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Article

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The Impact of Causal Factors Relationship over the Changes in Future Scenario Management under the Sustainability Policy of Thailand

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ABSTRACT

The objective of this research is to analyze the impact of causal factors relationship over the changes in future scenario management under the sustainability policy of Thailand by creating a model with validity called "Partial Least Square Path Modeling based on Autoregressive Integrated Moving Average with Observed Variables (PLS Path Modeling-ARIMAx)." The results showed that the three latent variables (economic, social, and environmental) were found to be causal related. From the PLS Path Modeling-ARIMAx (1,1,1), it is characterized as the best linear unbiased estimator (BLUE) with highest performance, where mean absolute percentage error (MAPE) equals to 1.55%, and root mean square error (RMSE) equals to 1.97% upon comparing them to other models. If the government implements this model to define a new scenario policy by stipulating future total energy consumption (2020-2039) below the national carrying capacity, with minimal error correction mechanism and great impact on model relationship, the future CO_2 emission (2020-2039) is expected to drop a growth rate continuously. When a new scenario policy is determined, CO_2 emission was found to increase at a growth rate of only 8.95% (2020/2039) or by 78.99 Mt CO_2 Eq. (from 2020 to 2039) going below carrying capacity set off at 90.05 Mt CO_2 Eq. (from 2020 to 2039). The result is clearly different in the absence of the new scenario policy.

Keywords: Sustainability Policy, New Scenario Policy, Spurious Model, Carrying Capacity, Short-Long Term
JEL Classifications: P28, Q42, Q43, Q47, Q48

1. INTRODUCTION

Thailand has implemented a policy sustainability policy, which has a national strategy by setting a national economic and social development plan from the past (1995) to the present (2019). The government has set a policy deems important for the development of the country called sustainable development goal, which is a policy to develop and simultaneously improve all economic, social and environmental dimensions. This has been set as a national strategy and Thailand has continued to implement these policies to become a developed country as many other countries do (The World Bank: Energy Use [Kg of Oil Equivalent Per Capita] Home Page, 2021). However, the action of the government has set a national development plan in the short-term period of 1-5 years, the medium-term national development plan in the period of 6-10 years, and the long-term national development plan from 11 to 20 years, where Thailand continuously follows various strategies in every aspect (Office of the National Economic and Social Development Council (NESDC), 2021).

Thailand's economic development plan, all in the short term, medium term, and long term, are for continuous development with various measures to be used for promoting economic growth, including more exports to foreign markets, attempt for new markets, more export volume, increase in variety of export products, foreign investment promotion, especially in

industrial sectors. In addition, Thailand has implemented various promotional measures, such as the reduction of various types of taxes; taxes are exempted in some sectors in order not to affect the income of foreign investors. Along with direct and indirect support, fees are reduced in every aspect to get more important partners and focus on Thailand to maximize production (NESDC, 2021). In addition, all types of tourism measures are set to continue to grow by calling out a large number of tourists to Thailand, especially tourists from Europe and China though different agreement with many countries to support and promote tourists continually (National Statistic Office Ministry of Information and Communication Technology, 2021). Thailand also reduces the amount of imports while encouraging more national production and promoting their own potential development to reduce the outflow of money to other countries. At the same time, Thailand encourages entrepreneurs in the country to have the ability to produce for export, as well as hiring foreign experts to help them gain more knowledge and come to work in Thailand. There is also a measure to encourage entrepreneurs in the country to borrow money at very low interest rates to achieve greater flexibility in operations. All types of taxes are reduced to stimulate domestic production and consumption (NESDC, 2021). Thailand further promotes the implementation of important mega-projects of the country, accelerate government spending for the continued benefit of the public, such as the construction of electric trains to cover the entire area and expansion of communication routes to cover many areas (Department of Alternative Energy Development and Efficiency, 2021).

In terms of policy implementation for social growth, the government has created various policies. Socially, the government has set various measures and promote various aspects, especially in education. The government has set a comprehensive minimum education rate and is a proactive measure. As a result, at present (2019), almost all the people in the country are educated approximately 90% (Thailand Greenhouse Gas Management Organization [Public Organization], 2021; NESDC, 2021), and the private sector is encouraged to open educational institutions to support the people thoroughly and the government continues to offer higher numbers in scholarships; be it domestic and abroad. The government has promoted employment rate by reducing the unemployment rate for a decline. It was found that at present the minimum wage rate is higher than many countries to encourage formal workers to have better incomes and livelihoods for families (NESDC, 2021). The government attaches great importance to Health and Illness so that all citizens can have a better access by setting a policy to help many people in remote areas for treatment and complete health care. The government has implemented a policy on social security and strictly monitored every area throughout the country continuously (Thailand Greenhouse Gas Management Organization [Public Organization], 2021). In addition, there are consumer protection measures to promote and follow up to achieve more concrete results continuously (NESDC, 2021).

The Thai government has implemented more appropriately and effectively in terms of society today (2019). There is an exponential growth rate coupled with the rate of economic growth. That is, when the economy grows, the society is growing in the same direction (Pollution Control Department Ministry of Natural Resources and Environment. Navigation of Thai Waterways Act, B.E. 2546, 2021). As for the implementation of Thailand's economic and social policies from the past (1990) to the present (2019), it is believed that the government has been working in the same direction and benefiting Thailand with efficiency and effectiveness. For the economy, there is an index to measure continuous growth, namely gross domestic production, which has grown steadily every year (Thailand Greenhouse Gas Management Organization [Public Organization], 2021). As for the Social Growth Index, it has shown with a growth in all areas through an evidence of the dramatic drop-in unemployment rate, higher access of public education, and health and hygiene are covered steadily every year (Sutthichaimethee and Ariyasajjakorn, 2018; United Nations, 2021).

However, it was found that, by considering the greenhouse gas emission rate of Thailand from the past to the present (1995-2019), the emission has continued to increase as well and goes higher than the carrying capacity Thailand has set for every year (Pollution Control Department Ministry of Natural Resources and Environment. 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, 2021). The CO_2 emission has been continuously increasing, especially in industrial sectors, transportation sectors, and electronic sectors (Thailand Greenhouse Gas Management Organization [Public Organization], 2021). The increase in CO_2 emission has a maximum growth rate of 70.25% (2019/1995) indicating a high growth rate compared to other countries, such as countries in Europe and China. Although Thailand has participated in all treaties since the 1995 international policy meeting in Italy under the theme of Human and Environment aimed to reduce greenhouse gas emissions, Thailand continues to face with the increase in the emission, and that exceeds the carrying capacity set every year (Department of Alternative Energy Development and Efficiency, 2021).

Therefore, the implementation of the policy sustainability policy aimed for sustainable development goal, it was still found that the economy and society grew in the same direction, but the environment continues to deteriorate. This shows that sustainable development goals will certainly not be successful in the future because of the continued decline of the ecosystem. The important reason is that in the past Thailand has established various policies, but it lacks important tools to help analyze and process, as well as lack of planning for the future itself. Given ineffective or inappropriate management tools, it may result in errors when making future policy, especially long-term policy making (11-20 years). Most of the models used by governments in decision-making are those that are not truly the best models and spurious, resulting in making wrong decisions. In addition, the models used lack of validity in many aspects, resulting in the misleading of Thailand administration. However, this research has noticed this weakness of tool modeling. Therefore, it has developed a model for decision-making to support formulating Thailand's policies and plans with maximum efficiency and effectiveness. In this

regard, the research has reviewed literature both in Thailand and other countries, thus creating a model presented in the paper, and it deems to differentiate from the past models to provide a guideline for its implementation, as well as future research both in Thailand and abroad.

2. LITERATURE REVIEW

In this section, it will further stress upon relevant studies and research work on various variables. There are many streamlined studies highlighting diverse relationships between important indicators that deem important for a revision. Azretbergenova et al. (2021) explored the relationship between renewable energy production and employment in 27 European Union member countries by using a Panel Data Analysis. Their study confirms a positive connection between renewable energy generation and employment with a 1% increase in renewable energy would rise employment by 0.08%. Specifically, Argentina tested the connection between renewable energy consumption and economic growth by Khobai (2021), and the long-run association is detected. Payne (2010) attempted to find the causal relationship between consumption of energy and economic growth. Surprisingly, no clear connection is detected in this study with respect to a certain nation or groups of nations. In contrast, Almulali et al. (2013) have found a positive connection between those two variables, and renewable energy is the concern in this context. The same relationship is presented upon accounting social factors over economic growth as per conclusion by Popa (2012). Extending on economic growth, Hoang (2021) studied its connection with electricity consumption, and financial development in ASEAN countries. To this particular analysis, a strong and positive impact on the growth is contributed by the above two factors. Within the same region, Wakimin et al. (2019) investigated both tourism demand and government expenditure over the environment. Upon analysis, they reveal the impact of both variables towards the environment in some countries in the region. In the contrary, Abubakirova et al. (2021) extended symmetric and asymmetric causality analysis to study the connection between oil prices and stock prices, but no causality has been found. In the region of African continent, Nathaniel et al. (2021) has found an impact of energy consumption, natural resources, and urbanization on ecological footprint in South Africa, whereas human capital plays a role in improving the environment. Alsaedi et al. (2021) explored the Australian electricity markets by examining the energy management nature of policies and framework on solar and wind pricing. In their analysis, such policies can lower the price of electricity and minimize some risks for investors at the same time.

Whereas Chowdhury and Kang (2021) articulated on the nexus of corporate environmental responsibility (CER) of the employees' perceptions and their desirability to an organization, and a direct connection is clearly shown from the analysis. Besides, Johl and Toha (2021) attempted to explore the relation between proactive eco-innovation and circular economy. Upon their analysis, a direct impact of eco-innovation on a firm's financial performance is revealed and presented. However, Liu (2021) studied the relation of fiscal expenditure on science and technology and infrastructure Public-Private Partnership (PPP). The development of PPP is positively impacted by the government fiscal expenditure. In fact, this PPP investment in energy together with economic growth would increase CO_2 emissions claimed by Adebayo et al. (2021). Mohsin et al. (2021) has found the potential of negative impact on the environmental sustainability in Pakistan. Abid et al. (2020) found non-renewable energy sources positively impacting economic growth and CO_2 emissions. In contrast, this phenomenon turns out to be negative impact on CO_2 emissions due to the oil prices, confirmed by Abumunshar et al. (2020). Lyeonov et al. (2019) investigated the DGP per Capita, greenhouse gas emissions and renewable energy to assess the impact of green investment on sustainable development. A link between these earlier variables is proven with the investment.

In another context, it is equally crucial to ponder upon the introduction of environmental laws as they are making an impact on this research, so that this research will have a better idea when it comes legality and framework in environment. Giddings et al. (2002) studied sustainable development policies by fitting all the factors; society, economy and environment. As for their conclusion, the subject of socio-economic structure becomes a challenge and marginalized due to the separation of the factors. However, such a development can be achieved by effective local laws and policies, especially environment and climate change related laws as proven by Ladan (2018). This enforcement is also guaranteed by the use of new law under the Canadian Environmental Assessment Act 2012, per ascribed to Gibson (2012). Craig et al. (2017) has examined the U.S. environmental law though the lens of adaptive governance. To their findings, a tool of adaptive governance including attention to process and procedure with standards allows flexibility in legal operation and stability in different dimensions of the communities; be it psychological, social, and economic. Whereas Kim and Mackey (2014) assessed the characteristics of international environmental law. To them, it is confirmed that the law itself is a complex adaptive system through treaties and institutions.

As can be observed, most studies focus on developing existing models while leaving some other rooms to explore, especially the PLS Path Modeling-ARIMAx. Hence, this research aimed to conduct a new dimension of the research by introducing the above model with high quality production policy. At the same time, it is ensured that the model will be non-spurious and best model for long-term forecasting.

Through a revision of previous relevant research, it has found that previous models are significantly different from this research work. This research emphasizes the elimination of spuriousness and constructs a model to be the best model in order to use as an important tool in implementing Thailand's policies and plans in the most complete and appropriate manner, as well as guide for further study and research both in Thailand and abroad. In addition, this research is also different from past research, especially it is made applicable for various sectors and long-term forecasting support. In this research, a model is developed and called "PLS Path Modeling-ARIMAx," and it applies advanced research principles and statistics. Such an application can be seen and discussed below.

1. Define latent variables and observed variables in the PLS Path

Modeling-ARIMAx model.

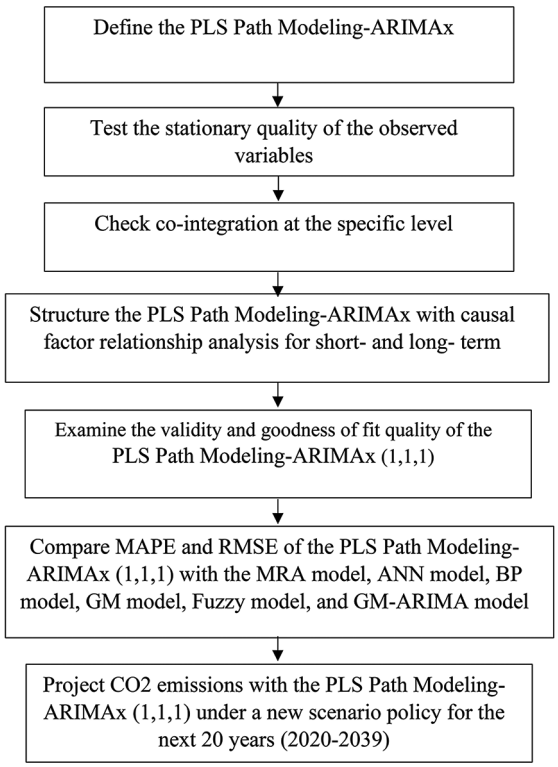
2. Perform a stationary testing of the observed variables by using the concept of Augment Dickey and Fuller (1981). Only stationary variables in the same level are used in this study (MacKinnon, 1991).
3. Test co-integration at the same level, where observed variables are stationary only, using the theory of Johansen and Juselius (1990).
4. Construct a PLS Path Modeling-ARIMAx by analyzing the relationship of all variables both short term and long term (Johansen, 1995).
5. Verify the validity and goodness of fit of the PLS Path Modeling-ARIMAx model.
6. Test a model performance using MAPE and RMSE of the PLS Path Modeling-ARIMAx, and compare its performance with other models, namely MRA model, ANN model, BP model, GM model, Fuzzy model, and GM-ARIMA model.

Forecast CO_2 emission with the PLS Path Modeling-ARIMAx model under new scenario policy for the future from 2020 to 2039 for a total of 20 years as shown in Figure 1.

3. THE MATERIALS AND METHODS

Partial Least Square Path Modeling based on autoregressive integrated moving average with observed variables (PLS Path Modelling-ARIMAX), the PLS is a variance-based model developed from OLS method using Principal Component Regression (PCR) as per Least Square Tool. The model evaluation is performed using the ARIMAX method, which is a method ensuring the assessment results with higher accuracy compared to the previous models. The details are as follows (Harvey, 1989; Byrne, 2009; Enders, 2010).

Figure 1: The flowchart of the PLS Path Modeling-ARIMAx.
Source: Author's Estimate (2021)



The PLS Path Modeling-ARIMAX can be explained with the details as follows.

Given that $X = \{X_1, X_2, X_3, ..., XH\}$ represents the observed value of exogenous latent variable. Assuming that $\xi = \{\xi_1, \xi_2, \xi_3, \ldots, \xi_H\}$ is the exogenous latent variable (latent variable can be also called as score or component).

Given that $Y = \{Y_1, Y_2, Y_3, ..., YH\}$ represents the observed value of exogenous latent variable.

Assuming that $\eta = \{\eta_1, \eta_2, \eta_3, ..., \eta k\}$ is the exogenous latent variable.

The relationship between latent variable (LV) and manifest variable (MV) (indicator or proxy) can be reflective or formative depending on the following contexts: (Byrne, 2009)

1. Reflective indicator is a factor analysis relationship where the LV variable influences these MV's to mutually vary in each block. This variation can be called as outer-directed measurement model. As for this particular circumstance, the covariance of the MV variable is studied. The relationship between LV and MV's in any block can be written as follows Sutthichaimethee, 2018).

$$X_{jh} = \lambda_{xj} \xi_j; j = 1,2,3,...H; h = 1,2,3,...,m_j \text{ or } X = \Lambda_x \xi + \varepsilon_x \quad (1)$$

Where H is the total of exogenous latent variable, and m_j is the MV in block j

$$Y_{jh} = \lambda_{xj} \eta_j + \varepsilon_{yj}; j = 1,2,3,\ldots,K; h = 1,2,3,\ldots,n_j \text{ or } Y = \Lambda_y \eta + \varepsilon_y \quad (2)$$

Where K is the total of endogenous latent varibale, and n_j is the MV in block j as per Figure 2.

$E(\xi_j) = a_j$, $V(\xi_j) = 1$, $E(\eta_j) = b_j$, $V(\eta_j) = 1$, $E(\varepsilon_j) = 0$, $V(\varepsilon_j) = 1 \ldots \lambda_j$ (Sutthichaimethee and Dockthaisong, 2018).

2. Formative indicator is where the MV is mutually creating LV, and this model can be called as inner-directed measurement model. The goal of SEM in this case is to minimize the residual of the structural relationship (Sutthichaimethee, 2017).

The relationship between LV and each MV in any block can be written as follows.

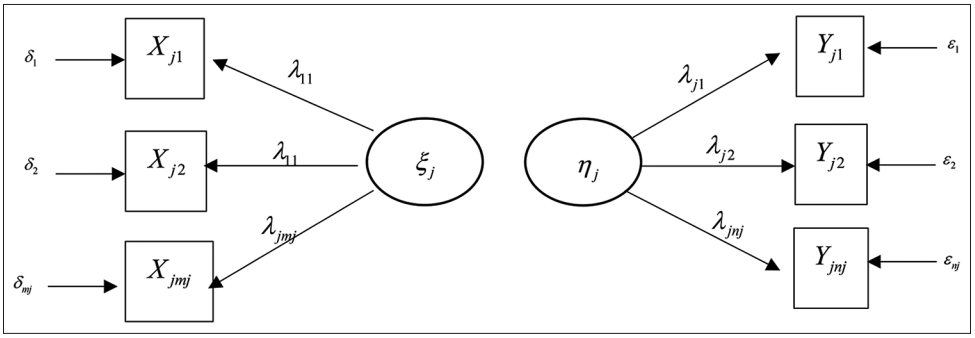
$$\xi_j = \pi_{xj} X_{jh} + \delta_{\xi j}; j = 1,2,3,\ldots H; h = 1,2,3,...,m_j \text{ or } \xi = \Pi_x X + \delta_\xi \quad (3)$$

$$\eta_j = \pi_{yj} Y_{jh} + \delta_{\eta j}; j = 1,2,3,\ldots K; h = 1,2,3,...,n_j \text{ or } \eta = \Pi_y Y + \delta_y \quad (4)$$

Analyzing the relationship in block j may also be possible to apply a multiple regression analysis.

$$\xi_j = \pi_{j0} + \pi_{j1} X_{j1} + \pi_{j2} X_{j2}, \ldots, \pi_{jm} X_{jm} + \delta_j \quad (5)$$

Figure 2: The relationship structure between LV and MV's in block j



$$\eta_j = \pi_{j0}+\pi_{j1}X_{j1}+\pi_{j2}X_{j2},\ldots,\pi_{jn}X_{jn}+\delta_j \quad (6)$$

Given that the coefficient π_j is the Multiple Linear Regression.

The reflective relationship is developed to positively correlate both MV and LV; loading and/or the regression coefficient must be positive, but it is still flexible allowing some negative values in some cases. However, such a negativity will signify the issues in the data. For example, the scale of measurement cannot be compared or the mean does not explain or the variable is meaningless. This issue can be tackled by converting the data into standard score, and that means to convert X,Y,ξ, $\hat{\eta}$ to standard score minus the mean and divided by the standard deviation (Sutthichaimethee and Ariyasajjakorn, 2017).

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

3.1. Autoregressive Integrated Moving Average Model

This model considers only nonstationary process; it is to convert nonstationary to stationary process by conducting a difference of d when $d \geq 1$ The series of difference at d of the original series (adjusted variance series) is considered as 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 known as ARIMA (Sutthichaimethee and Ariyasajjakorn, 2018).

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 is taking a 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) in a radius circle of 1 unit, indicating the capacity of stationary conversion by doing a difference.

The relationship between ARMA and ARIMA process can 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.

$$\phi(B)W_t = \theta_0+\theta(B)a_t \quad (7)$$

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

$$(1-\phi_1 B-\ldots-\phi_p B^p)(1-B)^d Z_t = \theta_0+(1-\theta_1 B-\ldots-\theta_q B^q)a_t \quad (8)$$

Where θ_0 is constant, and it is called 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,

$$Z_t = (1-B)^{-1}W_t \quad (9)$$

$$Z_t = \sum_{k=-\infty}^{t} W_t \quad (10)$$

If Equation (7) is absent from autoregression, it is then called as Integrated Moving Average (IMA (d, q)). Besides, it is absent from moving average, it is, therefore, called as integrated autoregressive (ARI (p, q)).

In applying the concept, ARIMA (p, d, q), where p, d, q are not >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 ARMA and ARIMA process, as shown in the above example.

3.2. The Relationship between ARIMA and ARMA Process

Based on the relationship between ARIMA (p, 1, q) and ARMA (p, +1, q) from Equation (7), the process of ARIMA (p, 1, q) can written as illustrated below.

$W_t = \phi_1 W_{t-1}+\phi_2 W_{t-2}+\phi_p W_{t-p}+a_t-\theta_1 a_{t-1}-\theta_2 a_{t-2}-\ldots\theta_q a_{t-q}$ or rewritten in the form of Z_t as,

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

$Z_t = (1+\phi_1)Z_{t-1}+(\phi_2+\phi_1)Z_{t-2}+(\phi_3+\phi_2)Z_{t-3}+(\phi_p+\phi_{p-1})Z_{t-p}-\phi_p Z_{t-p-1}+a_t-\theta_1 a_{t-2}-\theta_2 a_{t-2}-\ldots-\theta_q a_{t-q}$ and that has given the model of ARMA (p,+1, q), under one side equation characterized by $1-(1+\phi_1)B-(\phi_1+\phi_2)B^2-\ldots-(\phi_p+\phi_{p-1})B^p+\phi_p B^{p+1} = 0$. And that can be redrawn in a new form of left term in equation characteristic of AR (p), as shown below (Sutthichaimethee and Kubaha, 2018).

$$(1-\phi_1 B-\phi_2 B^2-\ldots-\phi_p B^p)(1-B) = 0 \quad (11)$$

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

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

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

In this section, it considers the property of ARIMA (p,d, q) mostly applied to benefit in the modelling and forecasting for specific p, d and q, which are ≤2. The said property can be further explained below (Sutthichaimethee and Kubaha, 2018).

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

The model of the above process is as shown below.

$$(1-B)Z_t = (1-\theta B)a_t \quad (12)$$

Where $W_t = (1-\theta B)a_t$, $Z_t - Z_{t-1} = (1-\theta B)a_t$, $Z_t = Z_{t-1} + a_t - \theta a_{t-1}$

The Equation (12) can be rewritten in the new form of weight π as illustrated below.

$$\frac{(1-B)}{(1-\theta B)} Z_t = a_t \quad (13)$$

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 of weight ψ, it derives $\psi_0 = 1$, $\psi_j = (1-\theta)$, $j>1$

4. EMPIRICAL ANALYSIS

4.1. Screening of Influencing Factors for Model Input

In this paper, the PLS Path Modeling-ARIMAx has determined the latent variables, and they consists of 3 factors, namely economic, social, and environmental factor. The observed variables comprises of 17 indicators, including per capita income (*Per*), urbanization rate (*Un*), industrial structure (*In*), total exports (*E–m*), indirect foreign investment (*Fo*), expenditure government rate (Ex), employment (*Em*), health and illness (*He*), social security (*So*), consumer protection (*Co*), education rate (*Ed*), energy consumption (En), oil consumption rate (*Oi*), energy intensity rate (*Ei*), carbon dioxide emissions (CO_2), renewable energy rate (*Er*), and green technology (*Gt*). The research has verified the indicators in terms of stationary by testing their unit root as to find whether all the indicators are non-stationary at level I(0) or otherwise. The research has thus verified their stationary at first difference I(1) instead as per illustrated in the following Table 1.

From Table 1, it was found that all the indicators at level I(0) are not stationary, so the research has had to improve by doing first difference of all indicators via the unit root testing. Later, it was found that the tau test of all indicators was higher than the MacKinnon critical value, indicating that at the first difference all indicators are significant at 1%, 5%, and 10%. The research was able to take the indicators to analyze co-integration, and that can be expressed as follows:

4.2. Analysis of Co-Integration

As for a co-integration analysis, this research has used all stationary indicators at the first difference level to analyze the long-term relationship. The results of the analysis are shown in Table 2.

From Table 2, it indicates that all the indicators are co-integrated at the first difference, where the trace test are 220.15 and 92.55. These values are greater than the MacKinnon at a significance level of 0.01 ($\alpha = 0.01$).

4.3. The Correlation Analysis of Causal Factors Relationship

The impact analysis of causal factors in this study consists of latent variables and indicators to analyze both short-term and long-term relationships. To demonstrate the influence of the relationship of both direct effect and indirect effect, the results can be shown in Figure 3.

Figure 3 shows the results of long-term correlation analysis from the PLS Path Modeling-ARIMAx (1,1,1). It has found that economic aspect has a direct effect and indirect effect on social aspect while having a direct effect and indirect effect on environment at a significance level of 0.01. The social aspect has a direct effect and indirect effect on economy, and it has a direct effect and indirect effect on environment at a significance level of 0.01. Whereas the environment has a direct effect on social aspect while having an indirect effect on economy at a significance level of 0.01, but it has no direct effect on economy.

The results of this study show that economy has the highest adaptability to equilibrium with the highest error correction mechanism (ECT_{t-1}) of −0.65 when comparing its value to social and environmental aspect. It has also found that industrial structure and total exports have the greatest impact on economic change, while social aspect has the adjustability to equilibrium lower below economic power with an error correction mechanism (ECT_{t-1}) of −0.31.

It was also found that employment has the greatest impact on social aspect. Whereas the environment has the lowest adjustability to equilibrium followed by economic and social aspect, respectively, with an error correction mechanism (ECT_{t-1}) of −0.05. It was also found that energy consumption has a greatest impact on the change in environment. Thus, the PLS Path Modeling-ARIMAx (1,1,1) model characterizes the direct effect and indirect effect causal factors relationship from the white noise model, revealing no spuriousness in the model. This result further explains that there is an absence of autocorrelation, multicollinearity, and heteroskedasticity. Hence, it was shown that the relationship of

Table 1: The verification of indicators in terms of stationary property at Level I (0) and First Difference I (1)

Tau Test				MacKinnon Critical Value		
Variables	Level I (0) Value	Variables	First Difference I (1) Value	1%	5%	10%
	−4.10	Δ In (*Per*)	−5.79***	−4.55	−3.40	−2.25
	−3.34	Δ In (*UN*)	−4.97***	−4.55	−3.40	−2.25
	−2.96	Δ In (*IN*)	−4.99***	−4.55	−3.40	−2.25
	−4.52	Δ In (*E–m*)	−5.58***	−4.55	−3.40	−2.25
	−3.41	Δ In (*Fo*)	−6.27***	−4.55	−3.40	−2.25
	−2.99	Δ In (*Ex*)	−4.69***	−4.55	−3.40	−2.25
	−3.20	Δ In (*Em*)	−4.77***	−4.55	−3.40	−2.25
	−3.57	Δ In (*He*)	−4.97***	−4.55	−3.40	−2.25
	−3.71	Δ In (*So*)	−4.85***	−4.55	−3.40	−2.25
	−3.95	Δ In (*Co*)	−4.69***	−4.55	−3.40	−2.25
	−3.22	Δ In (*Ed*)	−4.65***	−4.55	−3.40	−2.25
	−3.99	Δ In (*En*)	−5.01***	−4.55	−3.40	−2.25
	−4.32	Δ In (*Oi*)	−5.52***	−4.55	−3.40	−2.25
	−3.34	Δ In (*Ei*)	−5.01***	−4.55	−3.40	−2.25
	−4.60	Δ In (Co_2)	−5.21***	−4.55	−3.40	−2.25
	−4.02	Δ In (*Er*)	−4.92***	−4.55	−3.40	−2.25
	−4.91	Δ In (*Gt*)	−5.74***	−4.55	−3.40	−2.25

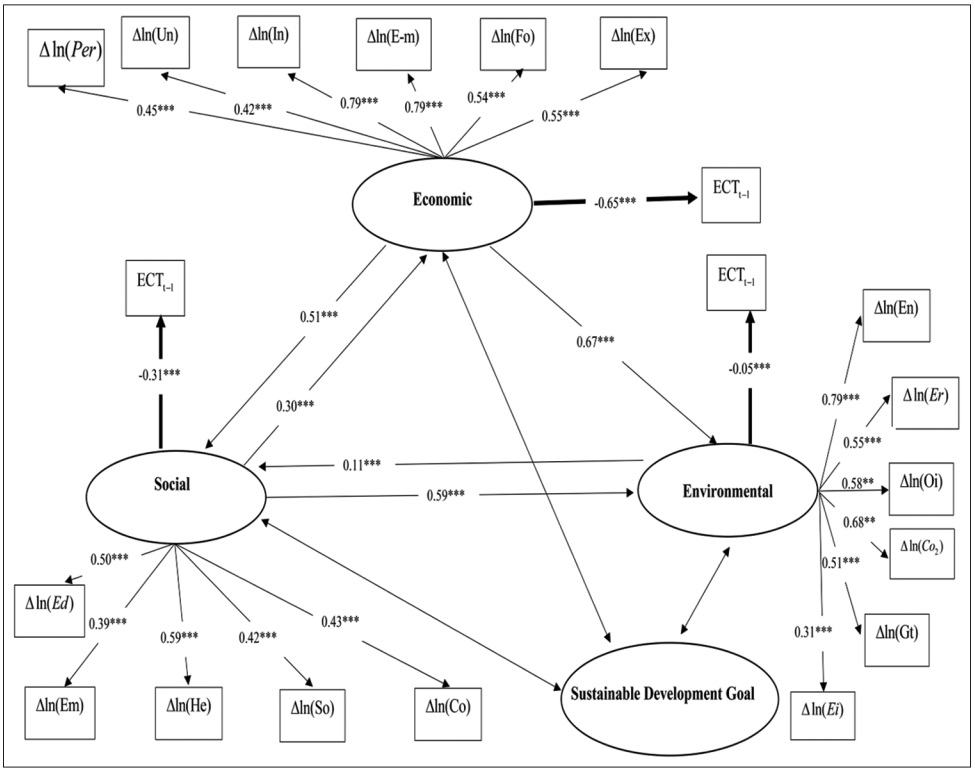
Per is the per capita income, *Un* is the urbanization rate, *In* is the industrial structure, *E–m* is the total exports, *Fo* is the indirect foreign investment, *Ex* is the expenditure government rate, *Em* is the employment, *He* is the health and illness, *So* is the social security, *Co* is the consumer protection, *Ed* is the education rate *En* is the energy consumption, *Oi* is the oil consumption rate, *Ei* is the energy intensity rate, CO_2 is the carbon dioxide emissions, *Er* is the renewable energy rate, *Gt* is the green technology ***Denotes a significance, α=0.01, compared to the Tau test with the MacKinnon Critical Value, Δ is the first difference, and ln is the natural logarithm. Source: Author's Estimate (2021)

Table 2: The Co-integration test by Johansen and Juselius

Variables	Hypothesized No of CE (S)	Trace Statistic Test	Max-Eigen Statistic Test	MacKinnon Critical Value 1%	MacKinnon Critical Value 5%
Δ In (*Per*) Δ In (*UN*) Δ In (*IN*) Δ In (*E–m*) Δ In (*Fo*) Δ In (*Ex*) Δ In (*Em*) Δ In (*He*) Δ In (*So*) Δ In (*Co*) Δ In (*Ed*) Δ In (*En*) Δ In (*Oi*) Δ In (*Ei*) Δ In (Co_2) Δ In (*Er*) Δ In (*Gt*)	None***	220.15***	270.01***	17.25	13.20
	At Most 1***	92.55***	89.05***	12.75	9.25

***Denotes significance α=0.01. Source: Author's Estimate (2021)

Figure 3: The results of the correlation analysis of the causal factors both short-and-long term



such causal factors is characterized by the BLUE relationship as follows:

From Table 3, the PLS Path Modeling-ARIMAx (1,1,1) is the best model due to its validity and passing BLUE validation,

Table 3: Results of relationship size analysis of the PLS Path Modeling-ARIMAx

Dependent Variables	Type of effect	Independent Variables			
		Economic	Social	Environmental	Error Correction Mechanism (ECT_{t-1})
Economic	DE	-	0.30***	-	−0.65***
	IE	-	-	−0.25***	-
Social	DE	0.51***	-	−0.11***	−0.31***
	IE	-	-	−0.39***	-
Environmental	DE	0.67***	0.59***	-	−0.05***
	IE	0.11***	0.18***	-	-

In the above, ***Denotes significance α=0.01, χ^2/df is 1.10, RMSEA is 0.01, RMR is 0.002, GFI is 0.99, AGFI is 0.97, R-squared is 0.97, the F-statistic is 211.50 (probability is 0.00), the ARCH test is 21.05 (probability is 0.1), the LM test is 1.35 (probability is 0.10), DE is direct effect and IE is indirect effect

leading to the absence of heteroskedasticity, multicollinearity, and autocorrelation. In addition, the research also found that the model has goodness of fit. The results showed that the RMSEA and RMR are close to 0, whereas the GFI and AGFI are close to 1.

Thus, the PLS Path Modeling-ARIMAx (1,1,1) tells that economy has a direct effect on social dimension equivalent to 51% at a significance level of 1%. The economy has a direct effect on the environment equivalent to 67% at a significance level of 1%. The social aspect has a direct effect on economy equivalent to 30% at a significance level of 1%. In addition, the social aspect has a direct effect on environment equivalent to 59% at a significance level of 1%. Consequently, the environment has a direct effect on the social aspect equivalent to 11% at a significance level of 1%. Furthermore, the PLS Path Modeling-ARIMAx (1,1,1) demonstrates that economy has a direct effect on social aspect equivalent to 51% at a significance level of 1%. The economy has a direct effect on environment equivalent to 67% at a significance level of 1%. The social aspect has a direct effect on economic equivalent to 30% at a significance level of 1%. Besides, the social aspect has a direct effect on environment equivalent to 59% at a significance level of 1%. Last but not least, the environment has a direct effect on social equivalent to 11% at a significance level of 1%.

From the PLS Path Modeling-ARIMAx (1,1,1) model, the research has found that the error correction mechanism (ECT_{t-1}) showing the adaptability to equilibrium with different magnitudes. The economy has an error correction mechanism (ECT_{t-1}) of −0.65 at a significance level of 1%. This finding indicates the ability to adjust to equilibrium as quickly as possible, followed by social and environmental aspect with magnitude size of −0.31 and −0.05, respectively, at a significance level of 1%.

In addition, when the research examines the performance of the model, it was found that the PLS Path Modeling-ARIMAx (1,1,1) applies MAPE and RMSE values in comparison to other models, namely MRA model, ANN model, BP model, GM model, Fuzzy model, and GM-ARIMA model. The performance can be understood from the organization below.

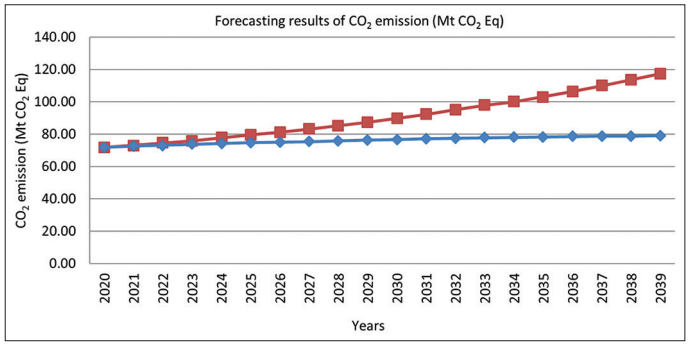
Table 4 shows that the PLS Path Modeling-ARIMAx (1,1,1) model has the lowest values in both MAPE and RMSE at 1.55% and 1.97%, respectively, when comparing to other models' performance. The GM-ARIMA model has the MAPE and RMSE at 3.02% and 4.11%, respectively. While the GM model has both MAPE and RMSE at 3.45% and 4.01%, respectively. When it comes to the Fuzzy model, it has MAPE and RMSE at 4.72% and 5.96%, respectively. The BP model has MAPE and RMSE at 6.25% and 7.76%, respectively. Whereas the ANN model has MAPE and RMSE at 7.49% and 9.23%, respectively.

Table 4: The performance monitoring of the forecasting model

Forecasting Model	MAPE (%)	RMSE (%)
MRA model	15.05	17.10
ANN model	7.49	9.23
BP model	6.25	7.76
Fuzzy model	4.72	5.96
GM model	3.45	4.01
GM-ARIMA model	3.02	4.11
PLS Path Modeling-ARIMAx (1,1,1)	1.55	1.97

Source: Author's Estimate (2021)

Figure 4: The forecasting results of CO_2 emission from 2020 to 2039 in Thailand



By considering the MRA model, it has MAPE and RMSE at 15.05% and 17.10%, respectively. The results of this study show further that the PLS Path Modeling-ARIMAx (1,1,1) is suitable to support the modeling in this paper, and it has an ability to perform policy-based long-term forecasting for future sustainability policy.

4.4. The CO_2 Emission Forecasting Model based on the PLS Path Modeling-ARIMAx (1,1,1)

From the analysis results, it shows that the PLS Path Modeling-ARIMAx (1,1,1) is a suitable model for long-term forecasting. By assuming that the government decides to define a scenario, this model can show that the environment should be defined as well. This is due to the lowest error correction mechanism (ECT_{t-1}) compared to economic and social aspect.

This research, therefore, defines a new scenario policy using energy consumption below the carrying capacity set by Thailand (2020)

under environmental law. The PLS Path Modeling-ARIMAx (1,1,1) is later applied to predict long-term CO_2 emission for the next 20 years (2020-2039) in order to align with the long-term goals of Thailand as shown in Figure 4.

Figure 4 shows that CO_2 emission over the next 20 years from 2020 to 2039 in Thailand continue to increase with a growth rate of 38.76% (2039/2020), which is higher than carrying capacity set off at 90.05 Mt CO_2 Eq. (2020-2039). When the research defines a new scenario policy, the CO_2 emission for the next 20 years from 2020 to 2039 in Thailand is expected to increase at a declining rate with a growth rate of 8.95% (2039/2020) or rise by 78.99 Mt CO_2 Eq. (2020-2039).

5. CONCUSSION AND DISCUSSION

This research has developed the PLS Path Modeling-ARIMAx (1,1,1), which deems to be the best model based on the causal relationship of the latent variables; economic, social, and environmental. As for the economic indicators, they comprises of per capita income (*Per*), urbanization rate (*Un*), industrial structure (*In*), total exports (*E–m*), indirect foreign investment (*Fo*), and expenditure government rate (*Ex*). While the social indicators consists of employment (Em), health and illness (*He*), social security (*So*), consumer protection (*Co*), and education rate (*Ed*). In terms of environmental indicators, they include energy consumption (*En*), oil consumption rate (*Oi*), energy intensity rate (*Ei*), carbon dioxide emissions (CO_2), renewable energy rate (*Er*), and green technology (*Gt*). This research further explains that the economy has a direct effect on social aspect while having a direct effect and indirect effect on the environment. As for social dimension, it has a direct effect on economy while having a direct effect and indirect effect on environment. The environment is also found to have a direct effect on social aspect and indirect effect on economic and social dimension as high as 25% and 39%, respectively. Besides, the environment has been detected with the slowest adjustability to equilibrium compared to economic and social dimensions, respectively. Therefore, it is imperative for governments to establish a new scenario policy under environmental law to keep in control below the carrying capacity, particularly controlling in energy consumption as it is the most influential indicator over the environment. However, if the government accelerates to promote economic and social growth as slow as this present pace, without having any environmental growth promotion, the ecosystems will be destroyed, and policy making on sustainability will not be effective and face immeasurable consequences in the future.

For this research, the PLS Path Modeling-ARIMAx (1,1,1) for long-term forecasting (2020-2039) was created and perceived the most suitable model for long-term forecasting (2020-2039). The model is confirmed with no issues of heteroskedasticity, multicollinearity, and autocorrelation. However, when performing a comparison between an undefined new scenario policy and defined one, this research finds that future CO_2 emissions (2020-2039) carry different growth rates. At the same time, CO_2 emission growth rate is below the carrying capacity when a new scenario policy is to be defined.

Therefore, the results of this research show that the PLS Path Modeling-ARIMAx (1,1,1) can help in policy formulation and planning for sustainability realization. The government should also pay more attention to the environment, because it has the slowest correction mechanism. If this subject is to be neglected, further damage in the future will occur, and damage goes beyond repair. Upon reviewing relevant research, this research is seen different from past studies with a newly developed model known as "Path Analysis-VARIMA-OVi model." The model applies various concepts and theories, and manages to fill the research gap. In addition, this research can also be applied to other sectors as a tool for national policymaking. In this research, the research deploys software named LISREL along with EVIEWS to help support knowledge creation. In the future, the model can be further advanced to support the planning.

As of the recommendation, this paper runs through a comprehensive review of past related research papers from several countries and sectors enabling to discover the research gap. Unlike other models of the past, the PLS Path Modeling-ARIMAx (1,1,1) model is fully scrutinized and not spurious. In this research, it employs LISREL software along with EVIEWS for knowledge creation. However, it is important for those who will apply the findings of this research consider the selection of indicators as they must be comprehensive in each sector while their influence can be truly determined. Also, a new scenario policy should be established for comparison and further development in the short-term, medium, and long-term planning. In particular, it is important to focus on long-term research modeling, because it is risky to occur spuriousness compared to other short-and-medium-term. Therefore, this research is believed to pave as a good modelling guideline for future implementation and development of the country to truly achieve sustainability in the future.

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