Pruethsan Sutthichaimethee; Danupon Ariyasajjakorn

Article

The management efficiency of the sustainable development policy under Thailands energy law : enriching the SEM-based on the ARIMAXi model

Reference: Pruethsan Sutthichaimethee/Danupon Ariyasajjakorn (2021). The management efficiency of the sustainable development policy under Thailands energy law : enriching the SEM-based on the ARIMAXi model. In: International Journal of Energy Economics and Policy 11 (5), S. 472 - 482.
http://econjournals.com/index.php/ijeep/article/download/9995/6046.
doi:10.32479/ijeep.9995.

IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals
ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(5), 472-482.

EJ EconJournals

The Management Efficiency of the Sustainable Development Policy under Thailand's Energy Law: Enriching the SEM-based on the ARIMAXi model

Pruethsan Sutthichaimethee*, Danupon Ariyasajjakorn

Faculty of Economics, Chulalongkorn University, Wang Mai, Khet Pathum Wan, Bangkok 10330, Thailand.
*Email: pruethsan.s@chula.ac.th

Received: 28 May 2020 **Accepted:** 20 April 2021 **DOI:** https://doi.org/10.32479/ijeep.9995

ABSTRACT

The purpose of this research is to analyze the relationship of causal factors and the error correction ability of these factors, including economic growth, government policy, and environmental growth, under the energy law of Thailand. This research proposes a novel structural equation model called the "Structural Equation Model based on Autoregressive Integrated Moving Average with Observed Variables (SEM-based on the ARIMAXi model)". The validity of this proposed model is confirmed upon testing the goodness of fit and white noise property. Upon analysis, this research reveals that the SEM-based on the ARIMAXi (1,1,1) model is composed of causal factors, where economic growth was found to be related to environmental growth with an influential impact rate of 0.76 per cent at a confidence interval of 99 per cent. The relationship between economic growth and government policy was also detected to have a 0.51 per cent impact at a confidence interval of 99 per cent. Furthermore, this research identifies government policy as being related to environmental growth with an impact of 0.19 per cent at a confidence interval of 99 per cent. In addition, this research indicates that economic growth is the strongest factor with an error correction ability of -0.74, followed by government policy and environmental growth factors with an error correction ability of -0.45 and -0.06, respectively. With the weakest error correction ability in environmental growth, this suggests that the government must intervene in taking action to preserve the environment.

Keywords: Structural Equation Model, Greenhouse Gases, Carrying Capacity, Energy Consumption, Error Correction Mechanism, Causal Factors
JEL Classifications: P28, Q42, Q43, Q47, Q48

1. INTRODUCTION

Over the past 30 years, Thailand has undergone rapid and continual development (The World Bank: Energy Use (Kg of Oil Equivalent Per Capita) Home Page, 2020; Office of the National Economic and Social Development Council: NESDC, 2020). The government has contributed to this development through various active and passive measures as to realize economic growth. The government has also empowered domestic production and processes in order to satisfy domestic consumption and overseas exports (NESDC, 2020; National Statistical Office Ministry of Information and Communication Technology, 2020). The said production has also focused on certain industries, especially textiles, gems and jewelry, car parts accessories, and agricultural industries. The result of this focus is the large amount of national revenues (NESDC, 2020). Indeed, the Thai government has its own agencies and representatives overseas ready to support Thai businesses in their penetration and expansion into foreign markets (National Statistic Office Ministry of Information and Communication Technology, 2020). At the same time, the government has also emphasized production bases within the country in order to optimize from a mechanism of foreign direct investment. This process is done by collaborating with key trading partners investing in the key local industries. This collaboration has enabled Thailand to increase national revenue while continuously providing laborers in Thailand with career opportunities. Further efforts have also borne fruit when Thailand has established various industrial areas and expanded these industries across all provinces within the country (NESDC, 2020; National Statistical Office Ministry of Information and Communication Technology, 2020).

In addition, the government encourages foreign businesses to manufacture products and services and attract foreign investors to make investments in Thailand, and in return enjoying various tax incentives (Sutthichaimethee, 2017 NESDC, 2020). This promotion has allowed Thailand to enjoy economic growth all these years, and this growth is reflected in the continuous increase in gross domestic products in various related aspects (NESDC, 2020; National Statistical Office Ministry of Information and Communication Technology, 2020; Sutthichaimethee, 2018). Furthermore, the government has made additional efforts to attract foreign tourists, especially European and Chinese travelers, to visit Thailand by exempting them from various taxes. This promotion also allows Thailand to generate revenues, resulting in the improvement of national income and the economy as a whole (Sutthichaimethee et al., 2019; NESDC, 2020). This governmental effort has enabled the creation of job opportunities for the people, allowing them to work in different occupations, such as tour guides and in souvenir shops and local restaurants (NESDC, 2020; Sutthichaimethee and Naluang, 2019). From its own perspective, the government has established various measures in generating higher national income for Thailand to stimulate economic growth and job creation for people in the country. Among them, the investment in many large and mega projects across the country. In this regard, the government set a policy of using the Gini coefficient as a significant indicator to show Thailand's inequality of income distribution, with a rate of 0.4 to 0.5 have been calculated for the country (National Statistical Office Ministry of Information and Communication Technology, 2020). The said policy is also considered a crucial tool for Thailand in achieving the sustainable development goals and economic growth (Sutthichaimethee, 2016; NESDC, 2020).

However, the sustainable development goals under energy law (Pollution Control Department Ministry of Natural Resources and Environment. Enhancement and Conservation of National Environmental Quality Act, BE 2535, 2020) in Thailand must be determined and the importance of doing so recognized in terms of economic growth and government policy. The best indicator of these goals can be reflected through environmental growth (Pollution Control Department Ministry of Natural Resources and Environment. Navigation of Thai Waterways Act, BE 2546, 2020). From the past (1990) to present (2019), total energy consumption has grown continuously at a higher rate (United Nations Framework Convention on Climate Change, UNFCCC, Bonn, Germany, 2016). Furthermore, the energy intensity has also increased continuously (NESDC, 2020; Pollution Control Department Ministry of Natural Resources and Environment, 2020). The same incremental trend is evident in the greenhouse gas emissions of Thailand, especially CO_2 emission, which has risen from 1990 until 2019 (Department of Alternative Energy Development and Efficiency, 2020; Thailand greenhouse gas management organization (public organization), 2020; Sutthichaimethee and Ariyasajjakorn, 2017). Therefore, there is no doubt as to why the environment and national ecosystems have suffered damage.

In this extent, it is important to analyze the relationship between the causal factors, namely economic growth, government policy, and environmental growth, and study their error correction ability under Thailand's energy law. This study is believed to offer a significant contribution in terms of producing a policy tool to support national policy making and planning in Thailand, thus enabling Thailand to further achieve sustainable development. This study also notes that no other research has touched upon this subject matter, and that therefore exists a research gap which this study attempts to fill. This study is believed to benefit most stakeholders, particularly researchers and the government, in utilizing the proposed tool for national policy formulation and planning.

2. LITERATURE REVIEW

This section highlights available and relevant studies expressing the current contributions and efforts on the focus of casual factors analysis, forecasting, and modelling, relative to environmental actions and sustainable development.

There are many streamline studies investigating the relationship of different variables, including this study's factors. Among them, Liu (2020) examined the nexus between primary energy consumption and real GDP among major Asian countries using a granger causality technique. His study is evident of weak relationship. However, the relationship is strengthened upon considering nominal GDP instead of real GDP due to the price effect of all the goods and services. Al-Mulali et al. (2013) accounted for renewable energy consumption instead of primary energy consumption in analyzing the above relationship. About 79 per cent of their analysis observes a bi-directional long run relationship, implying a higher income of the tested countries. Mathur et al. (2016) further explored the relationship of the energy consumption with energy efficiency, CO_2 emissions, and economic growth. As a result, they prove a negative impact of per capita energy consumption on economic growth represented by per capita GDP in developing countries. However, a positive impact is detected in developed countries. By accounting for difference income level, Ahmed and Azam (2016) optimized a frequency domain analysis to assess the same above connection. They suggest that a sustainable economic growth and development aspect must be incorporated into an appropriate and effective public policy.

Building upon the above connection between energy consumption and economic growth, Payne (2008) found no clear relationship. At the same time, Croes and Vanegas (2008) examined the nexus of tourism development, economic expansion, and poverty reduction in Nicaragua. Their study shows a stable relationship in the long run. To Saidi et al. (2017), they have, otherwise, found a long-term positive relationship between energy consumption and economic growth at a global scale of 53 countries. While in G7 economies including Canada, France, Germany, Italy, Japan, UK and the USA, both GDP and economic welfare are found directly relevant to energy consumption, illustrated by Menegaki and Tugcu (2017); Fahimi et al. (2018) investigated the impact of tourism and human capital development on economic growth. Their study suggests an economic diversification in order to strengthen the role of tourism for a sustainability. However, Kozhokulov et al. (2019) further found that the tourism can positively affect social growth in addition to economic development. This finding was also agreed by Sugiyarto et al. (2015).

Considering the subject of sustainable development, Giddings et al. (2012) claimed that sustainable development shall be driven by environment, society and economy as they are interconnected. Rivera (2013) viewed a combination of political opportunity and societal visibility as an implementation tool for the selection of sustainable development goals. Ladan (2018) emphasized on the importance of temperature checking of the key factors of sustainable development including economic, social, and environmental pillars, in implementing the SDGs. Furthermore, Moerloose (2017) explained the connection between law and development, and such a connection can be further enhanced through an implementation of international development project and adoption of national development policies. Whereas Tecklin et al. (2011) investigated the character and impact of environmental regime on Chile's environmental policy-making process. As a result, they find that the impact of such a regime strongly influences on environmental law and policy higher than the character.

In case of environmental law framework, Gibson (2012) reviewed the key characteristics of a new environmental assessment law enacted by the Canadian government. His study demonstrates the importance of efficiency improvement of the environmental assessment in order to maintain the effectiveness of the global environmental performance. Craig et al. (2017) agreed that a flexibility in adaptive governance of the U.S. environmental law can be enhanced through committing process and procedure as well as intensive use of substantive standards. Ruhl (2009) identified ten trends of structural impact where the environmental law is implemented. Among them, he found an integration of a human rights pillar in climate change adaptation policy. In the U.S., Huber (2011) explored a transition policy in American environmental law. He illustrated that the cost of regulatory initiatives impact on the form and extent of transition relief. However, Heinzerling (2011) explored a new direction how the environmental law brings about. In this extent, Kim and Mackey (2014) found international environmental law as a complex self-organizing system describing modern properties. Bartel and Barclay (2011) investigated motivational postures relative to environmental law. Their study derives four postures: one associated with compliance, and three associated with non-compliance with the law. In addition, Zeben (2013) improved a competence allocation approach for European environmental law by accounting economies of scale, regulated jurisdiction conditions, and heterogeneity of preferences. While Pourhashemi et al. (2012) affirmed that the determination of international community's duties and commitments can improve the efficiency of current legal administration in responding to the environment-related immigration.

In term of modeling and forecasting, Urbina and Aoyama (2011) adopted a fuzzy risk assessment framework to measure the benefit of investing in pipeline safety. Their study illustrates that such an investment is significantly less cost effective in some areas. Ren (2018) developed a multi-criteria decision-making tool by integrating the interval analytic hierarchy process (IAHP) into the intuitionistic fuzzy combinative distance to assess the alternative energy storage technologies. As of a result, a pumped hydro is found to be the most sustainable technology among other studied alternatives. While Wang (2012) stated that China uses an environmental cadre evaluation as a tool to preserve its environment. Whereas Liou et al. (2015) developed an integrated fuzzy DEMATEL-fuzzy analytic network process model in order to understand and assess construction projects and their overall risks. Their model is confirmed of its validity and efficiency, enabling managers to know the overall risks of construction projects with a lowest risk project selection. This same finding is also affirmed by Ghasemi et al. (2018) after applying a Bayesian Networks approach to analyze portfolio risks. On another note, Islam et al. (2017) extended a fuzzy Bayesian belief network (FBBN) for risk assessment, and a positive potential for such an assessment is detected. Hatefi et al. (2019) proposed a model employing a Dempster-Shafer evidence-based theory to assess environmental risk. They have found that proposed model has a high potential for project risk assessment given an uncertain environment. To Shams et al. (2017), they forecasted greenhouse gases (GHGs) in Bangladesh, and they expect an annual emission of 1.29 million tons CO_2 equivalent (CO_2e) due to the composting.

On other note, Nowell et al. (2005) proposed a model to test a real-world social network in terms of chain massages. Upon their analysis, they verify that one-third of the friendships in network are independent of geography or location. Watts et al. (2002) proposed a model to explain an ability to identify persona identities. With this model, many network searchable problems can be solved. Besides, Backstrom et al. (2010) developed an algorithm to explain the interaction between geology and social relationship. This algorithm is found efficient and reliable, which can be used to explain for a larger network. Jones et al. (2017) found a smaller impact of social influence on political mobilization. This result is further used to describe that online social networks can be an important force to change offline behaviors. Also, Adamic and Adar (2005) found local search strategies are less effective for online student network due to incomplete data and undefined hierarchical structures. Kumar et al. (2010) assessed online social networks comprising five million people and ten million friendship links. Their study shows that such a network is structured by three major communities: non-participants, normal participants, and core participants. In the meantime, Leskovec et al. (2008) studied statistical properties of community structure within social and information networks. They prove that community structure in these networks are different from what have been presented in the current literature. Gallos et al. (2012) observed people interaction in online networks. Interestingly, they demonstrate that men have a higher potential to interact with the most popular people compared to women.

The review of the related literature reveals the need for conducting this study in order to fill the gap that has been left academically.

Therefore, this study attempts to contribute to the literature and produce the best model for policy makers and other stakeholders to use and benefit from. With the in-depth analysis, this study discovers some interesting facts, which will be elaborated upon in the following sections.

3. MATERIALS AND METHODS

3.1. The SEM-based on ARIMAX$_i$ Model

The SEM-based on ARIMAX$_i$ model is a model developed using Structural Equation Model based on Autoregressive Integrated Moving Average with exogenous variables. This model applies the concept of the SEM model and adopts the ARIMAX in the estimation process. This development and adoption can be further explained below.

3.1.1. The analysis methodology of the structural equation model based on ARIMAX$_i$

Central to understanding before analysis of the structural equation model is the realization that the SEM is a tool used to examine the consistency between the developed structural equation model and empirical data. Therefore, such consideration of the structural equation model is only one method used to confirm the consistency of the applied theories with the data collected. The developed structural equation model deemed reasonable depends on the theories used as reference. The hypothesis of a structural equation model can be developed as "the hypothesized model is consistent with empirical data" (Sutthichaimethee, 2018; Harvey, 1989), or written in the form of statistical hypotheses as follows:

Type 1

- H_0: The hypothesized model is consistent with the empirical data
- H_1: The hypothetical model is inconsistent with the empirical data.

Type 2

- H_0: Matrix $\sum$ = Matrix S
- H_1: Matrix $\sum \neq$ Matrix S.

As per the process of analyzing the structural equation model, there are five important steps in the analysis. The first step is to define the specifications of the model. The second step is to identify a possible constant value for the model. The third step is to estimate the model parameters. The fourth step is to validate the model. Finally, the last step is to modify or correct the model (Enders, 2010; Sutthichaimethee, 2017; 2016). The above steps are elaborated in detail as follows.

3.1.1.1. Defining the specification of the model

This model specification is considered the most important step or "the core" of the structural equation model analysis. This is because this step allows the researchers to relate the theories, studies, and information needed for the model's development before data collection and analysis. The researchers need to identify the particular model for the consistency check in the form of variance-covariance data. As for this identification, the researchers must explain the reasons used to choose or exclude the observed variables from this specific model. This early step is claimed as the most difficult stage in analyzing the structural equation model. In fact, the developed model becomes appropriate only when the particular model is reasonably determined. The variance and covariance of this particular model are found to be consistent with the empirical data (Sutthichaimethee and Ariyasajjakorn, 2017; Sutthichaimethee and Ariyasajjakorn, 2018; Enders, 2010).

3.1.1.2. Identifying a possible value of the model

This model identification is the process that connects with the model specifications by providing reasonable considerations for the use of a program for model validation. This step is also perceived as one important step. If a possible value is incorrectly identified, the analysis result is not generated as desired. Simply put, this model identification is to see whether the model can be applied to estimate a single parameter (Sims, 1980; Sutthichaimethee and Ariyasajjakorn, 2017). If the number of calculated equations is less than the number of unknown parameters in the model and only one parameter is estimated for each unknown parameter (positive degrees of freedom), the model is termed an "over-identified model." If the number of calculated equations is equal to the number of unknown parameters in the model and only one parameter is estimated for each unknown parameter (zero degrees of freedom), the model is termed "just-identified model." These two degrees of model enable the researchers to analyze the structural equation model. However, if the model is under-identified, it refers to a model in which the number of calculated equations is greater than the number of unknown parameters, and the estimation of one parameter for each unknown parameter cannot be done due to the negative degrees of freedom. In order to examine one possible value of the model before estimating the parameters as an over-identified model, just-identified model or under-identified model, the degree of freedom can be taken for a consideration by applying the formula of degree of freedom (Sutthichaimethee et al., 2015; Sutthichaimethee and Kubaha, 2018).

3.1.1.3. Estimating a parameter of the model

As of this research, it develops a forecasting model for a causal factor relationship analysis and short-term prediction. This development is built upon the following flow of research process.

3.2. Autoregressive Integrated Moving Average Model

This model considers only the nonstationary process; it converts a nonstationary to a stationary process by conducting a difference of d when d ≥1. The series of difference at d of the original series (adjusted variance series) is considered the stationary series, which can be explained by a number of ARMA models. This ARMA process of difference at d is called Autoregressive Integrated Moving Average, or ARIMA.

The AR (1) process can be stationary if $|\phi|<1$. When considering $|\phi|=1$, it is the model case of which $Z_t=Z_{t-1}+a_t$. This case takes the difference in consideration where $W_t=Z_t-Z_{t-1}$, resulting in a new form of W_t as $W_t=a_t$. This a_t is seen as the easiest stationary process. Once the difference process of $W_t=a_t$ has become stationary, this result is then called a random walk. In this scenario, it can be seen that $\phi(B)=0$ ($\phi(B)=1-B$ in this case) is in a radius circle of 1 unit, indicating the capacity of stationary conversion by doing a difference.

The relationship between the ARMA and ARIMA processes can be explained when series Z_t is consistent with ARIMA. If series $W_t = \nabla^d Z_t = (1-B)^d Z_t$, it is stationary and consistent with ARIMA. In contrast, if series $W_t = \nabla^d Z_t$ as ARMA (p, q), the Z_t process then becomes ARIMA(p, d, q), and that can be written in equation as shown below.

$$\Phi(B)W_t=\theta_0+\theta(B)a_t \tag{1}$$

$$\Phi(B)(1-B)^d Z_t=\theta_0+\theta(B)a_t$$

$$(1-\Phi_1 B-\ldots-\Phi_p B^p)(1-B)^d Z_t=\theta_0+(1-\theta_1 B-\ldots\theta_q B^q)a_t \tag{2}$$

Where θ_0 is constant, it is called an integrated process. This is because Z_t can be written in the summation form of stationary W_t. For instance, when d=1, it will give $(1-B)Z_t=W_t$.

Hence,

$$Z_t=(1-B)^{-1}W_t \tag{3}$$

$$Z_t = \sum_{k=-\infty}^{t} W_t \tag{4}$$

If Equation (1) is absent from autoregression, it is then termed integrated moving average (IMA (d, q)). Furthermore, if it is absent from moving average, it is therefore termed integrated autoregressive (ARI (p, d)).

In applying the concept, ARIMA (p, d, q), where p, d, q are not greater than 2, is generally used. Before considering the detailed process of ARIMA (p, d, q) with different p, d, and q in application, the process of ARIMA (p, 1, q) and ARIMA (p, 2, q) is taken into account in order to explain the relationship between the ARMA and ARIMA process, as shown in the above example.

3.3. The Relationship between the ARIMA and ARMA Process

Based on the relationship between ARIMA(p, 1, q) and ARMA(p+1, q) from Equation 1, the process of ARIMA(p, 1, q) can written as illustrated below.

$$W_t=\phi_1 W_{t-1}+\phi_2 W_{t-2}+\ldots+\phi_p W_{t-p}+a_t-\theta_1 a_{t-1}-\theta_2 a_{t-2}-\ldots\theta_q a_{t-q}$$

Or rewritten in the form of Z_t as,

$$Z_t-Z_{t-1}=\phi_1(Z_{t-1}-Z_{t-2})+\phi_2(Z_{t-2}-Z_{t-3})+\ldots+\phi_p(Z_{t-p}-Z_{t-p-1})+a_t+\theta_1 a_{t-2}-\ldots-\theta_q a_{t-q}$$

$$Z_t=(1+\phi_1)Z_{t-1}+(\phi_2+\phi_1)Z_{t-2}+(\phi_3+\phi_2)Z_{t-3}+\ldots+(\phi_p+\phi_{p-1})Z_{t-p}-\phi_p Z_{t-p-1}+a_t-\theta_1 a_{t-1}-\ldots-\theta_q a_{t-q}$$

And that has given the model of ARMA (p+1, q), under one side equation characterized by

$$1-(1-\phi_1)B-(\phi_2+\phi_1)B^2-\ldots-(\phi_p+\phi_{p-1})B^p+\phi_p B^{p+1}=0 \tag{5}$$

And that can be redrawn in a new form of left term in equation characteristic of AR(p), as shown below.

$$(1-\phi_1 B-\phi_2 B^2-\ldots-\phi_p B^p)(1-B)=0 \tag{6}$$

With the above equation, it can be observed noticed that the equation has one root equivalent to 1, indicating the property of a non-stationary process. While the other root from the left term of equation characteristic of AR (p) is the root of the equation characteristic of W_t stationary process, which is part of AP (p).

The above explanation can conclude that the ARIMA (p, 1, q) process is the process of ARMA(p, 1, q), where one root of equation characteristic is equivalent to 1, and p is the residual root of the equation characteristic of the stationary process.

3.4. The Most Popular Applied ARIMA (*p, d, q*)

This section considers the property of ARIMA (p, d, q) most applied to benefit in the modelling and forecasting for specific p, d and q, which are less or equal to the said property.

The process of ARIMA (0, 1, 1) or IMA (1, 1)

The model of the above process is as shown below.

$$(1-B)Z_t=(1-\theta B)a_t \tag{7}$$

Equation (5) can be rewritten in the new form of weight π as illustrated below.

$$\frac{(1-B)}{(1-\theta B)}Z_t = a_t \tag{8}$$

Given that $\alpha=1-\theta$, it produces

$$\frac{(1-B)}{(1-\theta B)} = 1-\alpha B-\alpha(1-\alpha)B^2-\alpha(1-\alpha)^2 B^3-\ldots$$

Therefore, the new form is $Z_t = \alpha\sum_{j=1}^{\infty}(1-a)^{j-1}Z_{t-j}+a_t$. As for weight Ψ, it derives $\Psi_0=1$, $\Psi_j=(1-\theta)$, $j>1$.

3.5. Measurement of the Forecasting Performance

In this research, we evaluate the performance of the SEM-based on the ARIMAX$_i$ model by using MAPE and RMSE, and compare these values with the same values of other existing models. In this case, the other models are the multiple regression model (MR model), back propagation neural network model (BP model), artificial neural natural model (ANN model), fuzzy analytical network process (FANP model), gramma test adaptive neural fuzzy inference system (GT-ANFIS model), and the autoregressive integrated moving average model (ARIMA model). The calculation equations are shown as follows (Enders, 2010; Harvey, 1989; Pacheco and Sanches Fernandes, 2013; Sutthichaimethee, 2018):

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{\hat{y}_i - y_i}{y_i}\right| \quad (9)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{y}_i - y_i\right)^2} \quad (10)$$

4. EMPIRICAL ANALYSIS

4.1. Screening of Influencing Factors for Model Input

By considering the variables used in this research, the SEM-based on the $ARIMAX_i$ model was developed based on the latent variables or factors, including economic growth (ECG) government policy (GPG), and environmental growth (ENG). With regards to the economic growth (ECG) factor, this consists of five indicators, namely urbanization rate (Ub), industrial structure (ID), total net exports (EM), indirect foreign investment (II), and foreign tourists (FO). In terms of the government policy (GPG) factor, this accounts for three indicators, namely employment rate (ER), health and illness (HE), and technology rate (TE). Finally, the environmental growth (ENG) factor, comprise four indicators, including energy consumption (EE), energy intensity (EI), carbon dioxide emission rate (CO_2), and green technology rate (GT). In testing a stationary process of the variables, the Augmented Dickey–Fuller theory is referred to by conducting a unit root test for all 12 factors at level I(0). If there are any indicators deemed as non stationary based on the MacKinnon critical value, the first difference I(1) process will be carried out. Table 1 exhibits the analysis results of stationary testing (Dickey and Fuller, 1981).

Table 1 explains the stationary outcome at first difference level I (0) of all indicators adopted in the SEM-based on the $ARIMAX_i$ model. Based on the unit root test, this produces a tau test value of every indicator greater than MacKinnon critical value. This result shows the stationarity quality of the variables at a significance level of 1%, 5%, and 10%. Therefore, this research adopts all the indicators with a stationary quality at the first difference level I(0) for further examination of co-integration according to the concept of Johansen and Juselius, 1990. The results of such testing is illustrated in Table 2 (MacKinnon, 1991; Johansen, 1995; Sanches Fernandes, 2013).

4.2. Analysis of Co-integration

Table 2 demonstrates the results of the co-integration testing of the indicators. The results reveal that every indicator is co-integrated, where the trace statistic test is estimated at 111.58 and the Max-Eigen statistic test is valued at 102.65. When these two are compared with the McKinnon critical value, this research affirms a greater co-integration value than the McKinnon critical value at a significance level of 1% and 5%. Once the co-integration is tested, all those indicators are adopted to develop the SEM-based on the $ARIMAX_i$ model, as shown in Figure 1.

4.3. Formation of Analysis Modeling with SEM-based on the $ARIMAX_i$ (1,1,1) Model

The SEM-based on the $ARIMAX_i$ (1,1,1) model is composed of the relationship and its impact of the latent variables, which are economic growth (ECG) government policy (GPG), and environmental growth (ENG). This research uses all 12 indicators that are stationary and co-integrated at first difference to analyze the relationship of causal factors in terms of direct effect and indirect effect analysis, as shown in Figure 1.

Table 1: The testing results of stationary process at first difference I (1)

Stationary at first difference I(1)		MacKinnon critical value		
Variables	**Tau test**	**1%**	**5%**	**10%**
Δln(Ub)	–5.23***	−4.25	−3.11	−2.45
Δln(ID)	–5.54***	−4.25	−3.11	−2.45
Δln(EM)	–5.01***	−4.25	−3.11	−2.45
Δln(II)	–4.79***	−4.25	−3.11	−2.45
Δln(FO)	–4.58***	−4.25	−3.11	−2.45
Δln(ER)	–4.91***	−4.25	−3.11	−2.45
Δln(HE)	–4.57***	−4.25	−3.11	−2.45
Δln(TE)	–4.91***	−4.25	−3.11	−2.45
Δln(EE)	–4.99***	−4.25	−3.11	−2.45
Δln(EI)	–4.72***	−4.25	−3.11	−2.45
Δln(CO_2)	–4.92***	−4.25	−3.11	−2.45
Δln(GT)	–4.69***	−4.25	−3.11	−2.45

Ub is urbanization rate, ID is industrial structure, EM is total net exports, II is indirect foreign investment, FO is foreign tourists, ER is employment rate, HE is health and illness, TE is technology rate, EE is energy consumption, EI is energy intensity, CO_2 is carbon dioxide emission rate, GT is green technology rate *** denotes a significance, α =0.01, compared to the Tau test with the MacKinnon critical value, Ά is the first difference, and ln is the natural logarithm

Table 2: Co-integration test of Johansen and Juselius

Variables	Co-integration value		MacKinnon critical value	
Δln(Ub), Δln(ID), Δln(EM), Δln(II), Δln(FO), Δln(ER), Δln(HE), Δln(TE), Δln(EE), Δln(EI), Δln(CO_2), Δln(GT)	Trace statistic test	Max-Eigen statistic test	1%	5%
	111.58***	102.65***	15.45	12.51

***Denotes significance α=0.01, **Denotes significance α=0.05

Figure 1 shows the relationship of causal factors in the SEM-based on the $ARIMAX_i$ (1,1,1) model. The relationship and its influence of the latent variables, including economic growth (ECG) government policy (GPG), and environmental growth (ENG). The same Figure further exhibits the impact of the indicators, that affect particular latent variables. calculation results. Furthermore, it demonstrates the error correction ability of the said variables reflected by an error correction mechanism (ECT_{t-1}). Besides, this research also tests the white noise and validity of the SEM-based on the $ARIMAX_i$ (1,1,1) model. Table 3 is the analysis result estimated using the software.

Table 3 shows the impact of the relationship of the SEM-based on the $ARIMAX_i$ (1,1,1) model after assessing its validity and white noise. Based on the analysis, this research has revealed both the direction and size of the impact of the relationship coupled with its error correction ability. Such a discovery can be explained as follows. This research first found that economic growth (ECG) has direct effect on environmental growth (ENG) with an impact size of 0.76 at a confidence interval of 99%. Next, it shows that economic growth (ECG) has direct effect on government policy

Figure 1: Causal relationship in the SEM-based on the ARIMAX$_i$ (1,1,1) model

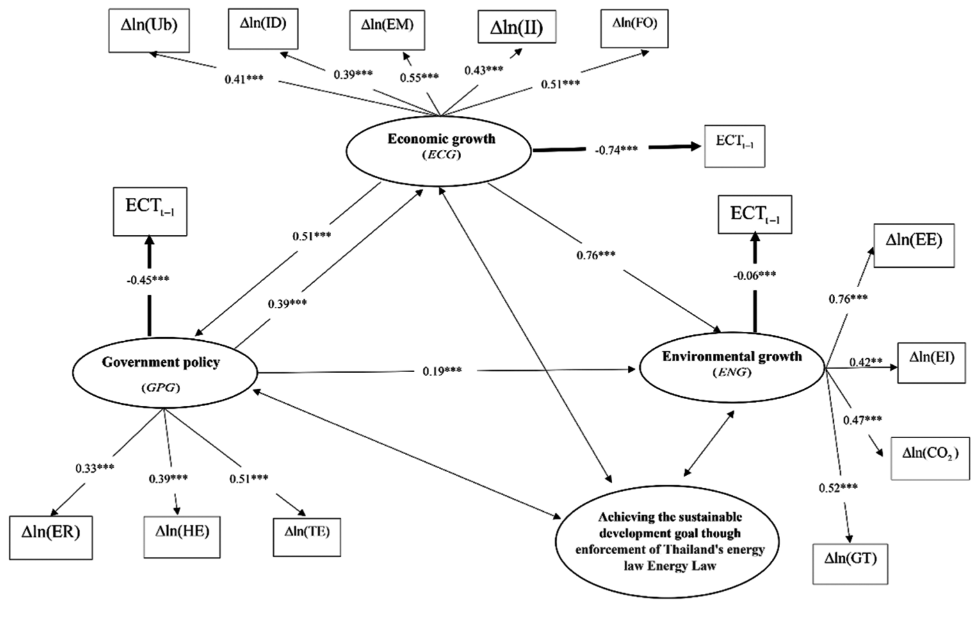

Table 3: The impact analysis result of the relationship and error correction ability based on the SEM-based on the ARIMAX$_i$ (1,1,1) model

Dependent variables	Type of effect	Independent Variables			
		Economic growth (ECG)	Government policy (GPG)	Environmental growth (ENG)	Error Correction Mechanism(ECT_{t-1})
Economic growth (ECG)	DE	-	0.39***	-	–0.74***
	IE	-	0.17***	-	-
Government policy (GPG)	DE	0.51***	-	-	–0.45***
	IE	0.13***	-	-	-
Environmental growth (ENG)	DE	0.76***	0.19***	-	–0.06***
	IE	0.09***	0.12***	-	-

In the above, ***denotes significance α=0.01, **denotes significance α=0.05, χ^2/df is 1.35, RMSEA is 0.04, RMT is 0.001, GFI is 0.92, AGFI is 0.96, R-squared is 0.97, the F-statistic is 201.05 (probability is 0.00), the ARCH test is 20.11 (probability is 0.1), the LM test is 1.52 (probability is 0.10), DE is the direct effect, and IE is the indirect effect.

(GPG) with an impact size of 0.51 at a confidence interval of 99%. The Government policy (GPG) was found to have a direct effect on economic growth (ECG) with an impact size of 0.39 at the same confidence interval. Lastly, government policy (GPG) was found to have direct effect on environmental growth (ENG) with an impact size of 0.19 at the same confidence interval.

In addition to this impact, the SEM-based on the ARIMAX$_i$ (1,1,1) model was also assessed on the error correction ability. This research shows that economic growth (ECG) has the strongest error correction ability with a degree of –0.74, followed by government policy (GPG) with a degree of –0.45. Environmental growth (ENG) has the weakest error correction ability with a degree of –0.06 at a confidence interval of 99%. As a result, environmental growth (ENG) is believed to be an essential aspect, which most requires government attention and a new scenario policy.

Based on this research, the SEM-based on the ARIMAX$_i$ (1,1,1) model can be used to develop a new scenario policy, in which energy consumption (EE) is controlled at a constant and less than the current limit (2019). This condition is explained by knowing that energy consumption (EE) has impact on environmental growth (ENG). Therefore, a new scenario policy is developed and CO_2 emission is forecasted. These two processes are there to ensure that the developed model can be truly meaningful for policy formation and planning. Moreover, this research has assessed the performance of the SEM-based on the ARIMAX$_i$ (1,1,1) model by comparing it with other existing models, as detailed below.

Table 4 illustrates the performance of the SEM-based on the ARIMAX$_i$ (1,1,1) model in comparison with other models. The SEM-based on the ARIMAX$_i$ (1,1,1) model was found to outperform other models with an MAPE and RMSE of 1.09 and 1.15, respectively. The ARIMA model has an MAPE and RMSE of 4.31 and 4.92, respectively. Next, the GT-ANFIS model has an MAPE and RMSE of 4.59 and 5.54, respectively. The following is the FANP model with an MAPE and RMSE of 5.69 and 6.02, respectively. The ANN model estimates the MAPE and RMSE at 8.11 and 9.08, respectively. While the BP model produces an MAPE and RMSE equivalent to 12.05 and 14.91, respectively. Lastly, the MR model generates an MAPE and RMSE of 20.91 and 23.46, respectively. Hence, the SEM-based on the ARIMAXi (1,1,1) model was found to be the most appropriate tool for projecting CO_2 emissions for the next 10 years (2020-2029). This application can be further understood in the following discussion.

Figure 2: Forecasting results of CO_2 emissions during 2020 to 2029 in Thailand under a new scenario policy

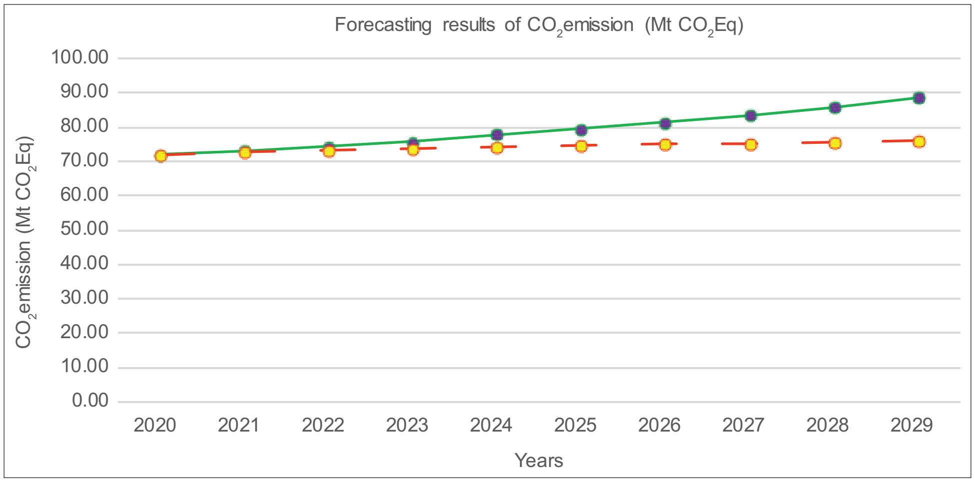

Table 4: The performance monitoring of the forecasting models

Forecasting model	MAPE (%)	RMSE (%)
MR model	20.91	23.46
BP model	12.05	14.91
ANN model	8.11	9.08
FANP model	5.69	6.02
GT-ANFIS model	4.59	5.54
ARIMA model	4.31	4.92
SEM-based on the $ARIMAX_i$ (1,1,1) model	1.09	1.15

4.4. A Forecasting CO_2 Emission Based on the SEM-based on the $ARIMAX_i$ (1,1,1) Model

In forecasting CO_2 emission based on the SEM-based on the ARIMAXi (1,1,1) model, this research uses the period of the next 10 years (2020-2029) under a new scenario policy together with accounting for a standard carrying capacity, as shown in Figure 2.

Figure 2 shows the result of the SEM-based on the ARIMAXi (1,1,1) model under a new scenario policy used to forecast CO_2 emissions from 2020 to 2029. According to this result, the CO_2 emission is estimated to increase with a growth rate of 1.52% (2029/2020) or equivalent to 76.2 Mt CO_2 Eq. (by 2029). This estimated figure is lower than a carrying capacity set at 80.05 Mt CO_2 Eq. assuming that a new scenario policy is implemented. However, in case of absent policy, the CO_2 emission is projected at 88.59 Mt CO2 Eq. (by 2029), which is greater than the set carrying capacity.

5. CONCLUSION AND DISCUSSION

This research is basically developed to propose the SEM-based on the ARIMAXi (1,1,1) model. This model accounts for three key latent variables, namely economic growth (ECG) government policy (GPG), and environmental growth (ENG). Under these variables, 12 indicators were used to study, urbanization rate (Ub), industrial structure (ID), total net exports (EM), indirect foreign investment (II), and foreign tourists (FO), employment rate (ER), health and illness (HE), technology rate (TE), energy consumption (EE), energy intensity (EI), carbon dioxide emission rate (CO_2), and green technology rate (GT). Based on the research analysis, all these 12 indicators were non stationary at level I(0). However, they were found to be stationary after doing a first difference at level I(1). Once the stationary process is confirmed for all variables, they are next taken to analyze a long-term relationship by conducting co-integration testing. This research confirms that every indicator is found to be co-integrated at the first difference level, and it is used to model the SEM-based on the ARIMAXi (1,1,1) model. After analyzing the relationship, this research affirms that economic growth (ECG) has direct effect on environmental growth (ENG) the most. Next, economic growth (ECG) is found to have direct effect on government policy (GPG), while government policy (GPG) is found to directly affect economic growth (ECG). Furthermore, government policy (GPG) is proven to have direct effect on environmental growth (ENG), respectively. Furthermore, the SEM-based on the $ARIMAX_i$ (1,1,1) model indicates that economic growth (ECG) has the strongest error correction ability, followed by government policy (GPG). However, environmental growth (ENG) is found with the weakest error correction ability, suggesting that the government is required to intervene in order to control matters in this regard. The government is expected to define a new scenario policy by maintaining a constant energy consumption (EE) within the current year limit (2019). This is because the changes in energy consumption (EE) will have a great impact on environmental growth (ENG).

In addition to the consideration of a new scenario policy, this research also forecasts future CO_2 emissions for the next 10 years during 2020 to 2029. Based on the research findings, the CO_2 emissions are projected to rise with a growth rate of 1.52% (2029/2020) or 76.2 Mt CO_2 Eq. (by 2029), which is lower than the standard carrying capacity set at 80.05 Mt CO_2 Eq. This projected CO_2 emission under a new scenario policy is also found to be lower than the CO_2 emission case without a new scenario policy. Therefore, this research is believed to be the most suitable tool used for supporting the national policy making and planning of Thailand in order to map out the right operations to attain sustainable development.

As for recommendations in implementing the developed model, it is necessary to consider green technology use at a growing rate. This is because the impact size of green technology in environmental growth is great after energy consumption. When energy consumption remains constant, it is essential for the government to replace such consumption with the use of green technology at an increasing rate. Another recommendation lies within the research framework. It is important for the relevant researchers to give attention to the research process with model validity and white noise testing in order to produce the most accurate analysis results while reducing any potential errors that may occur; thus, the model is not spurious. The researchers may also consider different sectors of study as to reflect a better outlook for policy making.

A limitation of this research is seen through a few possible areas. Among the greatest concerns, the government mainly focuses on economic development, leading to the existing measures serving economic purposes. This imbalance may create a bias among used indicators across all studied areas. In some cases, some indicators are not found or missing in a new scenario policy, and they might also have an impact on the process and formation of policy and planning. For instance, in the case of crude oil, whose prices are controlled by the government. This intervention of the government may not reflect the real economic outlook as it is supposed to.

This research, therefore, includes important features that allow wider application across all the sectors in different contexts. The developed model is also found to be distinct and suitable for both medium- and long-term forecasting. This is because of the scrutinized research processes and attempt to narrow down the research gap, enabling the most possible accurate analysis results used to complement policy formulation and management planning in achieving sustainability for Thailand.

6. ACKNOWLEDGMENTS

This research is supported by Rachadapisek Sompote Fund for Postdoctoral Fellowship, Chulalongkorn University.

REFERENCES

Adamic, L., Adar, E. (2005), How to search a social network. Social Networks, 27(3), 187-203.

Ahmed, M., Azam, M. (2016), Causal nexus between energy consumption and economic growth for high, middle and low income countries using frequency domain analysis. Renewable and Sustainable Energy Reviews, 60, 653-678.

Al-Mulali, U., Gholipour, H.F., Janice, L., Che Sab, C.N. (2013), Examining the bi-directional long run relationship between renewable energy consumption and GDP growth. Renewable and Sustainable Energy Reviews, 22, 209-222.

Backstrom, L., Sun, E., Marlow, C. (2010), Find Me if You Can: Improving Geographical Prediction with Social and Spatial Proximity. Raleigh, North Carolina, USA: Conference: Proceedings of the 19th International Conference on World Wide Web.

Bartel, R., Barclay, E. (2011), International environmental law as a complex adaptive system. Journal of Rural Studies, 27(2), 153-170.

Craig, R.K., Garmestani, A.S., Allen, C.R., Arnold, C.A., Birgé, H., DeCaro, D.A., Fremier, A.K., Gosnell, H., Schlager, E. (2017), Balancing stability and flexibility in adaptive governance: An analysis of tools available in U.S. environmental law. Ecology and Society, 22(2), 1-15.

Croes, R., Vanegas, S.R. (2008), Blockchain technology and its relationships to sustainable supply chain management. Journal of Travel Research, 47, 94-103.

Department of Alternative Energy Development and Efficiency. (2020), Available from: http://www.dede.go.th/ewtadmin/ewt/dede_web/ewt_news.php?nid=47140. [Last accessed on 2020 Jan 10].

Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49, 1057-1072.

Enders, W. (2010), Applied Econometrics Time Series, Wiley Series in Probability and Statistics. Tuscaloosa: University of Alabama.

Fahimi, A., Akadiri, S.S., Seraj, M., Akadiri, A.C. (2018), Testing the role of tourism and human capital development in economic growth. A panel causality study of micro states. Tourism Management Perspectives, 28, 62-70.

Gallos, L.K., Rybski, D., Liljeros, F., Havlin, S., Makse, H.A. (2012), How people interact in evolving online affiliation networks. Physical Review X, 2(3), 1-11.

Ghasemi, F., Mahmoudi Sari, M.H., Yousefi, V., Falsafi, R., Tamošaitien, J. (2018), Project portfolio risk identification and analysis, considering project risk interactions and using Bayesian networks. Sustainability, 10(5), 1609-1631.

Gibson, R.B. (2012), In full retreat: The Canadian government's new environmental assessment law undoes decades of progress. Impact Assessment and Project Appraisal, 30(3), 179-188.

Giddings, B., Howood, B., O'Brien, G. (2012), Environment, economy and society: Fitting them together into sustainable development. Sustainable Development, 10(4), 187-196.

Harvey, A.C. (1989), Forecasting, Structural Time Series Models and the Kalman Filter, Cambridge. Cambridge, UK: Cambridge University Press.

Hatefi, S.M., Basiri, M.E., Tamošaitien, J. (2019), An evidential model for environmental risk assessment in projects using Dempster-Shafer theory of evidence. Sustainability, 11(22), 6329-6344.

Heinzerling, L. (2011), New directions in environmental law: A climate of possibility. Harvard Environmental Law Review, 35, 263-273.

Huber, B.R. (2011), Transition policy in environmental law. Harvard Environmental Law Review, 35, 91-130.

Islam, M.S., Nepal, M.P., Skitmore, M., Attarzadeh, A. (2017), Current research trends and application areas of fuzzy and hybrid methods to the risk assessment of construction projects. International Journal of Project Management, 33, 112-131.

Johansen, S. (1995), Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. New York: Oxford University Press.

Johansen, S., Juselius, K. (1990), Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics, 52, 169-210.

Jones, J.J., Bond, R.M., Bakshy, E., Eckles, D., Fowle, J.H. (2017), Social influence and political mobilization: Further evidence from a randomized experiment in the 2012 U.S. presidential election. PLoS One, 12(4), 1-9.

Kim, R.E., Mackey, B. (2014), International environmental law as a complex adaptive system. International Environmental Agreement, 14, 5-24.

Kozhokulov, S., Chen, X., Yang, D. (2019), Assessment of tourism impact on the socio-economic spheres of the Issyk-Kul region (Kyrgyzstan). Sustainability, 11(14), 3886-3903.

Kumar, R., Novak, J., Tomkins, A. (2010), Structure and evolution of online social networks BT-link mining: Model, algorithms, and applications. In: Link mining: Models, Algorithms, and Applications. Berlin, Germany: Springer. p337-357.

Ladan, M.T. (2018), Achieving sustainable development goals through effective domestic laws and policies on environment and climate change. Environmental Policy and Law, 48(1), 42-63.

Leskovec, J., Lang, K.J., Dasgupta, A., Mahoney, M.W. (2008), Statistical Properties of Community Structure in Large Social and Information Networks. Beijing, China: Conference: Proceedings of the 17th International Conference on World Wide Web. p695-704.

Liou, J.J.H., Tamosaitiene, J., Zavadskas, E.K., Tzeng, G.H. (2015), New hybrid COPRAS-G MADM Model for improving and selecting suppliers in green supply chain management. International Journal of Production Research, 54(1), 114-134.

Liu, W.C. (2020), Making environmental law for the market: The emergence, character, and implications of Chile's environmental regime. Sustainability, 12(6), 1-16.

MacKinnon, J. (1991), Critical values for cointegration test. In: Engle, R., Granger, C., editors. Long-run Economic Relationships. Oxford: Oxford University Press.

Mathur, S., Kanak, A., Sohini, S., Ishita, G.T. (2016), Does domestic energy consumption affect GDP of a country? A panel data study. Renewable and Sustainable Energy Reviews, 16(2), 229-273.

Menegaki, A.N., Tugcu, C.T. (2017), Energy consumption and sustainable economic welfare in G7 countries, a comparison with the conventional nexus. Renewable and Sustainable Energy Reviews, 69, 892-901.

Moerloose, S. (2017), Law and development as a field of study: Connecting law with development. Law and Development Review, 10(2), 179-186.

National Statistic Office Ministry of Information and Communication Technology. (2020), Available from: http://www.web.nso.go.th/index.htm. [Last accessed on 2020 Jan 05].

Nowell, V., Novak, J., Kumar, R., Raghavan, P., Tomkins, A. (2005), Geographic routing in social networks. PNAS, 102(33), 11623-11628.

Office of the National Economic and Social Development Council: NESDC. (2020), Available from: http://www.nesdb.go.th/nesdb_en/more_news.php?cid=154 and filename=index. [Last accessed on 2020 Jan 05].

Pacheco, F.A.L., Sanches Fernandes, L.F. (2013), The multivariate statistical structure of DRASTIC model. Journal of Hydrology, 476, 442-459.

Payne, J.E. (2008), Survey of the international evidence on the causal relationship between energy consumption and growth. Journal of Economic Studies, 37(1), 53-95.

Pollution Control Department Ministry of Natural Resources and Environment. Enhancement and Conservation of National Environmental Quality Act, B.E. 2535. (2020), Available from: http://www.pcd.go.th/info_serv/reg_envi.html. [Last accessed on 2020 Jan 10].

Pollution Control Department Ministry of Natural Resources and Environment. Navigation of Thai Waterways Act, B.E. 2546. (2020), Available from: http://www.pcd.go.th/info_serv/reg_envi.html. [Last accessed on 2020 Jan 15].

Pollution Control Department Ministry of Natural Resources and Environment. (2020), Principle 4: In Order to Achieve Sustainable Development, Environmental Protection Shall Constitute an Integral Part of the Development Process and Cannot be Considered in Isolation from it. Available from: http://www.infofile.pcd.go.th/law/Environmental%20law55_1.pdf?CFID=1741861 and CFTOKEN=32274043. [Last accessed on 2020 Jan 15].

Pourhashemi, S.A., Khoshmaneshzadeh, B., Soltanieh, M., Hermidasbavand, D. (2012), Analyzing the individual and social rights condition of climate refugees from the international environmental law perspective. International Journal of Environmental Science and Technology, 9, 57-67.

Ren, J. (2018), Sustainability prioritization of energy storage technologies for promoting the development of renewable energy: A novel intuitionistic fuzzy combinative distance-based assessment approach. Renewable Energy, 121, 666-676.

Rivera, M. (2013), Political criteria for sustainable development goal (SDG) selection and the role of the urban dimension. Sustainability, 5(12), 5034-5051.

Ruhl, J.B. (2009), Climate change adaptation and the structural transformation of environmental law. Environmental law (Northwestern School of Law), 40(363), 363-431.

Saidi, K., Rahman, M.M., Amamri, M. (2017), The causal nexus between economic growth and energy consumption: New evidence from global panel of 53 countries. Sustainable Cities and Society, 33, 45-56.

Shams, S., Sahu, J.N., Rahman, S.M.S., Ahsan, A. (2017), Sustainable waste management policy in Bangladesh for reduction of greenhouse gases. Sustainable Cities and Society, 33, 18-26.

Sugiyarto, A., Blake, A., Sinclair, T.M. (2003), Tourism and globalization: Economic impact in Indonesia. Annals of Tourism Research, 30(3), 683-701.

Sutthichaimethee, P. (2008), Forecasting economic, social and environmental growth in the sanitary and service sector based on Thailand's sustainable development policy. Journal of Ecological Engineering, 19(1), 205-210.

Sutthichaimethee, P. (2016), Model of environmental problems priority arising from the use of environmental and natural resources in machinery sectors of Thailand. Environmental and Climate Technologies, 17(1), 18-29.

Sutthichaimethee, P. (2017), Varimax model to forecast the emission of carbon dioxide from energy consumption in rubber and petroleum industries sectors in Thailand. Journal of Ecological Engineering, 18(3), 112-117.

Sutthichaimethee, P., Ariyasajjakorn, D. (2017), Forecasting model of GHG emission in manufacturing sectors of Thailand. Journal of Ecological Engineering, 18(1), 18-24.

Sutthichaimethee, P., Ariyasajjakorn, D. (2017), The revised input-output table to determine total energy content and total greenhouse gas emission factors in Thailand. Journal of Ecological Engineering, 18(6), 166-170.

Sutthichaimethee, P., Ariyasajjakorn, D. (2018), Forecast of carbon dioxide emissions from energy consumption in industry sectors in Thailand. Environmental and Climate Technologies, 22(1), 107-117.

Sutthichaimethee, P., Chatchorfa, A., Suyaprom, S. (2019), A forecasting model for economic growth and CO_2 emission based on industry 4.0 political policy under the government power: Adapting a second-order autoregressive-SEM. Journal of Open Innovation: Technology, Market Complex, 5, 69.

Sutthichaimethee, P., Dockthaisong, B. (2018), A relationship of causal factors in the economic, social, and environmental aspects affecting the implementation of sustainability policy in Thailand: Enriching the path analysis based on a GMM Model. Resources, 7(4), 87-97.

Sutthichaimethee, P., Kubaha, K. (2018), A relational analysis model of the causal factors influencing CO_2 in Thailand's industrial sector under a sustainability policy adapting the VARIMAX-ECM model. Energies, 11(7), 1704.

Sutthichaimethee, P., Naluang, S. (2019), The efficiency of the sustainable development policy for energy consumption under environmental law in Thailand: Adapting the SEM-VARIMAX model. Energies, 12, 3092.

Sutthichaimethee, P., Tanoamchard, W., Sawangwong, P., Pachana, P., Witit-Anun, N. (2015), Environmental problems indicator under environmental modeling toward sustainable development. Global Journal of Environmental Science and Management (GJESM), 1(4), 325-332.

Tecklin, D., Bauer, C, Prieto, M. (2011), Making environmental law for the market: The emergence, character, and implications of Chile's environmental regime. Environmental Politics, 20(6), 879-898.

Thailand Greenhouse Gas Management Organization (Public Organization). (2020), Available from: http://www.tgo.or.th/2015/thai/content.php?s1=7 and s2=16 and sub3=sub3. [Last accessed on 2020 Jan 10].

The World Bank: Energy Use (Kg of Oil Equivalent Per Capita) Home Page. (2020), Available from: https://www.data.worldbank.org/indicator/EG.USE.PCAP.KG.OE. [Last accessed on 2020 Jan 10].

United Nations Framework Convention on Climate Change, UNFCCC, Bonn, Germany. (2016), Global progress in environmental law. Environmental Policy and Law, 46(1), 23-27.

Urbina, G., Aoyama, U.A. (2011), Measuring the benefit of investing in pipeline safety using fuzzy risk assessment. Journal of Loss Prevention in the Process Industries, 45, 116-132.

Wang, A.L. (2012), The search for sustainable legitimacy: Environmental law and bureaucracy in China. Harvard Environmental Law Review, 37, 365-440.

Watts, D.J., Dodds, P.S., Newman, M.E.J. (2002), Identity and search in social networks. Science, 296(5571), 1302-1305.

Zeben, J.V. (2013), Subsidiarity in European environmental law: A competence allocation approach. Harvard Environmental Law Review, 30(3), 415-464.