TRADE, CO_2 EMISSION, ENERGY CONSUMPTION AND GDP NEXUS IN THAILAND

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ABSTRACT

This research article evaluates the effective link between CO_2 emission, GDP, energy usage and trade in Thailand by applying the bond test co-integration approach for the period 1981 to 2018. The empirical findings suggest that there are two long-term causal connections among the variables. Three one-way Granger causal associations are established in the short term, ranging from GDP squared, GDP and energy usage to carbon dioxide emission. CUSUM and CUSUMSQ tests had been applied to monitor the constancy in the parameter of the chosen framework. The findings have significant policy ramifications.

Keywords: Trade, CO_2 Emission, Energy Consumption, GDP, Thailand

INTRODUCTION

Over the recent few decades, Carbon dioxide emission could be considered under the heading of the main international ongoing concerns (Jermsittiparsert & Chankoson, 2019; Haseeb, Nasih, Haouas, Mihardjo & Jermsittiparsert, 2020). Worldwide organizations, such as United Nations (UN) and the World Economic Forum (WEF), have sought to lower the detrimental influences on the economy of human-caused climate change. One of the essential steps to lower the Greenhouse Gases (GHGs) is the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UFCCC).

This proposal was confirmed by Thailand, as a developing country in 2003, to reduce the continued rise in the amount of GEG emissions. Back to the history of the GHC inventory for 1994, the greenhouse effect was shown to be relatively limited. Indeed the domestic greenhouse gas emissions in Thailand amounted to just 0.84% of world emissions in 2012. The total emissions of Thailand from 1990 to 2012 stood at 0.75%. Thailand's 2012 GHG per capita was 5.63 t e and per GDP (US$ million) emissions were 409.54 t e which were lower than the world average. Concerning the emissions profile, 67 per cent of all the GHG emissions in Thailand came from the energy sector in 2000. So the evaluation of Thailand's gross emissions by source reveals the predominance of energy in the emission balance. For the base period of 1989, Thailand released a total of 112 Tg COz and 7.0 Mg. The most anthropogenic emissions in Thailand were produced by energy usage, representing 63% of the total emissions of carbon dioxide. The automobile sector was the biggest producer of emissions (43.5% of the overall emissions of carbon dioxide from the energy sector). 31.7% of the total carbon dioxide emission (the second largest proportion of CO_2 emissions) is generated by forests and industrial productions. Wastes constitute a relatively small cause of emissions, by just 1 million tons of CO_2 (3.6 per cent of Thailand gross emissions) (Ministry of Environment Land Planning, 2001).

The World Bank reports that deaths in Thailand due to air pollution rose about 31,000 in 1990 to nearly 49,000 in 2013. Increased levels of air pollution have been generated in Thailand by industrial development. The latest study points to agricultural burning as the cause of PM 2.5 emissions in Thailand. PM 2.5 is a calculation of the particulates in the air smaller than 2.5 microns.

Citation Information: Sukpasjaroen, K., & Chankoson, T. (2021). Trade, CO_2 emission, energy consumption and Gdp nexus in Thailand. *Journal of Management Information and Decision Sciences, 24*(S1), 1-15.

Around 0.8% of the world's CO_2 emissions are generated by Thailand, which is the much lesser rate of per capita emission than the worldwide average (3.25 metric tons, relative to 3.97 per capita worldwide in 2002). Furthermore, from 1991 to 2002, Thailand's cumulative emission of CO_2 has been doubled. (United Nations environment program, UNEP, 2002, chapter 2).The Environmental and Management Authority of the Thailand Administration of the Territory is implementing a substantial project in cooperation with both the National Environment Protection Agency and the International Center for Technology of the Environment (CITET). The goal of this program, by defining, characterizing and reducing fixed (industries) or mobility (transport) pollutant emissions, is to improve the quality of air (Chabban, 2008).

Since 2005 and 2008 renewable energy programs have now permitted the government to save 1.1 trillion dollars in electricity bills, compared to preliminary clean energy infrastructure spending of 200 million dollars. In December 2009, the administration initiated the very first national solar power program as well as other additional measures to increase the proportion of renewable energy sources under 1 per cent to 4.3 per cent in 2014. To execute this programme, overall funding was projected at $2.5 billion, along with the National Fund for 175 million, public sector for 530 million dollars, private sector funding for 1660 million dollars, and foreign collaboration for $24 million, each of them invested in forty renewable projects of energy for 2016. The Production of Energy Export Infrastructure accounts for approximately 40% of income. By 2016, the energy savings might hit 22 per cent, under a decrease in CO_2 emissions

Financial or tax assistance includes a value-added tax privilege award, a decrement in customs duties including a reduced-income bank loan. The reimbursement is funded by the STEG government's monthly utility bills, by the help of local banks to fund projects for Solar Water Heating (SWH) at discounted prices. As compared to the sizes of the monthly payments for an SWH program, this structure has provided direct financial advantages for users. For the very initial two phases (2005–2006), a supplementary interest rate incentive was given to the ultimate borrower and the loan interest rate would be reduced to 0%.

This assistance had been withdrawn in 2007 and the loan reimbursement yearly interest rates were 6.5%. The government subsidizes 20 per cent of device costs or $75 per m^2, whereas the cost of procurement and installation is supposed to be at least 10 per cent of the cost. Greater than 50,000 families in Thailand have solar hot water now dependent on credit worth greater than 5 million dollars in 2005 and 7.8 million dollars in 2006. The government established a rather optimistic goal of 750,000 m^2 from 2010 to 2014, which is equivalent to much larger states like Spain as well as Italy with a system region of up to 400,000 m^2. PERSOL has assisted to avoid gross CO_2 emissions of 214,000 tons by 2008. Several other jobs were generated as a solar market was served by 42 technology suppliers and over 1000 installation firms. The tourism and industrial industries, with 47 resorts operating at the end of 2009, are also participating, and efforts are being made to promote the increased usage of solar energy by the industry (UNEP, 2010).

Recently, some centres and organizations, just like the International Trade Centre, and the World Trade Organization, have concluded that the climate is positive and that trade is mutually beneficial. ICTSD has now become an important aspect. Their main aim is to introduce trade programs as well as environmental and natural resources programs. It includes stakeholders and offers fresh and creative thought about how commercial policies can make an important contribution to the conservation and development of natural resources-based livelihoods in developing countries.

Until 29 March 1995, Thailand has worked as a WTO participant. Thai economists also built in partnership with the organization a theoretical approach to look into how opening up trade may influence the environment and emissions. In such a context, the influence of trade liberalization was first measured on the environmental impact of the NAFTA and was divided through three independent impacts: size, structure and strategy. First of all, the influence of the size

1532-5806-24-S1-83

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indicates the effects of expanded commercial economic activity on GHG emission. The primary idea is whether the opening of trade would raise economic activities and reduce the usage of energy. All else being equivalent would result in higher GHG emissions from this rise in the size of economic activity as well as energy usage. Additionally, the impact of the composition refers to how trade liberalization converts a combination of a producing nation into such goods which have a competitive benefit. The impact on the greenhouse gas emission will rely on the areas of comparative advantage for a state. Since growing sectors are lower energy-intensive versus the contracting industries, the main consequence of such an impact would arise in lower GHG emissions. Furthermore, it is hard to identify in anticipation whether such a composition impact leads to higher or reduced emissions of greenhouse gases. Ultimately, the impact of technology shows that expanding trade will contribute to energy quality betterments. The manufacturing of products and services will also minimize the emission of GHGs, improve energy productivity by increasing the supply of products, service and technology, and enable a trade to tackle the problems of global warming (WTO, 2013).

As the connection among trade openness as well as environmental efficiency at the statistical stage is not reviewed adequately, this article intends to add to the latest research by evaluating for 1971-2008, by applying recent strong econometric methods, the causal link among carbon dioxide emissions, real GDP, energy usage and trade openness in Thailand. We participate in the literature in three aspects. Firstly, none of the research has yet stressed the relevance of this issue in a developing nation like Thailand. Secondly, the research will indeed be conducted while applying simultaneously indicators of energy use and openness to trade using the restricted test technique for co-integration and the ARDL approach within an environmental model setting. Thirdly, in response to the various theories about the connection among variables, the signs and magnitude of the respective coefficients are examined.

The remaining of the article is structured accordingly. The study of literature is discussed in Segment 2. The data and our scientific method are discussed in Part 3. The empirical findings are discussed in Part 4. The conclusion and political consequences are given in Part 5.

LITERATURE REVIEW

Within the latest economic literature, the influence of economic growth, energy use and trade openness have now become a prevalent topic. In addition to showing that there is an inverse U-shaped correlation among environmental pollution and income per capita, this topic has mainly been investigated as part of the Environmental Kuznets Curve.

For various experiments through EKC, the validity of the EKC hypothesis is checked entirely for a particular country as well as a stabilized panel. But such researches can usually be divided into three statistical study groups. The first classification explores the association among growth in the economy and environmental contaminants or indeed the connection among growth in the economy, usage of energy and environmental contaminants (Ang, 2007; Apergis & Payne, 2009; Chebbi, 2010; Ekins, 1997; Fodha & Zaghdoud, 2010; Gale & Mendez, 1998; Grossman & Krueger, 1995; Selden & Song, 1994; Stem & Common, 2001; Stern, Common & Barbier, 1996; Vincent, 1997), while the second category explores the complex connection among growth in the economy, energy usage, environmental pollutants and trade (Halicioglu, 2009; Abdul Jalil & Mahmud, 2009; Jayanthakumaran, Verma & Liu, 2012; Suri & Chapman, 1998). The involvement of other variables which depends on the country or the panel of the studied country presents in the last group (Farhani, 2012; Farhani et al., 2013).

The effect of growth in the economy on the environmental degradation has been discussed by Gale & Mendez (1998) in the first group that doesn't contain trade, (Grossman & Krueger, 1995; Selden & Song, 1994; Vincent, 1997). Stern, et al., (1996); Ekins (1997); Stern & Common (2001)

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did criticize such findings due to the hugely significant impact that methodological preferences of pollutants might have on the outcome. In recent years, Ang (2007); Apergis & Payne (2009); Fodha & Zaghdoud (2010) also analyzed specifically the literature of the complex interaction among pollutant emission, energy usage and efficiency. Ang (2007) analyzed the French case by utilizing methods of co-integration and vector-correction modeling, with the findings of a clear long-term association. The long-term correlation reinforces the point that the growth of the economy has a causal impact on energy usage and contamination growth. The findings even show that somehow the short term causality varies through energy usage to the growth of the economy. The findings of Apergis & Payne (2009) have investigated the correlation of carbon dioxide emission, energy usage and the output for the six Central American states in the Panel Vector Correction framework and suggest that in the long term, energy usage has a direct and significant effect on carbon dioxide emission; however the actual performance is shown by the EKC theory.

Two several analyses have been published related to this research in the Thailand case (Chebbi, 2010; Fodha & Zaghdoud, 2010). The correlation between economic growth and pollutant emissions (CO_2 and SO_2) have analyzed by Fodha & Zaghdoud (2010), and shown a long-lasting interdependence among two-pollutant emissions and GDP. We further discovered that Thailand's growth of the economy will not be disrupted by carbon control measures and further spending in pollution control. Chebbi's (2010) paper gives some premonition into the connections among energy usage, carbon dioxide emissions and business growth components. In the long term, the findings would not support the assertion of impartiality among energy usage and the growth in the production sector. In the short term, the findings suggest that the ties among energy use and growth of the economy including economic growth and emissions from the environment (agriculture, manufacturing and services) are not consistent in all sectors (agriculture, manufacturing and services). To discern the discrepancies in the association between energy usage and growth in production by sector, he recommends pursuing wise energy and environment policy.

About trade in the second category, some of the researchers analyzed how emissions of contaminants, energy usage, production and trade are related to changing conditions. The influence of trade policy orientation on the paradigm of the ECC was examined by Suri & Chapman (1998), who analyzed the effects of the real movement among states of products embodying pollution. The EKC hypothesis was reported to be having considerably increased production, whereas developing as well as developed nations increased energy demands by exporting manufactured products. Simultaneously, the developed world was able to decrease its energy demands through importing manufactured products.

Previously, the ARDL Bounds Tests for Co-integration Method was used to investigate the causative link among carbon emission, energy use, income as well as trade-in Turkey. There have been two long-term equilibrium tests from that of the bounds. The first approach is to understand carbon emission through energy use, employment and business. The second method is that emission of carbon dioxide; energy consumption as well as trade are indicators of income. The empirical pieces of evidence indicate that the income is the major variables accompanied by most of the energy and trade in the first phase that supports the hypothesis of the EKC. The same Halicioglu (2009) technique for the Chinese case is generalized for Jalil & Mahmud (2009). The goal of this research is to determine either EKC is within the long term based on the ARDL technique or related to real GDP per capita. For the sampling timeframe supporting the EKC relation, a quadratic association was established among GDP and CO_2 emissions. Granger's causal test show that GDP to CO_2 emissions differ through one-way causality. Statistical findings show as well that the key indicator of CO_2 emissions is GDP and long-term energy usage. The results of trade on carbon dioxide emission are positive, and yet statistically insignificant.

In some other study, Jayanthakumaran, et al., (2012) examine the co-integration methodology as well as the ARDL technique in China and India over the yearly period, employing

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the long- and short-term linkages tests among CO_2 emissions, growth of the economy, energy use, trade and systemic breakdowns established by the endogenous factors. The outcomes demonstrate how wages, societal changes and energy use have been affected by the carbon emissions in China. There may be no clear causative link for India as far as systemic changes and carbon emissions are concerned as India's informal economy is far greater than that of the informal economy of China. Jayanthakumaran, et al., (2012) further infer that India has an extremely large amount of low-energy, uncompetitive micro-enterprises to meet the global marketplace.

Eventually, it is noted that somehow the controversy on the adoption of urbanization into the stimulus paradigm of the environment has recently been severe (El Hedi, Farhani, Shahbaz & Arouri, 2013; Hossain, 2011) or the adoption of financial development (A Jalil & Feridun, 2011; Ozturk & Acaravci, 2013; Shahbaz, 2013) or bulk of the population (Ahmed & Long, 2012, 2013). Those certain studies have similarly demonstrated that the addition in the EKC equation of controlling variables could increase the adumbration of the impacts of both the production sector (Cole, 2004; Hettige, Mani & Wheeler, 2000; Tisdell, 2001) or the welfare aspects, like those for schooling, healthcare and even more broadly development of human (Gangadharan & Ecological, 2001; Hill & Magnani, 2002; Magnani, 2000), deception, democracy and some more institutional dimensions (Dasgupta, Hamilton, Pandey & Wheeler, 2006; Farzin & Bond, 2006; Lopez & Mitra, 2000) and connected as well both the manufacturing sectors and development of humans (Costantini & Monni, 2006).

Nevertheless, the indications and magnitudes of the corresponding coefficients of the additional variables also differed as well as the assumptions about the links among variables posed some concerns.

METHODOLOGY

Theoretical Framework

Over the previous decagon, there has increasingly been discussion on the issue of excluded variable bias of the income-emission association. Ang (2007); Apergis & Payne (2009, 2010); Lean & Smyth (2010); Arouri, et al., (2012) proposed the connection among income and pollution to the energy usage, as a workaround for avoiding the overlooked variability bias. Also, Antweiler, et al., (2001); Cole & Elliott (2003); Ang (2009) claimed that trade should be included as well. They showed that the environmental impact of trade relies on the nation being examined. Latest is the influence of trade on the nexus to minimize the difficulties of missing vector bias in the empirical calculation, Halicioglu (2009); Jalil & Mahmud (2009); Jayanthakumaran, et al., (2012). In a special multivariate system, we employ this approach. Therefore the subsequent equation is provided for our quadratic log EKC equation used to analyze the interactions among carbon dioxide emission (C), real GDP (Y), real GDP square (Y2) and openness of trade (T) as well as usage of energy (E) in Thailand:

$$C_t = \alpha_o + \alpha_1 . Y_t + \alpha_2 . Y_t^2 + \alpha_3 . E_t + \alpha_4 . T_t + \varepsilon_t$$

There t, α_o and ε indicate time, fix territory impact, as well as white noise stochastic disturbance simultaneously. C refers to the CO_2 emission per capita, Y shows real GDP per capita at constant US dollars for 2005; Y2 refers to real GDP per capita square, E refers to per capita energy usage in kg of oil substitute, and T refers to market transparency (equivalent to the export-import ratio to the GDP). Every variable in Equation (1) is in the innate logarithms. The WDI Indices collect all the yearly data from 1971 to 2008.

α_1,α_2,α_3, and the parameter α_4 contribute to long-lasting carbon elasticity of real GDP production, actual square GDP, energy usage and trade-opening.

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As for predicted signs in Equation (I), it should be assumed that perhaps the α_1 A sign is positive, while for the EKC hypothesis, a negative sign for α_2 is predicted to also be valid. The α_3 a signal is projected to be optimistic as increased energy usage would improve the economy's size and raise carbon dioxide emission. Relying on the economic stage of prosperity for a region, the anticipated sign of $\alpha_4$is varied. This sign is predicted as negative in the context of the developing world because such countries stop exporting and start importing such contamination-intensive items from other states that have less stringent regulations for the preservation of the environment. Nonetheless, this symbol perception in developing nations is inverted as they continue to always have filthy factories with a significant proportion of contaminants (Grossman & Krueger, 1995). Increased trade transparency also implies that emissions rise because of a comparative benefit in polluted manufacturing under lax environmental laws (Jayanthakumaran et al., 2012).

Estimation Method

Over the past two decagons, numerous econometric methods have been used to analyze environmental contamination. There are multiple instances of a univariate method of co-integration with an example of Engle & Granger (1987), the originally proposed methods for FMOLS by Phillips & Hansen (1990), and the original processes for DOLS by Saikkonen (1991); Stock & Watson (1993). There are still several cases in which multivariate methods for cointegration such as Johansen (1988); Johansen & Juselius (1990); Johansen (1995) are theoretically greatest possible likelihood. The most popular method by investigators has been a recently pursued method of co-integration, known as Auto-Regressive Distributed Lag by Pesaran, et al., 2001. In contrast to other single co-integration methods, this co-integration technique, also called bounds checking, has many benefits. It resolved issues of endogeneity and was not capable of evaluating hypotheses on the projected long term co-efficient relevant to the Engle-Granger approach (Engle & Granger, 1987), examined projected long- or short-term coefficients for the given framework, employed the ARDL methodology for checking the long-term interaction among variables genuinely I(0) and purely I(1), or partially incorporated; and the tiny sample characteristics of the bounds testing system were also demonstrated to be much higher than those of multivariate co-integration (Narayan, 2005).

The subsequent unregulated error correction regression of equation (I) had been calculated by the dependent variable as carbon dioxide for Thailand:

$$\Delta C_t = \beta_o + \sum_{i=1}^{p} \beta_1 . \Delta C_{t-i} + \sum_{j=0}^{q} \beta_2 . \Delta Y_{t-j} + \sum_{k=0}^{r} \beta_3 . \Delta Y_{t-k}^2 + \sum_{l=0}^{s} \beta_4 . \Delta E_{t-l} + \sum_{m=0}^{w} \beta_5 . \Delta T_{t-m} + \beta_6 . C_{t-1} . \beta_7 . Y_{t-1} + \beta_8 . Y_{t-1}^2 + \beta_9 . E_{t-1} + \beta_{10} . T_{t-1} + \mu_t \quad \text{(II)}$$

Bounds checking might be the initial step of the ARDL process of cointegration. Proportionately, the mutual test of signification, which indicate no co-integration hypo (H_o:β_i=0; ∀ i=6, 7, 8, 9, 10) against by the alternatives one (H_i:β_i=0; ∀ i=6, 7, 8, 9, 10), would be carried out for the equation (II).

The co-integration bounds checking procedure entails the F-testing for the chosen ARDL methodology, which includes adequate preference criterion lag lengths such as the criterion of Akaike Information as well as the criterion of Schwarz Information. The Maximum 2 lags are added to the level of the variable at this point and afterwards, optimal lag numbers are chosen.

In the second step, it can also be probable to carry out with the specified ARDL description, the general ECM of the equation (II) is constructed as:

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$$\Delta C_t = \phi_0 = \sum_{i=1}^{p} \theta_1 . \Delta C_{t-i} + \sum_{j=0}^{q} \theta_2 . \Delta Y_{t-j} + \sum_{k=0}^{r} \theta_3 . \Delta Y_{t-k}^2 + \sum_{l=0}^{s} \theta_4 . \Delta E_{t-l} + \sum_{m=0}^{w} \theta_5 . \Delta T_{t-m} + \lambda . ECT_{t-1} + \varepsilon_t \quad \text{(III)}$$

Here Δrepresents the initial form of differences; λ represent the parameter for error correction, ECTt − 1 indicate the remaining from the predicted model of co-integration in equation (I), and ε_t shows the disturbance term that supposed to have no relation to the null mean. We define the lagging residual as an error correction term (ECT−1) calculated in equation (IV), and then estimate the short term model parameters:

$$ECT_{t-1} = C_{t-1} - \widehat{\alpha}_1 . Y_{t-1} - \widehat{\alpha}_2 Y_{t-1}^2 - \widehat{\alpha}_3 . E_{t-1} - \widehat{\alpha}_4 . T_{t-1} \quad \text{(IV)}$$

The co-integration ARDL Bound technique is accompanied through the maximum likelihood from Johansen & Juselius (1990) to give an insight into the conclusions.

A concise recall of the multivariate technique of co-integration of the Johansen & Juselius (1990) can be seen here:

$$X_t = A + \sum_{i=l}^{k} \Gamma_i . X_{t-i} + \varepsilon_t \text{(V)}$$

There X_t (C_t, Y_t, Y_t^2, E_t, T_t) is the representation of the matrix of the I(1) endogenous variables, "A" shows the vector of the fixed terms, a matrix of the coefficient is shown by Γ, the lag length is denoted by k, a matrix of residual is shown by ε_t.

All of the equation (V) variables are known to be endogenous theoretically.

Through trace and maximum eigenvalue checks, the co-integrating spectrum can also be identified. The unregulated vector auto-regressive structure lag length in the equation (V) might be formed on the maximisation of the Probability Ratio criteria and minimization of Final PredictoryErrors, Akaike, Schwarz, and Hannan – Quinn (HQ) criteria.

Granger Causality Tests

The Granger Causal check is measured to execute by VECM (Pesaran et al., 1999). Such a panel, which is preceded by Engle & Granger (1987), explores the long-lasting and short term dynamic interactions. In that first phase, the long term parameters are estimated in equation (I). The residuals contributing to an equilibrium deviation shall be obtained. The second stage determines the short term adjustment parameter. In combination with the panel Granger causation analysis the subsequent equations are being used:

$$\begin{pmatrix} \Delta C_t \\ \Delta Y_t \\ \Delta Y_t^2 \\ \Delta E_t \\ \Delta T_t \end{pmatrix} = \begin{pmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \\ \phi_4 \\ \phi_5 \end{pmatrix} + \sum_{k=1}^{m} \begin{pmatrix} \theta_{1,1,k} & \theta_{1,2,k} & \theta_{1,3,k} & \theta_{1,4,k} & \theta_{1,5,k} \\ \theta_{2,1,k} & \theta_{2,2,k} & \theta_{2,3,k} & \theta_{2,4,k} & \theta_{2,5,k} \\ \theta_{3,1,k} & \theta_{3,2,k} & \theta_{3,3,k} & \theta_{3,4,k} & \theta_{3,5,k} \\ \theta_{4,1,k} & \theta_{4,2,k} & \theta_{4,3,k} & \theta_{4,4,k} & \theta_{4,5,k} \\ \theta_{5,1,k} & \theta_{5,2,k} & \theta_{5,3,k} & \theta_{5,4,k} & \theta_{5,5,k} \end{pmatrix} . \begin{pmatrix} \Delta C_{t-k} \\ \Delta Y_{t-k} \\ \Delta Y_{t-k}^2 \\ \Delta E_{t-k} \\ \Delta T_{t-k} \end{pmatrix} + \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{pmatrix} . ECT_{t-1} + \begin{pmatrix} \mu_{1.t} \\ \mu_{2.t} \\ \mu_{3.t} \\ \mu_{4.t} \\ \mu_{5.t} \end{pmatrix} \quad \text{(VI)}$$

If the fixed state effect is ϕ_j (j=1,2,3,4,5); the maximum lag duration defined by the Schwarz Information Criterion(SC) is k (k=1, ...,m), ECT_{t-1} is projected to have a lagged error correction time based on the long-term association set out in equation (I) and predicted through equation (IV), λ_j (j=1,2,3,4,5) is the coefficient of adjustment, and $\mu_{j,t}$ (j-1,2,3,4,5) is the concept of disturbance expected to have zero means of adjustment.

Contrary to equation (III), every vectors of error-correction in the equation (VI) calculated in almost similar lag structure is an unregulated VAR setting (p=q=r=s=w=m).

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Instability Tests

The nature of a co-integration resulting through the equation (II) according to Bahmani-Oskooee & Chomsisengphet (2002) indicated that the calculated coefficients would not inevitably imply that they have been stabilized. In general, Chow (1960); Brown, Durbin & Evans (1975); Hansen (1992); Hansen & Johansen (1999) search for the volatility of regression model coefficients. A previous awareness of structural breaks during the evaluation time is known from the Chow (1960). The stability checks requiring I(1) variables in Hansen (1992); Hansen & Johansen (1999) processes demonstrate long-lasting parameter accuracy, without even the inclusion of a model's short-lasting directions, as stated in Bahmani-Oskoee & Chomsisengphet (2002). The long-term dynamics to the Short run can, therefore, be integrated by residuals into stability checks of Brown, et al., (1975), recognized as both the cumulative sum, as well as the cumulative sum of squares. The stats of CUSUM and CUSUMSQ are recurrently modified and compared to the break-points of the framework. Plots of such statistics within critical limits of 5 per cent, the coefficients of a particular regression will be assumed to be constant. Farhani (2012a) describes the experiments in further description.

EMPIRICAL RESULTS

Unit Root Test Results

Two root unit tests are carried out through the implementation of the time-series features of the equation (I) variables: Test of Phillips & Perron (1988) and test of Dickey & Fuller (1981). Every series in Equation (I) are shown by the findings in Table 1 and seem to have a unit root at the levels however in their initial discrepancies seems stationary. We, therefore, assume that they would be incorporated at 1 per cent significance level at order one, I (1) (Table 1).

Table 1
TESTS OF UNIT ROOT

		C	Y	Y^2	E	T
ADF	Levels	-2.33404	-0.44015	-0.08411	-1.92849	-2.44911
		(0.1671)	(0.8916)	(0.9439)	(0.3161)	(0.1359)
	First differences	-7.31123	-9.030495	-8.55652	-8.25972	-4.44250
		(0.0000) *	(0.0000) *	(0.0000) *	(0.0003) *	(0.0011) *
PP	levels	-2.79396	-0.41856	-0.03733	-2.77522	-2.31244
		(0.0689) ***	(0.8955)	(0.9489)	(0.0716) ***	(0.1735)
	First differences	-7.21074	-8.65244	-8.150293	-8.09961	-4.42409
		(0.0000) *	(0.0000) *	(0.0000) *	(0.0000) *	(0.0012) *

ADF, as well as PP, consider non-stationary null hypo. To pick the correct lag length for the ADF, the program EViews 7 is employed. The appropriate lag period is the lag rates which inflate the Akaike information criteria.

In PP, the spectro-estimation approach can also be used for the Barlett kernel. The Newey – West approach is being used to choose bandwidth. * And * * * reflect the 1- and 10-per cent statistical importance.

Co-integration Test Results

Provided the common integration properties of $C_t Y_t Y_t^2 E_t$ and T_t, equation (II) were determined in two phases. The long-term association of equation (I) in the first stage of the ARDL process was taken by two moves. First, by minimal final forecasting error criteria, Akaike Information Criteria, Schwarz Information Criteria and Hannan-Quinn, as well as by maximized

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Citation Information: Sukpasjaroen, K., & Chankoson, T. (2021). Trade, CO_2 emission, energy consumption and Gdp nexus in Thailand. *Journal of Management Information and Decision Sciences, 24*(S1), 1-15.

probability ratio, the order of lags, that would be used to evaluate later VAR or VECM structures. The outcomes of such a step are being shown, except AIC, to preserve the optimum lag (Table 2). With this lag, the outcome of the maximal eigenvalue analysis of Johansen, which is established on Johansen (1988) as well as the updated version of Reinsel & Ahn (1992), indicates that there have been three co-integrated connections at 5 per cent (Table 2, b).) Second, the lag order (p, q, r, s, w) of the first variables of a differential equation (II) was acquired from the minimal of the Akaike information criteria and Schwarz information criterion parameters (the lag duration has been employed for two). The optimal lags are chosen for Akaike information criterion by minimizing this criteria: p=2, q=2, r=2, s=0, w=1 while minimizing Schwarz information criterion is chosen: p=0, q=0, r=0, w=1, s=0 (Tables 2). Diagnostic variations also arise in the implementation of such requirements (Farhani et al., 2013; Farhani, 2012). In this case, the intention of the study to monitor autocorrelation for innovations needs to be understood very well. It is recommended to evaluate a framework that contains the minimum lags and that addresses the lack of residual autocorrelation also, in compliance with the parsimony theory (Raykov & Marcoulides, 1999).

Table 2
FINDINGS OF CO-INTEGRATION AND MOST FAVOURABLE LAGS

The criterion for selecting VAR lags order						
Lags	**LogL**	**LR**	**FPE**	**AIC**	**SIC**	**HQ**
0	210.739	NA	5.39e-12	-11.7565	-11.5343	-11.6798
1	397.449	309.406[a]	5.32e-16[a]	-20.9971	-19.6639[a]	-20.5368[a]
2	422.238	33.9954	5.91e-16	-20.9850	-18.5409	-20.1413
3	449.132	29.1994	6.85e-16	-21.0932[a]	-17.5382	-19.8660

‘

Table 3
TEST[a] Of Johansen Maximal Eigenvalues

Deliberated no.of CEs	Eigenvalues	Statistics trace	Critical values 5%	Prob *
None*	0.79331	124.544	69.8189	0.0000
Not more then 1*	0.63573	67.7890	47.8561	0.0002
Not more then 2**	0.36958	31.4342	29.7971	0.0321
Not more then 3***	0.32403	14.8247	15.4947	0.0629
Not more then 4	0.01999	0.72675	3.84147	0.3939

’

Table 4
OPTIMAL LAG ORDER (P, Q, R, S, W)[a]

Lags	AIC	SIC	Lags	AIC	SIC
P=1, q=0, r=0, S=0, w=0	−3.27754	−2.79368	p=2, q=1, r=0, s=0, w=1	-3.38959	−2.767453
p=1, q=1, r=0, s=0, w=0	−3.22271	−2.69487	p=2, q=1, r=1, s=1, w=0	-3.20809	−2.541513
p=1, q=0, r=1, s=0, w=0	−3.22229	−2.69445	p=2, q=1, r=1, s=0, w=1	-3.33608	−2.669500
p=1, q=0, r=0, s=1, w=0	−3.30168	−2.77384	p=2, q=1, r=1, s=0, w=1	-3.29377	−2.582749
p=1, q=0, r=0, s=0, w=1	−3.35233	−2.82449	p=2, q=2, r=0, s=0, w=0	-3.18169	−2.559546
p=1, q=1, r=1, s=0, w=0	−3.25508	−2.68325	p=2, q=2, r=1, s=0, w=0	-3.17221	−2.505627
p=1, q=1, r=0, s=1, w=0	−3.30301	−2.73118	p=2, q=2, r=0, s=1, w=0	-3.18694	−2.520360
p=1, q=1, r=0, s=0, w=1	−3.30706	−2.73523	p=2, q=2, r=0, s=0, w=1	-3.36019	−2.693616
p=1, q=1, r=1, s=1, w=0	−3.29525	−2.67944	p=2, q=2, r=1, s=1, w=0	-3.15406	−2.443046
p=1, q=1, r=1, s=0, w=1	−3.30239	−2.68657	p=2, q=2, r=1, s=0, w=1	-3.31793	−2.606917
p=1, q=1, r=1, s=1, w=1	−3.32227	−2.66248	p=2, q=2, r=1, s=1, w=1	-3.26290	−2.507449
p=2, q=0, r=0, s=0, w=0	−3.29230	−2.75904	p=2, q=2, r=2, s=0, w=0	-3.28101	−2.569989
p=2, q=1, r=0, s=0, w=0	−3.23577	−2.65807	p=2, q=2, r=2, s=1, w=0	-3.27744	−2.521981
p=2, q=0, r=1, s=0, w=0	−3.23553	−2.65783	p=2, q=2, r=2, s=0, w=1	**-3.55541**	−2.799957
p=2, q=0, r=0, s=1, w=0	−3.28126	−2.70355	p=2, q=2, r=2, s=1, w=1	−3.50019	−2.700294

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p=2, q=0, r=0, s=0, w=1	−3.44491	**−2.86721**	p=2, q=2, r=2, s=2, w=0	−3.22841	−2.428519
p=2, q=1, r=1, s=0, w=0	−3.21184	−2.58970	p=2, q=2, r=2, s=2, w=1	−3.44668	−2.602358
p=2, q=1, r=0, s=1, w=0	−3.24393	−2.62179	p=2, q=2, r=2, s=2, w=2	−3.39162	−2.502846
"a" indicate the preferences of optimum lags					
"b" trace checks indicate that 3 equations co-integrate at the level of 5 per cent					
1 5 and 10 per cent level of significance is denoted by *, ** and ***.					
# MHM of MacKinnon et al. (1999) P values					
Values of minimal AIC as well as SIC shown in bold statistics					

The long-term, as well as short-term coefficients in Thailand, were determined with the ARDL method employing Equation (II) (Table 5)

Table 5 findings show that if we look at the one-year gap in the emission of carbon dioxide in the equation then the coefficient (0.29) has become much smaller. Table 5, therefore, notes that real per capita GDP with a real per capita GDP square would have a significant long-term as well as a short-term effect on the carbon dioxide emission per capita. Most specifically, a 1 per cent rise in real per capita GDP would raise the per capita CO_2 generated by 4.67 per cent across the long-term and by 6.66 per cent in the short-term, both are significant at 5 per cent. Contrarily, a 1 per cent rise in the square GDP per capita will correspond to a 0.28 per cent lower emissions of carbon dioxide in the long term and a 1.76 per cent fall in the short term, as both are significant at the level of 5 per cent.

Table 5
FINDINGS OF ARDL-ECM

a. ΔC_t as a dependent variable relying on ARDL (2,0,0,0,1) chosen lags rely on SIC			b. Vector co-integrating: the dependent variable is ΔC_t		
Regressor	Coefficient	T ratio	Regressor	coefficient	T ratio
ΔC_{t-1}	0.29197	2.2815**	Y_t	4.67092	−2.4643**
ΔY_t	6.66350	−3.6771**	Y_t^2	−0.27856	2.3433**
ΔY_t^2	−1.71864	3.6182**	E_t	0.44590	−3.9748**
ΔE_t	0.70008	3.4577**	T_t	0.00998	0.3997
ΔT_t	0.186138	−3.0377**	Constant	−21.7008	
Constant	0.01524	1.7477***			
R^2= 0.74	F=68.83**	DW=2.47	ECT_{t-1}	−0.54659	−2.3621**
SSR=0.03					
5 and 10 per cent level of significance is denoted by ** and ***.					
Durbin-Watson stat is shown by DW and the sum of the square residual is shown by SSR					

The elasticity of carbon dioxide emission for per capita real income in the long term is 4.7–0.3Y to support the results of the derivative study. The positive indication for real GDP (Y) per capita on a natural logarithm and the inverse signal for actual GDP (Y^2) per capita on a natural logarithm is supposed to defend the EKC hypothesis that contamination emissions originally rise with income and subsequently decline since income grasp to a certain point.

The empirical value of real GDP per capita square consists of showing laws that monotonously increase GDP with carbon dioxide emission rates. The findings, predicted in the EKC model, are supporting the eventual rise in pollutants emission by GDP and a decline preceding the GDP's stabilization stage. Yet per capita emissions of carbon dioxide as well as actual GDP per capita do not help the EKC statement.

The same table also shows the long-term as well as a short-term beneficial effect of per capita energy usage on the emission of carbon dioxide. The consequences indicate that a 1 per cent rise in per capita usage of energy would results to a long-term rise in the emission of carbon

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dioxide by 0.45 per cent and a substantial increase by 0.7 per cent in short term, both at 5 per cent significance level.

The trade findings show a limited yet positive short-term connection to carbon dioxide emission. Further, in-depth, a 1 per cent rise in the free trade would boost short-term emission of carbon dioxide about 0.19 per cent, dramatically at a 5 per cent level of significance. Our results are also coherent with the Selden & Song (1994); Grossman & Krueger (1995); Ang (2007); Halicioglu (2009); Jayanthakumaran, et al., (2012). We consider the u-shape association as well among pollution and production (Hussain et al., 2020).

The ECTt-1 error correction term reflects the motion at which carbon dioxide adapts to its long-term equilibrium after a collapse. With a minus sign predicted, the coefficient of −0.55 is substantial at a 5 per cent level, indicating that such an irregular divergence from the long-term carbon dioxide level in one year is reversed through 55 per cent in the next year. Furthermore, a substantial error correctional affirms that the reverser (Y_t, Y_t^2, E_t, T_t) and the dependent variable carbon emissions (C_t) achieve a stable long-term association.

Diagnostic checks indicate that almost all repetitive, functional, normal and heteroscedasticity checks have been done by the framework. R^2's higher value for the ECM-ARDL methodologies indicates a very good adaptation of the ARDL framework. Statistically important were the F-statistics, which calculated the joint value of all the regressors in the frameworks at a 5 per cent level and the Durbin-Watson statistics were higher than two for the model (Table 3).

Granger Causality Tests Results

There are three interrelationships among $C_t, Y_t, Y_t^2, E_t,$ and T_t based on maximal eigenvalue tests findings shown in the Table 2 B. The Granger causal check for equation (VI) was then executed that the error correction term was calculated for just four long term associations (Table 2, b). Table 6 sums up the long term and short-term correlation findings for Granger cause. The long-term connection prevails between variables in the context of equation (I) depends on the coefficient of the lag error-correcting term as the statistically relevant error-correction expression supports the findings of the bounds check. Absolute GDP, real GDP square, usage of energy, as well as trade induce to Carbon emission in the long-term. There could be further long-term Granger cause that interactively passes across error-correction expressions, such as energy carbon emission, actual GDP, real GDP square and trade through the use of energy.

Nonetheless, in the short-term Table 6 disclose that the associations between real GDP, real GD square and usage of energy to the emission of carbon are three one-way Granger variables. This finding supports Ang's (2007) research, which shows that environmental pollution would not affect the growth of the economy or energy use. Instead, global growth and energy have a causality impact on the emission of carbon. The findings advocate for improved safety of the environment because environmental pollution can have an impact on people’s health and thus decrease efficiency on the external benefit of economic resources. This implies that strategies with greater costs like taxes on the environment could also result in a replacement of raw components by decreasing or raising the level of pollution. The findings show that Thailand's long-term economic success hasn't been reverse to the introduction of energy storage initiatives. The findings, therefore, suggest that Thailand's economy would be far less sensitive to power disturbances that can harm the growth of GDP. To those polluting emissions, it is important to utilize more energy and economic growth in the short-term. Through implementing energy-saving techniques, this issue can be addressed.

Table 6
TEST OF GRANGER CAUSE

Measured variable	F-Stats	ECT_{t-1}

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	(Probilities)				[T-Statistics]
	ΔC_t	$\Delta Y_t - \Delta Y_t^2$	ΔE_t	ΔT_t	
ΔC_t		3.0498**	3.0525**	0.6519	−2.63858*
		(0.0456)	(0.0455)	(0.5887)	[−5.1635]
$\Delta Y_t - \Delta Y_t^2$	0.2349		2.1093	0.2420	−2.40044
	(0.8712)		(0.1225)	(0.8662)	[−1.3460]
ΔE_t	1.3955	0.9906		1.4251	−1.15355*
	(0.2656)	(0.4121)		(0.2571)	[3.5109]
ΔT_t	1.3939	0.0913	0.1406		−0.05291
	(0.2660)	(0.9642)	(0.9348)		[−0.1375]
1 and 5 per cent level of significance is indicated by * and **.					

Stability Tests

Equation's (II) error-correction models formed on SIC are chosen for CUSUM & CUSUMSQ instability checks implementation. The figures from CUSUM and CUSUMSQ would have been right within critical limits at 5 per cent, which means that those error correction specification coefficients seem to be stabilized. The chosen framework of carbon emission is therefore available for policy decisions consequently, as the policy adjustments in this equation tend to be sustainable over the expected duration, their impacts regarding explanatory emission variables do not cause significant disruption of the level of carbon emission (Halicioglu, 2009).

CONCLUSION

This study explores the vital connection among carbon emissions, real GDP, usage of energy and trade for Thailand. For the measurement of short term as well as long term elasticity of carbon dioxide emission, the long-term association with carbon dioxide emissions regarding explanatory variables has been employed. In terms of real GDP, the long-term carbon dioxide elasticity is 6.66–3.44Y. Analogously, the elasticity of carbon dioxide emissions regarding usage of energy is estimated at 0.7. Also, carbon dioxide emissions are estimated to be 0.19 elasticity in the long term regarding trade. The latest Chebbi, et al., (2011) research shows that somehow the direct impact on carbon dioxide emissions of free trade has been both positive in the short term as well as in the longer term. However, in the longer term, the indirect impact at least is adverse. The comprehensive impact would be both optimistic in the short term as well as within the long term, emphasizing the value of good environmental strategies for trade development.

The Granger causal check shows two long-term associations. Firstly, true GDP and actual square GDP, energy usage and trade seem to be responsible for the emission of carbon dioxide, secondly, a long-term Granger's cause, that involves from energy carbon dioxide emission, real GDP, actual squared GDP and trade to energy use. In the short term, however, Granger's causal check shows three unidirectional relations that range through real GDP, real GDP square, and usage of energy to the emission of carbon dioxide. The latest research of Fodha & Zaghdoud (2010) explores the link among Thailand's economic growth & emissions of pollutants, suggesting that either the one-way causality through income bring environment change and not the other way around implies a strategy towards reducing emission as well as making the additional expenditure for pollution reductions would not harm the growth of the economy. For Thailand to attain its long-term viable growth may be a probable political weapon.

The carbon dioxide-equation instability checks indicate that new policies which consider explicative variables of carbon dioxide emission equation do not advocate substantial fluctuations in

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CO_2 emission rates. The findings indicate that further environmental strategies must be formulated in Thailand to limit environmental degradation.

ACKNOWLEDGEMENT

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