic or environmental. Since technology is incorporated as a variable in a framework of how the market works, the current paradigm of growth is also defined as 'endogenous' growth theory. In identifying the most important environmental problems, particularly long scale and widespread environmental problems, along with climatic change, it has been mentioned that technological change has critical significance (Bruce et al., 1996; Weitzman, 1997). There can be some grounds for recognizing the value of technical improvements to minimize environmental emissions, including adjustments to the fuel mix; using more energy-efficient manufacturing techniques, and implementing the most appropriate end-of-pipe technology (Bruyn and Sander, 1997). It is argued that the most crucial assumptions regarding the nature and levels of technological change are the evaluation of climatic variations that is the matter of energy as well as the environment in the long term (Yeh and Rubin, 2012). Additionally, investment in research, as well as development and technical improvements, are often claimed as reasons for the decline in carbon dioxide emissions (Jones, 2002). The argument is that, if society accepts costs, new technological developments are seen as reducing the force of the emission resulting from actions of the economy over time, furthermore have been the chief quick fix to the problem of climatic variations. The (Sohag et al., 2015) research recently found that the growth of the economy, as well as trade openness, raises the intensity of energy usage while TI aims to improve energy efficiency and decrease the usage of energy, thereby ultimately minimizing carbon dioxide emissions.

Contrarily, some studies have conflicting consequences on the environmental scenario's position of technology advancement. In research comparing the TI benefits and the optimum control of the contamination (Parry, 2003), it was analyzed to determine

that if it would be TI or the optimum control of the contamination welfare (Pigouvian) that contributes further to the lowering of carbon dioxide emissions. Empirically, the advantages of optimal pollution management are shown to be higher than the social benefits of this. Smulders and Nooij (2003) study argued that induced innovation could only mitigate a decline in per-capita incomes but also that based on energy conservation policies it could not completely counteract its impacts.

The analysis reveals that no such previous studies are available in Malaysia which contains the collection of variables used by this research. The findings of this research will thus contribute significantly to the literary works on the evaluation of the connections between TI and emissions of carbon dioxide for Malaysia plus would also spread to other states in the area. The paper further adds to the literature on the environmental role of financial development as well as on the value of growth in the economy. In this analysis, the role of effective usage of energy consumption in preventing emissions can indeed be understood.

3. DETAILS ABOUT DATA, MODELS, AND TECHNIQUES

3.1. Sources of data

This research focuses on sustainable development as well as analysis of the environmental degradation indicators caused by carbon dioxide emissions. The paper examines the role played in the environmental scenario by growth, financial progress and openness of trade. The research gathered information from the WDI, 2016 because it is a worldwide resource in print by the World Bank, concerning variables such as carbon dioxide emissions (metric tons); growth of the economy (per capita real GDP) financial progress (broad cash), TI (patent applications). Data by the libraries of the International Monetary Fund and Mundi Malaysia Index were also compiled. Here is a control variable, the analysis employed energy usage. During the time between 1985 and 2012, the research examined yearly data since data for the patent applications (TI proxy) are accessible in Malaysia just from 1985 to onwards. The term is indeed following the research of (Sohag et al., 2015) over the timeframe from 1985 to 2012 (Mustapa and Bekhet, 1990), among others from 1990 to 2013.

3.2. Specification of Model

The technology deployment as an endogenous variable provides ways to boost the growth of the economy and productive use of energy. The environment-related research indicates that TI can be implemented to assess its influence on various dependent variables such as consumption of energy, emissions of carbon dioxide and growth of the economy (Chèze et al., 2013; Greaker and Pade, 2009; Sohag et al., 2015). The analysis extracted the role of carbon dioxide emissions from Romer's endogenous growth model and the production function also defined as:

$$Y=f(A, K, L) \quad (1)$$

In which y shows the obtained income, A denotes the technological improvements that Romer regards as endogenous, K indicates a company's capital stock and L reflects the skilled labour available for production. The research technology (A) was substituted by TI in this report. As it is evident that the quality of the environment is influenced by the growth of the economy, which represents the economy's real aggregate output, we can then consider writing carbon dioxide emissions function as:

$$CO_2=f(Y) \quad (2)$$

So, we can write it as:

$$CO_2=f(K,L,TI) \quad (3)$$

Therefore, since there are two different forms of capital, one is a pollutant and another is non-pollutant. Polluted capital is identified as the depleted source of energy emitting capital, while the other one is demonstrated as not depleted and non-emitting resources of energy:

$$K=K_e+K_{ne} \quad (4)$$

Thus, the non-renewable energy usage which is part of the capital is responsible for pollution of the environment, so we can modify the equation of carbon dioxide emissions as:

$$CO_2=f(TI,EC,L) \quad (5)$$

There EC tests energy usage in the kiloton of oil equivalent and corresponds to previous research which includes (Azam, et al., 2015; Saboori and Sulaiman, 2013; Sohag et al., 2015; Moreno et al., 2020; Nunez et al., 2020) along with other tests, TI is measured in patent application form based on the study of Ang (2010a; 2010b); Bonilla et al. (2014); Madsen et al. (2010) and L could be substituted for GDP since labour actions could indeed be taken as the economic activity and could be substituted for GDP. GDP has been calculated in US constant dollars 2005 close to the research of (Alam et al., 2015; Yun, 2020); Azlina et al. (2014); Begum et al. (2015); Saboori and Sulaiman (2013) along with others. Additionally, it could be inferred from literary works that TI could be improved by spending on research activities with the aid of a developed finance market. The analysis, therefore, contained financial development in the function of carbon dioxide emissions. An alternate of broad money (M2), subsequent the research of Ahmad et al. (2015); Akinlo et al. (2010); Alnaif (2012); Bekhet and Al-Smadi (2015); Jenkins and Katircioglu (2010); Li et al. (2015) along with others, calculated its financial development. The function of carbon dioxide emissions can, therefore, be described as:

$$CO_2 = f(EC,\ GDP, TI, M2)$$

By adding the log on both sides, this regression model may further turn into an econometric model:

$$\ln CO_2 = \beta_0 + \beta_1\ \ln EC + \beta_3\ \ln GDP^2 + \beta_4\ \ln TI + \beta_6\ \ln M2 + \mu$$

There, GDP2 denotes the squared term per capita income for EKC validation; GDP shows the per capita income of the state.

TI represents the technology advancement (TI) plus M2 shows the broad money that is a financial development alternate. EC indicates energy usage, and μ represents the model's error term.

3.3. Estimation Procedure

Initially, the data were tested on behalf of the fixed property moreover observed to be not stationary at the level. At first differences, the majority of the sample variables were identified to be stationary, i.e. incorporated in an order, I (1), and TI had been stationary in Level I (0) form. The research agreed to evaluate the long term connection between variables of the analysis build on the incorporation of the variables. The research embraced the long-term association between the variables as an ARDL model. To evaluate the short-term association among variables, the analysis used the error correction mechanism (ECM) in ARDL. The ARDL approach was chosen over other evaluation methods as the ordering of the variable to be used (e.g. I(0), I(1) or both) is not constrained (Persan and Pesaran, 1997). Second, the data generation process by the ARDL test captures ample deficiencies when moving from general to a specific system. Third, the ECM can be used to extract the ARDL in simple linear transformations to accommodate short term changes devoid of disrupting the balance within the long term. In short term imbalances, the error correction term has been employed to indicate the level of alteration for the long term. Fourthly, this technique beats the Johansen and Juselius methodology because of its special features concerning small samples (Pesaran9). Fifthly, this approach is not a residual association and thus endogenous due to its sufficient lag selection (Pesaran9). Sixth, the ARDL procedure can differentiate between dependent and independent variables. The study implemented a RESET test by Ramsey to verify the model's overall stabilization. To prevent the multicollinearity and auto-correlation issues, the study transformed variables into logs and then employed a twice log model, that was consistent by Ang (2009), Shahbaz et al., (2013) for Malaysia and Shahbaz (2012) for Portugal, among others.

4. EMPIRICAL FINDINGS

Data indicate that several of the variables seem to be not stationary in the level because of a rising pattern in the series, whereas the two variables have an unclear trend therefore they are stationary in levels.

4.1. Results of Unit Root Check

Generalized least squares ducky fuller, Augmented Ducky Fuller (1979), as well as Phillips-Perron (1988) measures of the unit root, have been examined for checking the stationarity of time-series data. The test revealed the presence of a unit root in the level form for dependent variable carbon dioxide emissions. The unit root checks further find that growth of the economy, its term of square and use of energy are all embedded within the level form unit root as its statistical values for the DF-GLS, ADF along with PP tests are lower than those of significant values in any relevant level and all probability values could not deny the non-stationary unit root hypothesis.

The research further found that although the TI would not contain unit root in the level form however were levelled stationary because the DF-GLS, ADF as well as PP test stats are higher than that of the critical values on all significance level as well as the sample prob value, therefore, rejects the null hypo at the unit root existence. It is also noticed that the tests of ADF and PP imply the existence of the unit root in the order, whereas the test of DF GLS discards the null hypothesis, arguing that the sequence is levelled stationary at 10% significance level. The findings are given in Table 1.

4.2. Results of ARDL

In the results of the unit root check, the ARDL bound test had been used to investigate the long-term relationship between the variables. It is not possible to apply the Johanson co-integration technique as not all variables are stationary at first difference. To identify long term relationships among the variables of the ARDL method, the researchers used a bond or F-significance analysis of lagged values. The F values determined by Pesaran et al. in 2001 were differentiated with the already provided critical values (Pesaran et al., 2001). For the results of the F-test for co-integration, the numeral of lags in the first difference variables is assumed incredibly crucial. The number of lags is chosen on the premise of another test which might not contradict linear classical regression presumptions. The SIC notes that a single lag of every variable should have been carried in the analysis. The outcomes of the F-state test suggested a long term connection among the variables because the measured F-value exceeds the tabulated value of the higher bounds of the Pesaran et al. (2001). Table 2 shows the ARDL co-integration outcome through the bound check.

The co-integrating value of ECTt−1 is the alternative means of testing the existence of a long term relationship among study variables. This long-term relationship is demonstrated by the adverse and significant value of the ECTt-1. The findings by the error correction (ECT) testing have also shown in the present study that the long term association exists since the value of ECTt−1 is negative and statistically significant. This ECT value is regarded as the place where the short term disequilibrium stir towards equilibrium in the longer term furthermore is recognized like the adjustment speed. In Table 3 of the research, the ARDL long-term findings are presented along with the diagnostic statistical test.

The long-term ARDL technique figures show that the growth in Malaysia seems to comprise a statistically significant as well as positive effect on emissions of carbon dioxide, as well as if country's growth of the economy increases by 1%, the Carbon dioxide emissions increases by 22.62%. So in the context of Malaysia, the growth of the economy on the costs of environmental contamination, there exist a positive effect on pollutant emissions from growth, consistent by the findings of Ang (2008); Azlina and Mustapha (2012); and Saboori et al. (2012) in favour of Malaysia, along with others. Malaysia's figures indicate an increase with per-capita income from the US $1383.29 to US$ 6841.44, which would be a growing trend as per-capita Carbon dioxide emissions increased as of 1.35 metric tons per person to 6.84 metric tons per person. It could, therefore, be asserted that Malaysia's growth of the economy is limited to environmental quality but even that higher incomes can decrease the environmental pollution as per the findings of the EKC, and the country might also concentrate more

Table 1: results of unit root check

Level forms	Test of ADF		Test of PP		Test of DF-GLS	
Variables	Intercepts	Trends and intercepts	Intercepts	Trends and intercepts	Intercepts	Trends and intercepts
$lnCO_2$	−2.027	−1.108	−2.027	−1.108	−0.717	−1.338
lnEC	−1.709	−1.554	−3.231	−1.257	−0.175	−1.725
lnGDP	−1.074	−1.438	−1.094	−1.513	0.407	−1.507
$lnGDP^2$	−0.926	−1.624	−0.943	−1.547	0.473	−1.619
lnTI	−2.785*	−4.068**	−2.785*	−4.066**	−2.459**	−4.221**
lnM2	−1.775	−2.940	−2.544	−2.866	−2.569*	−3.040*
First difference	**ADF test intercept**	**Trends and intercepts**	**PP test intercept**	**Trends and intercepts**	**DF-GLS intercept**	**Trends and intercepts**
$lnCO_2$	−4.315***	−4.710***	−4.317***	−4.710***	−4.420***	−4.903***
lnEC	−5.164***	−5.013***	−5.228***	−7.224***	−4.990***	−5.275***
lnGDP	−4.680***	−4.891***	−4.676***	−4.979***	−4.098***	−4.629***
$lnGDP^2$	−4.781***	−5.009***	−4.780***	−4.914***	−4.212***	−4.693***
lnM2	−5.408***	−5.352***	−6.366***	−6.657***	−4.912***	−5.333***

*, **, *** denotes 10%, 5% and 1% level of significance. GLS is generalized least squares, ADF is augmented ducky fuller, PP is Phillips-Perron, DF-GLS is generalized least square ducky fuller and GDP is a gross domestic product

Table 2: The models of ARDL co-integration

Models	ARDL	F-Stats	ECT_{t-1} (t-stats)	Results
$FlnCO_2$($lnCO_2$/lnEC lnGDP $lnGDP^2$ lnTI lnM2)	1	3.9*	−0.729 (−3.0)***	Co-integration
FlnEC (lnEC/$lnCO_2$ lnGDP $lnGDP^2$ lnTI lnM2)	1	2.9	−0.535 (−3.9)***	Co-integration
FlnGDP (lnGDP/$lnCO_2$ lnEC $lnGDP^2$ lnTI lnM2)	1	12.9***	−0.172 (−2.4)**	Co-integration
$FlnGDP^2$ ($lnGDP^2$/$lnCO_2$ lnEC lnGDP lnTI lnM2)	1	12.8***	0.152 (−2.2)**	Co-integration
FlnTI (lnTI/CO_2 lnEC lnGDP $lnGDP^2$ lnM2)	1	10.9***	−1.537*** (−7.8)	Co-integration
FlnM2 (lnM2/f($lnCO_2$ lnEC lnGDP $nGDP^2$ lnTI)	1	1.6	−0.568 (−2.5)**	No Cointegration
Critical bound value for F-Stats (%)		**Lower bound I(0)**	**higher bound I (1)**	
1		3.41	4.78	
5		3.23	4.65	
10		2.64	3.91	

*, **, *** denotes 10%, 5% and 1% level of significance. GDP is a gross domestic product, ARDL is auto-regressive distributed lag and ECT shows error correction test

Table 3: Long run results of ARDL

Variables	Coefficients	SE	t-stats	P
lnEC	0.00105	0.4339	0.0024	0.998
lnGDP	22.62	6.7297	3.3622	0.003***
$lnGDP^2$	-1.261	0.3926	−3.2132	0.005***
lnTI	-0.2020	0.0947	−2.1334	0.047**
lnM2	-0.0085	0.1102	−0.0776	0.939
C	-97.64	27.741	−3.5198	0.002
Diagnostic tests		**LM version**		**F values**
Serial correlation		2.22 [0.14]		1.522 [0.23]
Functional forms		0.11 [0.75]		0.066 [0.80]
Test of Ramsey				
Jarque-Bera		0.05 [0.98]		Not applicable
Heteroscedasticity		2.40 [0.12]		2.439 [0.13]
P(F-Stats)		136.3 [0.00]		

5% and 1% level of significance are denoted by ** and ***. ARDL is auto-regressive distributed lag, SE denotes standard error and GDP is a gross domestic product

about non-depleted and well-organized utilization of the energy to ensure that growth of the economy continually increases, rather than emissions. During the research period from 1377 in 1985 to 7205 in 2012, the number of patent applications, equally resident as well as non-resident, grew substantively. The outcomes of the long-term research show that technological development has a negative effect on pollution, but currently the negative effect is very low as innovation is at a period when pollution in the environmental sector could not be reduced to a larger degree since pollution will be reduced by 0.22% because of technology developments by 1%. The production process, the only ingredient of economic growth, contributes to a further environmental deterioration. The technological progress has an environmental impact on the reduction of pollution however it is in its initial phase and takes time to prove greater results.

The long term environmental effect of financial development is negligible however it is not necessary that the country's broad money increases as a percentage of GDP might influence the quality of the environment. The results of this research are probably following Shahbaz et al. (2013) work in Malaysia. Interestingly, the outcome of the research is identical to some of (Tamazian and Rao, 2010; Tamazian et al., 2009) who added financial developments within the framework plus stated that the financial progress could indeed minimize environment pollution. Also, in the case of Malaysia during the study, the EKC hypothesis is verified because in the long term there is an adverse association among high income (GDP square) and Carbon dioxide emissions. The connection between increased growth of the economy and environmental emissions is reversed because emissions rise as growth rises, however, the improvements to the connection as well

as a rise in income contribute to improvement in the sustainability of the environment and enhance the quality of the environment. Such research results are consistent with the work of (Saboori et al. 2012) for Malaysia, whereby quality of the environment is initially impaired in Malaysia and afterwards enhanced once the level of income has reached the thresholds since this government and the public are more careful with the environment and use more money to develop the value of the environment.

The usage of energy has a positive effect on environmental contamination and therefore will raise the amount of pollution that is similar to other several studies like (Ang 2008; Saboori and Sulaiman 2013) in addition to the study of (Sehrawat et al., 2015) for Malaysia as well. It has a negligible impact, meaning that Malaysia's use of energy resources might not be the sole source of environmental pollution. The outcome of the test demonstrates that no indication of sequential correlation in the framework was found as the F-statistical value and prob value is higher as well as the null hypothesis of no serial correlation in the model could not be rejected. The research also carried out the Normality test of Jarque Bera and found as to somehow the model has been normally distributed because the Jarque Bera test value is 0.049, as well as the *P*-value, is 0.976. The research found no evidence of heteroscedasticity because the null hypothesis of homoscedasticity could not be refuted with the F-statistics (2.40) and *P*-values (0.12). The model's operational nature is also evaluated for validity through Ramsay's RESET test, which concludes that perhaps the cubical and squared terms of the values in the framework shouldn't be implemented as the tests on the omitted variables in the framework are not suitable. The test values are 0.11 as well as a *P*-value of 0.75.

The short term findings of the paper indicate that Carbon dioxide emissions rise due to the lag value of the dependent variable. The short-term effects of energy usage are positive and not significant compared to long-term outcomes. The short term effect of the growth of the economy is positive as actions of the economy can contribute to further emissions while the income levels are too low. Contrarily, the short-term effect of TI also becomes negative and statistically significant. The technological development in its initial phase is seen in Malaysia to enhance environmental quality. Besides, the influence of financial development on the quality of the environment increases, and loans, as well as investments, appear efficient for improving the quality of the environment. The EKC hypothesis is not short-term since the rising rate of economic growth would harm the climate. This outcome could be clarified because EKC is not a short-run but a long-term phenomenon, therefore the EKC hypothesis would not grasp in the short term. Within the short term, the environmental effects of energy usage are insignificant. Table 4 lists the short-term results. Also, the influence of financial development on the quality of the environment increases, and loans, as well as investments, appear efficient for improving the quality of the environment. The EKC hypothesis is not short-term since the rising rate of economic growth would harm the climate. This outcome could be clarified because EKC would not be a short-run but a long-term phenomenon, so the EKC hypothesis would not grasp in the short term. In the short term, the environmental effects of energy usage are insignificant. Table 4 lists the short-term outcomes.

Table 4: Short term findings

Variables	Coefficients	SE	t-stats	P-values
D(LnEC)	0.766E-3	0.3162	0.0024	0.998
D($LnGDP_{PC}$)	16.624	4.846	3.430	0.003
$D(LnGDP)^2$	0.919	0.2792	3.2937	0.004
D(LnTI)	−0.069	0.03454	−2.0083	0.058
D(LnM2)	−0.0062	0.07986	−0.0780	0.939
ECM	−0.7289	0.2377	−3.0664	0.006
Diagnostic tests				
R^2	0.6698	Durbin-Watson Statistics		2.57388
Adjusted R^2	0.5230	SE of regression		0.06251
P (F-stats)	0.001	RSS		0.07033

EMC is error correction mechanism, GDP shows gross domestic product and SE represent standard error.

4.3. Granger Causality Tests Results

It is asserted that if the variables are intertwined in the long term, they require some kind of one-way or two-way causal connection among them. The test of Granger cause is used to check the direction of the relationship among variable. The research paper acquired the causality directions of the framework by using the granger cause within the model of vector error Correction as VECM contains the short-term as well as the long-term connection among the variables. The Wald test measures the short-term causal relation and the substantial significance of F-statistics demonstrates the short-term existence of causal relations. The long term causality of Granger is evaluated by the statistically significant and adverse coefficient value of the ECT lagged value along with its t-statistics. The present research demonstrates with the intention about the existence of two - way long-term causality among carbon dioxide emissions and growth of the economy that favours the research of Pao and Tsai (2011); Saboori and Sulaiman (2013). The research concluded a long-term two - way causality linking the emission of Carbon dioxide and TIs, that by the assumption that both TI and environment pollution influence one another. So the study indicated a long-term, one-way causality goes from energy usage to the emissions of carbon dioxide are closely related to the research of Apergis and Payne (2009), in favour of central America as well as for the Commonwealth Independent countries (Apergis and Payne, 2010). The research further indicates that the one-way causality association is consistent with the analysis carried out for Malaysia by Shahbaz et al. (2012). Table 5 shows the outcome of long plus short-term causality.

A bidirectional association between growth of economy and energy usage was claimed in the short term by Granger causality. In the same way, two-way causality is also identified among IT and economic growth. There is a one-way causality goes from the growth of the economy and TI to carbon dioxide emissions in the short term. The research also found a short-term, one-way causality goes from financial development to energy usage. Also, Carbon dioxide emissions are causing energy usage. Moreover, it could be asserted that the financial sector development will enhance the growth of the country, granger causality also goes from financial development to economic growth in the short term.

Not the least because all the diagnostic tests have been passed along with serial correlation, heteroscedasticity, functional test,

Table 5: Findings of long and short term causality

Variables	Results of short term causality						Long-term causality
	$LnCO_2$	ECT_{t-1} (t−stats)	$LnGDP_{pc}$	$LnGDP^2$	LnTI	LnM2	ECT_{t-1} (t-Stats)
$LnCO_2$	-	0.860 (0.43)	12.88 (0.002)	12.43 (0.002)	3.64 (0.04)	0.049 (0.82)	−0.32 (−3.64)***
LnEC	3.07 (0.07)	-	2.97 (0.07)	2.72 (0.09)	0.06 (0.80)	3.38 (0.05)	−0.09 (−1.17)
$LnGDP_{pc}$	1.67 (0.22)	3.56 (0.05)	-	15375 (0.000)	6.83 (0.007)	4.90 (0.02)	−0.14 (−2.49)**
$LnGDP^2$	1.63 (0.22)	3.69 (0.04)	15800 (.0000)	-	6.56 (.008)	4.96 (0.02)	−0.40** (−2.40)
LnTI	2.96 (0.10)	2.40 (0.13)	11.10 (.0007)	10.57 (0.000)	-	0.64 (0.43)	−0.73 (−1.99)*
LnM2	1.49 (0.24)	0.93 (0.34)	0.42 (0.52)	0.29 (0.59)	0.51 (0.47)	-	−0.21 (−0.84)

1% and 5% level of significance is denoted by *** and **. GDP represents the gross domestic product, CO_2 is carbon dioxide and ECT denotes error correction test

and normality testing and the model are confirmed to be correct. The research also illustrated the short and long term coefficients by implementing Brown et al. (1975) CUSUM and CUSUMSQ methods to assess coefficient stability.

5. CONCLUSION

Among fastest developing economies of South Asia, Malaysia has a significant number of GHGs released in the atmosphere, and that is the cause of emissions in the atmosphere, because of its heavy reliance on fuel and further liquids (40%), gas (36%) and coal (17%) to fulfil its energy demands (US EIA). The present research explored the connection between the quality of the environment and TI as well as contained other Carbon dioxide emissions factors. The paper revealed that within the short run, the country's growth has been at the charge of the quality of the environment, moreover the paper suggests that this would concentrate further on the future precautionary measures to green and sustainable economic growth. The research also indicated that the growth of the financial sector could contribute to improved environmental quality through investments in developed and environmentally friendly technologies, and therefore investment in the green and long-term environmental friendly technologies must be more centred. The TI Process has been at an early stage in Malaysia, and the study found that the emissions of Carbon dioxide are inversely related so that pollution can be minimized if properly treated. The study proposed that the state should invest more than that in the technological advancement to allow new technology to be imported that might help to limit further emissions of Carbon dioxide through the installation of the system. Energy usage does not have a significant increase in the carbon dioxide emissions which implies that efficiency of the energy is getting better to monitor its rising effect on environmental pollution.

The study's causal findings indicate that the primary cause of carbon dioxide emission is economic growth. The causal research findings were asserted that the energy usage is long-term defiance to the environment in Malaysia because a huge amount of GHG is being emitted into the air as a result of energy usage, such as oil, gas and coal etc, therefore, generate pollution. Contrarily, the study shows that TI, as well as environmental quality, is mutually changing so that TI is a good factor in the emissions of Carbon dioxide along with the betterment in the advancement of technology can direct Malaysia to meet the targets of Carbon dioxide emissions reduction. Besides the research found that in the case of Malaysia, financial developments would lead to a long-term reduction in environmental pollution. The research reveals that a country with higher income per capita as well as an advanced finance sector could lower the environmental contamination by spending further in IT and R & D actions.

These findings of the research could be useful for policymakers and manufacturers to use current energy resources to benefit people and the environment. Due to its geographical position, the coast is vulnerable to floods as well as other regions might be to the verge of intense drought, the paper is particularly relevant as it is highly sensitive to climate change. The current research highlighted the basic indicators of emissions from pollution and attempted to detect the effect to understand the future damages that they induce and to formulation methods of carbon emission reduction and environmental protection to contribute to the reduction of risks from flooding and severe droughts. The conflicting statements and findings examining the association between the empirical and conceptual research variables render this subject more interesting and call for further analysis. The findings of the study would be used by future students and researchers within that area, as they would have an understanding of the importance of the study variables through theoretical as well as empirical grounds. This research will contribute to society as this will increase public consciousness of environmental deprivation and its hazardous effects on the weather patterns.

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