A New Scenario Management Model in the Establishment of Administrative Measures

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Abstract. *This research aimed to study the magnitude of the impact resulting from changes in the factors of the future scenario policy under Thailand's sustainability policy for the upcoming two decades, spanning from 2020 to 2039 by developing a best linear unbiased estimator (BLUE) model. The model was named structural equation modeling based on autoregressive integrated moving average with observed variables at first difference (SEM-var(1)). The central gap between this model and other model was the applicability of the proposed model for effective medium-term forecasting without spuriousity. As for the findings, the latent variables of the three sectors were causally found upon using the SEM-var(1) model with the highest performance, with a mean absolute percentage error (MAPE) of 1.50 percent and a root mean square error (RMSE) of 1.75 percent. Furthermore, the new scenario policy was established by requiring at least 20 percent green technology and keeping future total energy consumption (2020-2029) below the country's carrying capacity. As a result, the future CO_2 emission growth rate (2020-2029) would be 7.05 percent (2020-2029) or 39.01 Mt CO_2Eq (from 2020-2029), which was less than the carrying capacity set by not exceeding 65.04 Mt CO_2Eq (from 2020-2029). As for the administrative measures, Thailand must operate administrative legislation measures within environmental law by considering three key elements: 1) Principles of Environmental Protection Measures Planning, 2) Principles of Environment Damage Management, and 3) Principle of Polluters Pays. This result further indicated that the model is best suited for application in the formulation of future national administration plans.*

Keywords:

Administrative measure, environmental law, sustainability, mixed methods research, protection measures

1. Introduction

Thailand, from the past (1992) to the present (2023), has implemented a policy on sustainability and taken strict action measures to ensure the sustainable development goal policy is run effectively and sustainably as a national strategy. The government has set this policy as an urgent agenda item and has prioritized it by integrating it as part of the country's administration policy. This is done by ensuring simultaneous growth in economic, social and environmental. [1] The government has divided the national agenda into three categories, divided into three different time periods: short-term policies (1–5 years), medium-term policies (1–10 years), and long-term policies (1–20 years). Along with this, the government is trying to explore a way to manage these three phases for continuous development and to identify weaknesses and shortcomings in policy implementation. The management strategies of each sector are set differently according to the advice given by academics and analysts in national development management [1]-[2]. The management of Thailand's economic development plan in the short term, medium term, and long term is carried out in a number of ways, including: acquiring more market share in the international market and increasing the penetration into foreign markets to increase the export volume and diversify export products; dominating the market widely and continuously; promoting the industrial sector, both by foreign and domestic investors, to generate revenue as much as possible for Thailand. Thailand also has ways to attract investors, such as tax breaks and exemptions, especially for green technology, direct and indirect subsidies, and fee reductions [1]-[3].

There are measures which are deemed effective and part of the government's special support, including the promotion of tourism for foreign tourists, in order to generate cash inflow into the country, especially tourists from Europe, America, and China, by continually providing direct and indirect support [2]-[4]. Simultaneously, the promotion of domestic production and the reduction of imports remain in place. As for the case of imports, it has been focused on importing raw materials and producing domestic consumption in Thailand while increasing exports. Along with promoting and supporting domestic entrepreneurs with the ability to produce for potential exports, continuous support comes in different forms, including measures to encourage domestic entrepreneurs with the lowest interest rate borrowing and a longer repayment period; taxes are reduced to stimulate domestic production and consumption; and the tax elimination of certain goods [2]-[3], [5]. In addition, the government also supports social policies to promote continuous growth. The government has set various

measures and promoted various aspects, especially to raise the level of education and health for everyone. Such developments have been demonstrated to be successful and can clearly create a society for development, such as the illiteracy rate of about 10 percent [1]-[2]. The government also encourages the opening of more educational institutions at all levels, including sending students to study abroad with the provision of funding from the private sector [2]. Also, the government has promoted the labor force with the aim of enabling them to have a better life. However, the current minimum wage rate is significantly lower compared to the past [3]. In addition, the government has continued to implement social security policies, and people are seen as better off, with a better quality of life [2]-[3].

For the implementation of the aforementioned policies, it has been found that Thailand has consistently performed appropriately, resulting in an increased gross domestic production (GDP) growth rate [2], [6]-[8]. In terms of the social growth index, it has been found that the unemployment rate is much lower while people are engaging in higher education and better sanitation. 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, 2023). However, when considering the environment, Thailand's greenhouse gas emission rate from the past to present (1992–2023) has continued to rise, especially CO_2 emissions, which are seen to continuously increase and found to be higher than the carrying capacity. Especially in the industrial sectors, the CO_2 emission rate is higher than any other sector [9]. Navigation of Thai Waterways Act, B.E. 2546, 2023). The rate of increase in CO_2 emissions has increased by up to 75.45 percent (2023/1992). Although Thailand has imposed strict measures, it is still unfavorable for the country if the CO_2 emission rate continues to increase, as it will impose serious consequences and it will be difficult to correct them [9]-[10]. Enhancement and Conservation of National Environmental Quality Act, B.E. 2535, 2023). Therefore, the implementation of the sustainability policy becomes a national strategy to achieve sustainable development in both the medium and long term. This strategy can be realized only when economic, social, and environmental growth are simultaneously empowered. Once an ecosystem is destroyed, it is deemed impossible to restore it to its original state in a short time. From the study of related research, national strategy documents and meeting minutes domestically and internationally, it indicates that Thailand has formulated various policies, yet the country lacks the essential tools. Having the right, accurate, best tool is essential to help predict the future with the most accuracy, which, in the past, Thailand has been found to lack. Thus, the researcher has realized this need as a research gap, and therefore developed a new scenario management model to be used for research and decision-making in the country's future policy and planning, particularly the medium-term plan. This is because the plan can be improved and better reflects the shortcomings, if any, compared to other short-term and long-term plans [10]. If Thailand has quality research tools, it will result in successful and sustainable management of the country.

2. Literature Reviews

In this section, it sheds lights and provide depth discussion on current and previous studies on environmental laws in energy sector together with environmental policy management for sustainability realization. At the same, the discussion will bring about existing forecasting models used different levels in various contexts, but its relevancy to the topic remains significant. There are many streamlined research and studies working on explaining the connection of different relevant variables. Grecksch and Klöck [10] reviewed climate change adaptation during 2008 to 2018 with the deployment of the Earth System Governance network through the distributional perspectives of access and allocation to the adaptation. Upon analysis, justices, equity, and fairness are found to be the basis of all the dimensions for adaptation. Within the same network, Gupta and Lebel [11] presented a tool to comprehend the above perspectives in multi-disciplinary orientation with its application in water management and climate change. While Gonenc, Piselli, and Sun [12] demonstrated the dynamics of unfair access and allocation of environmental benefit from the global economic system upon reinvestigating their relationship from the Economic, Social, and Governance (ESG) project in 2008-2017. Gupta and Lebel [13] further found that international trade, investment, and aid are there to improve access and efficient resource allocation while reducing risk. Gupta and Tienhaara [14] further extended on the role of foreign investment in the areas of minerals, energy and water especially in developing countries. In consideration of the sustainable developments goals and inclusive development, Gupta and Vegelin [15] found that ecological and relational inclusiveness are fared less compared to social inclusiveness. Whereas Fernandez [16] indicated the positive impact of various policies in the trucking sector on environment, especially in air emissions reduction, as certain trucking characteristics are improved. This assessment was based under the North American Free Trade Agreement (NAFTA) with econometrics analysis. Quesada and Weikard [17] analyzed the International Environmental Agreements for biodiversity conservation by using a game-theoretic analysis, and found the impact lies within this agreement. To Busscher, Parra, and Vanclay [18], they applied an environmental justice framework to understand land grabbing in Argentina. Their study has indicated that existing injustices tend to be more pressing than land grabbing, resulting in unhealthy living, insecurity, and disproportion in social and environmental burden. Dooley and Gupta [19] methodized the governance by expertise approach to enhance the environmental mitigation effort with the consideration of land-based mitigation. Their study has extended a need of greater open political debate over various mitigation mechanism. Sandler [20] believed that capitalist exploitation leads to

social evils, and for the elimination, the norm of environmental debate should be brought into the table for a discussion; be it from market instruments or government regulation. Norren [21] analyzed the worldview of African philosophy of Ubuntu, the Buddhist Gross National Happiness, and the native American idea of Buen Vivir on the SDGs with the application of cross-cultural comparison. Upon their analysis, the SDGs are negatively viewed as they do not fully address the interconnection between human, nature, and well-being. Therefore, Sénit [22] articulated on various sustainability discourses in the public space through the negotiation tool of the sustainable development goals. The study later explains one of significant outputs, describing the bias in progressive sustainability discourses, where responsibilities are state-centric oriented.

In future prediction, exiting models and tools are necessary to review as to explore gaps and opportunities to improve when it comes to policy making and determination. Faran and Olsson [23] claimed that the carbon dioxide removal (CDR) is part of geoengineering mechanisms to combat climate change through an application of approach of risk–reward nexus (RRN). While Bardi, Ayouni, and Hamdaoui [24] deployed an Autoregressive Distributed Lag (ARDL) method to study the nexus between structural policies and economic growth in eight nations bordering the Mediterranean from 1975 to 2012. From their study, it contributes to support the positive connection of public expenditure on education and economic growth, especially better economic openness and incoming foreign directing investment. Conversely, Mykhnenko and Wolff [25] found negative impact of the above connection when political processes are upscaled. In principle, the transnational advocacy networks are designed to complement the European Union environmental legislative framework while strengthening the implementation of international agreements on pollution prevention and biodiversity protection. Through concrete discussion by Bocse [26], there has been proven that the environmental TANs are not as horizontal as per assumption made in the TANs literature. This finding is brought for another innovation in the networks, and expects to fulfil the above objective better. Shen and Faure [27] claimed that a strong government intervention leads to success in green buildings, which later help fulfill the national commitment under the Paris Agreement on Climate Change. Switzer, Gerber, and Sindico [28] explored the law and policy of the Chinese export restrictions and climate change consideration towards mineral access. By putting this dispute under the World Trade Organization dispute settlement system, their study shows that the litigation on such restrictions would destroy the legitimacy of the WTO. While Handrlica and Sancin [29] attempted to explore various nuclear liability regimes within the existing international conventions in the event of nuclear incidents due to natural disaster in Slovenia. Their study has found that no liability is determined for the operator of the concerned nuclear installation. Gupta, Pistorius, and Vijge [30] assessed the fragmentation set around the international financing mechanism REDD+ or fully known as Reducing Emissions from Deforestation and Forest Degradation in Developing Countries and related Forest Activities. Upon their analysis, the REDD+ Partnership has partially complemented the fragmentation in global environmental governance.

Upon reviewing of past related research, it has found that many researchers' gaps are observed. In this research, the best model was developed with proven validity and the absence of model spuriousity. The former models were seen as differently conducted as compared to this research. The research results derived from this research would be used for appropriately formulating Thailand's policies and plans during the specified period. And more importantly, this research could be appropriately applied to different sectors, allowing researchers to develop further knowledge and lead to the development of Thailand even better. For this research, a model called the SEM-var(1) model was constructed by using advanced statistics for research purposes. The steps are shown as follows:

1. Define latent variables and indicator variables in the SEM-var(1) model.

2. Test the stationary of indicator variables using the concept of Augment Dickey and Fuller [31]. The stationary is defined at the first difference I(1) level only.

3. Test co-integration at the same level I(1) where observed variables are stationary only using the theory of Johansen Juselius [32]-[33]

4. Model and analyze the influence of correlation from the SEM-var(1) model. [34]

5. Verify the validity, spuriousness, and goodness of fit of the SEM-var(1) model.[35]-[37]

6. Check performance using MAPE and RMSE of the SEM-var(1) model with other models, including the regression model, the ANN model, the BP model, the Fuzzy model, and the GM-ARIMA model. [38]

7. Forecast CO_2 emissions with the SEM-var(1) model under the new scenario policy of the sectors that appear in the highest scenario values from 2020–2029, totaling 10 years, as shown in Fig 1. [38]-[39]

8. Administrative measures.

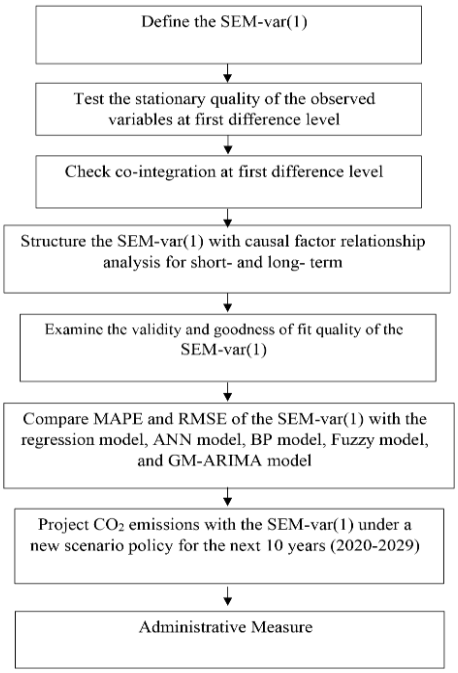

Fig. 1 The flowchart of the SEM-var (1) model.

3. The Material and Method

3.1 Structural Equation Modeling: SEM

Structural Equation Modeling (SEM) is a statistical analysis technique that combines analysis with the following names: Covariance structure analysis, Latent variable analysis, Confirmatory factor analysis, also abbreviated as LISREL, Analysis. Jöreskog developed it as a concept in 1969 and later as a packaged program LISREL [40]

SEM is an integrated approach between models that contain multiple equations at the same time to measure variable in psychology and sociology research. Factual variable, physical variable, and latent variable can all be found in equations. In other words, SEM is a great statistical technique for confirmation (confirmatory) research rather than exploratory research. It is commonly used to determine whether a model is based on a theory, review related research in a causal relationship, and examine how accurate the causal model is compared to real data. As a result, it is used to find a feasibility analysis of the model rather than a suitable model. In psychology and sociology research, variable measurement focuses on determining the construct validity of latent variable that compose a set of indicators. This is an instance of confirmatory factor analysis. In addition, SEM analysis could still identify the disparities. In practice, researchers can simultaneously analyze either variable. [41]-[43]

3.2 Estimation of Parameters in the SEM-var(1) model

In the path map of the structural equation model, there are a number of parameters to be estimated, including the correlation coefficient. Errors in measuring route coefficients and deviations from predictions Estimation is based on solving the equations in each path to the data obtained by a correlation matrix or a convolution matrix for the technique used to estimate the parameters. [43]

1. Maximum Likelihood (ML), a popular technique, is used to estimate data with a normal distribution.

2.Generalized Least Squares (GLS), Generally Weighted Least Squares (WLS), and Asymtotically Distribution Free (ADF) are estimated when the data has a nonnormal distribution. ADF, in particular, is a simple estimating technique. Although the outcome of a distribution does not follow a normal distribution, a large sample size is required for estimation.

3.3 Measurement Model Fit Conformance Examination

In the measurement model of each latent trait variable, three model conformances must be examined**:** [37]-[40]

1. Singularity of a set of indicators denotes the fact that a set of indicators or sets is unidimensional. Questions that assess latent attribute variables can be combined into a single element or have only one dominant element. A singularity test uses corroborative component analysis (CFA) to show that a set of metrics contains a single latent attribute that must be measured, which is an important part of demonstrating the accuracy of the classification. Discriminant validity refers to the degree to which one latent trait variable differs from the other. The average variance extracted from the two latent trait variables that is greater than the square correlation can also be used to validate discriminant validity. It is a more precise value than taking into account the correlation coefficient between the two variables.

2. Reliability of the set of indicators refers to the set's internal consistency in each latent attribute variable. It is a numerical value that represents the degree of representation of a set of metrics' latent attribute variables or the accuracy of a measurement model.

$$construct reliability = \frac{(\Sigma \text{ standardized loading})^2}{(\Sigma \text{ standardized loading})^2 + \Sigma \varepsilon_j} \quad (1)$$

The calculation must be performed independently for each latent attribute variable, and the resulting value must exceed 50. The value of construct reliability represents convergent validity, which is the share of variance shared by all indicators in the same passive attribute variable.

1. Average Variance Extracted, which it is calculated from

$$\text{average variance extracted} = \frac{\Sigma(\text{standardized loading})^2}{n} \quad (2)$$

2. Construct Validity. It is measured by the coherence index between the hypothetical model and the empirical model.

3.4 Measuring Model Consistency with the Goodness of Fit Index

In SEM, there are three sets of model conformance indices: [37]-[39], [44]

1. Absolute fit indices

2. It is an overall fit test with chi – square test ($\chi 2$ - test). Therefore, the $\chi 2$ test is more of a consistency consideration than testing whether a given model is valid or not.

3. Considering the residual discrepancies or the difference between the members of the matrix of S and the members of the matrix of $\Sigma(\theta)$ whether it is a zero matrix or not, a residual matrix is obtained between the two matrices. When the difference between the members is not equal to 0, it means that the model specification has failed. This method is the easiest. Residuals are used to test whether empirical data and models based on hypotheses match up. This is done by looking at how well the data and models fit together. (Byrne, 2009)

-Root Mean Square Residual (RMR). The RMR approach calculates the error as the mean of the difference between the diagonal half members and the diagonal difference of the matrix. Consistent models should have mean tolerances close to 0. In other words, RMR is an index that measures the average difference between the data and the theoretical model based on a sample of data differences (the average of the fitted residuals).

$$\text{RMR} = \left[2\sum_{i=1}^{p+a}\sum_{j=1}^{1}(S_{ij} - \hat{\sigma}_{ij})^2 / (p+q)(p+q+1) \right]^{1/2} \quad (3)$$

-Root Mean Square Residual error of approximation (RMSEA) of Joreskog & Sorbom [39],[41] is calculated from the formula

$$\text{RMSEA} = \sqrt{\frac{(\chi^2 - df_k)}{(N-1)}} \quad (4)$$

According to Joreskog and sorbom [37] an RMSEA value of 0.05 indicates a good level of consistency when using this method for calculating the degree of freedom variance. If the value increases to 0.08, the population estimate is inaccurate [45]-[46]. The RMSEA readings are still unclear. Is the result still deemed consistent if it deviates from 0.05 by a small margin? Using a sample size of 500 or more, the study determined that the RMSEA value was adequate for use in confirmatory models and competing models [42].

-The Normed Fit Index (NFI) of Bollen

-Incremental Fit Index (IFI) of Bollen [37]

-Relative Fit Index (RFI) of Bollen [37]

-Tucker-Lewis Index (TLI) or Non-Normed Fit Index (NNFI). This measure was intended to mitigate problems with the mean of the sampling distribution. RFI and NNFI both modify the baseline df of the model. The NNFI value varies between 0 and 1. When NNFI = 1, the model is most accurate. [37] discovered that the relationship between sample size and the mean sampling distribution of this indicator was minimal. As the sample size increased, the RFI and NNFI values approached parity.

-The Comparative Fit Index (CFI). CFI is a modified version of Bentler and Bonett's NFI. The normative range for the CFI is 0 to 1. This index is not influenced by the model's complexity. When the index is greater than or equal to.09, the model is consistent [35], [37].

-Goodness of fit index (GFI). The GFI compares the variance and covariance of S predicted by $\Sigma(\theta)$ quantitatively. When the model is consistent, the lowest fitting function is the numerator. The denominator consists of the consistent fit functions of the other models. Or, when all parameters are 0, use the following calculating formula: [37]

-Adjusted goodness of fit index (AGFI). It is calculated based on the GFI, but takes into account the number of variables measured and the size of the whole sample. AGFI is therefore an adjustment of the model's df. The formula is as follows: [35], [37]

-Parsimony Normed fit index (PNFI). PNFI has evolved from NFI multiplied by PR. [37].

-Bollen's Critical N (CN) [35], [37]

4. Empirical Analysis

4.1 Screening of Influencing Factors for Model Input

In this paper, the SEM-var(1) model has specified latent variables in three different sectors; economic, social, and environmental. The variables come with the indicator variables of 16 factors, consisting of income (GDP), the rate of urbanization (Uv), the structure of industries (Iv), trade balance (Emv), indirect foreign investment (Fv), employment rate (Esv), health and illness (Hsv), the prevalence of social security (Ssv), consumer protection (Csv), education rate (Esd), energy consumption (Eev), oil consumption rate (Oev), energy intensity rate (Eei), carbon dioxide emissions (CO_2), renewable energy rate (Erv), and green technology (Gev). The researcher conducts logarithm of those indicators and verifies them with a unit root test, resulting in all the indicators being non-stationary at level I(0). Hence, they are required to test at the first difference I(1) level as per ascribed below.

Table 1 The stationary test at level I(0) and the first difference I (1) level.

Tau Test				MacKinnon Critical Value		
Variables	Level I(0) Value	Variables	First Difference I(1) Value	1%	5%	10%
$\ln(GDP)$	-3.10	$\Delta\ln(GDP)$	-5.55***	-4.50	-3.75	-2.15
$\ln(Uv)$	-3.95	$\Delta\ln(Uv)$	-4.82***	-4.50	-3.75	-2.15
$\ln(Iv)$	-4.00	$\Delta\ln(Iv)$	-5.91***	-4.50	-3.75	-2.15
$\ln(Emv)$	-3.15	$\Delta\ln(Emv)$	-5.89***	-4.50	-3.75	-2.15
$\ln(Fv)$	-2.45	$\Delta\ln(Fv)$	-5.02***	-4.50	-3.75	-2.15
$\ln(Esv)$	-3.11	$\Delta\ln(Esv)$	-4.55***	-4.50	-3.75	-2.15
$\ln(Hsv)$	-3.00	$\Delta\ln(Hsv)$	-4.79***	-4.50	-3.75	-2.15
$\ln(Ssv)$	-3.74	$\Delta\ln(Ssv)$	-4.85***	-4.50	-3.75	-2.15
$\ln(Csv)$	-4.01	$\Delta\ln(Csv)$	-4.91***	-4.50	-3.75	-2.15
$\ln(Esd)$	-3.09	$\Delta\ln(Esd)$	-4.85***	-4.50	-3.75	-2.15
$\ln(Eev)$	-4.15	$\Delta\ln(Eev)$	-5.90***	-4.50	-3.75	-2.15
$\ln(Oev)$	-4.40	$\Delta\ln(Oev)$	-5.72***	-4.50	-3.75	-2.15
$\ln(Eei)$	-3.10	$\Delta\ln(Eei)$	-5.55***	-4.50	-3.75	-2.15
$\ln(Co_2)$	-4.19	$\Delta\ln(Co_2)$	-5.82***	-4.50	-3.75	-2.15
$\ln(Erv)$	-3.05	$\Delta\ln(Erv)$	-4.88***	-4.50	-3.75	-2.15
$\ln(Gev)$	-4.39	$\Delta\ln(Gev)$	-5.99***	-4.50	-3.75	-2.15

From Table 1, all indicator variables were non-stationary at level I(0) by considering the tau test, which was seen to be less than the MacKinnon critical value at 1 percent, 5 percent, and 10 percent. Therefore, the first difference testing was conducted and the result showed that the tau test of all indicators was higher than the MacKinnon critical value, indicating that all indicator variables at the first difference I(1) were stationary at a significance level of 1 percent, 5 percent, and 10 percent. The indicator variables were analyzed and tested for co-integration, which could be expressed as follows:

4.2. Analysis of Co-Integration

The researcher used all the stationary indicators at a first difference to analyze the long-term relationship by processing a co-integration analysis according to Johansen (1995). The analysis results are shown in Table 2.

From Table 2, it demonstrates that the indicator variables at the first difference were co-integrated, where the Trace statistic test and Max-Eigen statistic test, 120.11 and 99.07, respectively, are greater than the MacKinnon critical value at a significance level of 1 percent ($\alpha = 0.01$).

Table 2 Co-integration test by Johansen and Juselius.

Variables	Hypothesized No of CE(S)	Trace Statistic Test	Max-Eigen Statistic Test	MacKinnon Critical Value	
				1%	5%
$\Delta\ln(GDP)$, $\Delta\ln(Uv)$, $\Delta\ln(Iv)$, $\Delta\ln(Emv)$, $\Delta\ln(Fv)$, $\Delta\ln(Esv)$, $\Delta\ln(Hsv)$, $\Delta\ln(Ssv)$, $\Delta\ln(Csv)$, $\Delta\ln(Esd)$, $\Delta\ln(Eev)$, $\Delta\ln(Oev)$, $\Delta\ln(Eei)$, $\Delta\ln(Co_2)$, $\Delta\ln(Erv)$, $\Delta\ln(Gev)$	None***	210.50***	199.05***	15.50	14.45
	At Most 1***	120.11***	99.07***	11.15	10.50

4.3 Influence Analysis of Causal Factors Relationship

The influence analysis of causal factors in this research consisted of the economic sector, social sector, and environmental sector. The relationship between the short term and the long term was analyzed in order to demonstrate the influence of both direct effect and indirect effect, as shown in Fig 2.

Fig. 2 shows the results of an analysis of the relationship between causal factors and the influence of causal factors using the SEM-var(1) model. At a statistical significance level of 0.01, it is clear that the economic sector has both direct and indirect effects on the social and environmental sectors. The same is true for the social sector, which also has both direct and indirect effects on the economic and environmental sectors. In terms of the environmental sector, it has no direct effect and indirect effect on the economic and environmental sector at a statistically significance level of 0.01. The results of this research show that the economic sector has the ability to adjust to equilibrium most quickly, with the highest error correction mechanism (ECT_{t-1}) of -0.51 compared to the social sector and environmental sector. As for the structure of industries, it is an influential indicator on the economic sector the most, followed by the social sector, with an error correction mechanism (ECT_{t-1}) of -0.39.

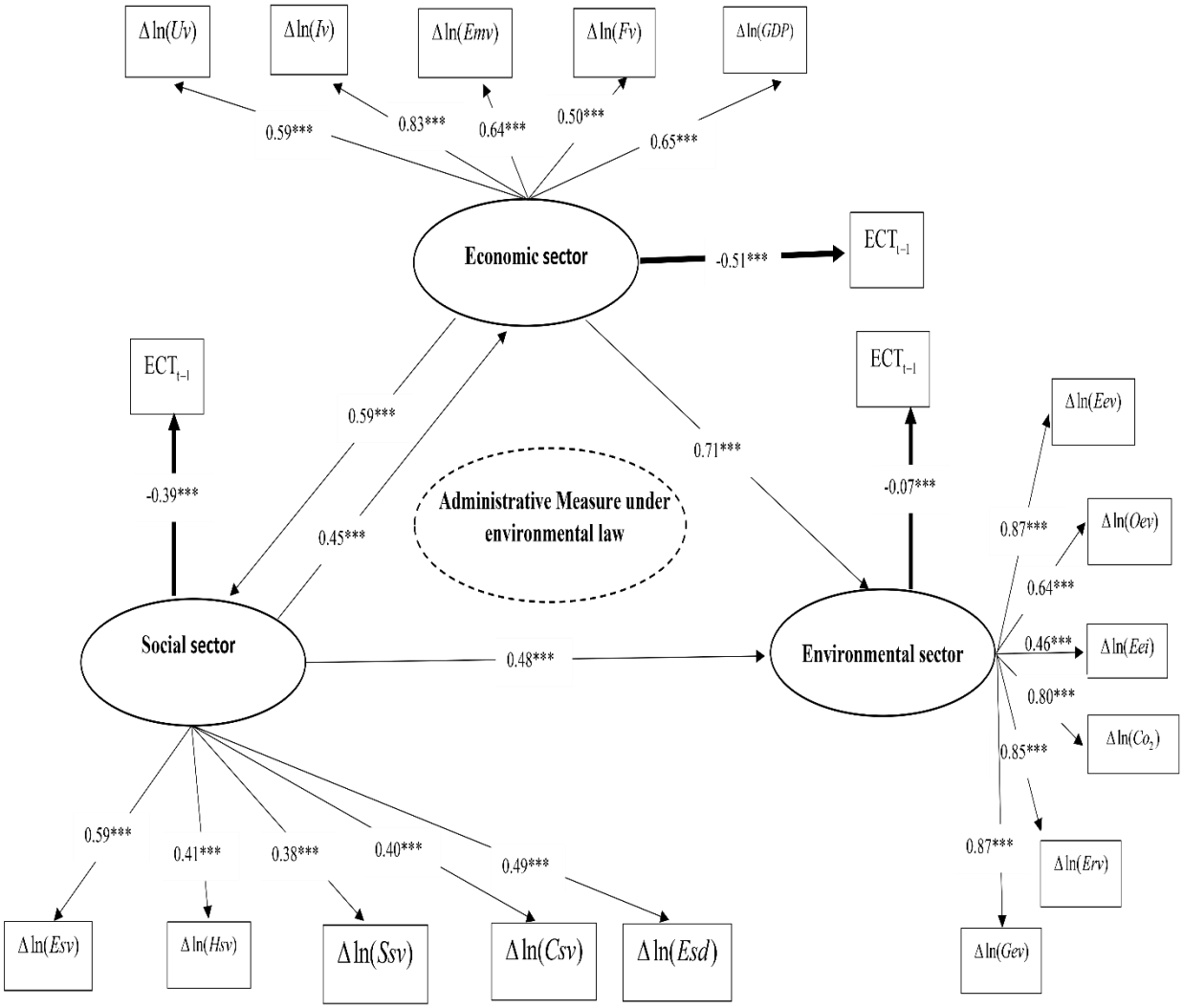

Fig. 2 Results of the analysis of the correlation of both short- and long-term causal factors.

While the most influential indicators are employment rate and the environmental sector. The results indicate that they both have the slowest adjustment ability to equilibrium, respectively, with an error correction mechanism (ECT_{t-1}) of -0.07. As for the indicators that have the greatest influence on the environmental sector, they are green technology and energy consumption. Based on this research, a scenario can be formulated using green technology and energy consumption to determine the country's next medium-term management plan. In addition, the researcher has shown details in Table 3 as follows:

Table 3 Results of relationship size analysis of the SEM-var(1).

Dependent Variables	Type of effect	Independent Variables			
		Economic	Social	Environmental	Error Correction Mechanism (ECT_{t-1})
Economic	DE	-	0.45***	-	-0.51***
	IE	-	-	-	-
Social	DE	0.59***	-	-	-0.39***
	IE	-	-	-	-
Environmental	DE	0.71***	0.48***	-	-0.07***
	IE	0.11***	0.05***	-	-

From Table 3, the SEM-var(1) model was tested for its validity and BLUE properties. The tests show the absence of spuriousity in the model, further explaining that the model does not encounter issues, such as heteroskedasticity, multicollinearity, and autocorrelation. The researcher also found that the model has a goodness of fit at all values; χ^2/df is 1.02, RMR is 0.002, RMSEA is 0.02, GFI is 0.88, AGFI is 0.95, R-squared is 0.96, the F-statistic is 172.50 (probability is 0.00), the ARCH test is 20.45 (probability is 0.1), and the LM test is 1.55 (probability is 0.10).

Based on the SEM-var(1) model, the researcher discovered the value of the error correction mechanism, which shows the ability to adjust to equilibrium. Within this research, the economic sector was found with the strongest ability, with an error correction mechanism (ECT_{t-1}) of -0.51 at a significance level of 1 percent, indicating the ability to adjust to equilibrium with a sensitivity of 51 percent. Respectively, the findings found that the social sector was the next in rank with an error correction mechanism (ECT_{t-1}) of -0.39 at a significance level of 1 percent, indicating the ability to adjust to equilibrium with a sensitivity of 39 percent. As for the environmental sector, it was found to have the slowest equilibrium capability, with an error correction mechanism (ECT_{t-1}) of -0.07 at a significance level of 1 percent. Therefore, defining a scenario shall take the economic sector as the first priority in formulating the strategy of Thailand. In addition, upon examining the performance, the results of the SEM-var(1) model and other models were concluded by using MAPE and RMSE values. The other models were the regression model, the ANN model, the BP model, the Fuzzy model, and the GM-ARIMA model as per explained below.

Table 4 The performance monitoring of the forecasting model.

Forecasting Model	MAPE (%)	RMSE (%)
Regression model	17.42	18.25
ANN model	9.08	9.77
BP model	7.14	8.59
Fuzzy model	5.05	6.05
GM-ARIMA model	3.48	4.03
SEM-var(1)	1.05	1.55

Table 4 shows that the SEM-var(1) model has the highest performance and is most suitable for application in Thailand's policy and planning tools compared to other former models. The lowest MAPE and RMSE values were 1.05 percent and 1.55 percent, respectively. The next model in rank was the GM-ARIMA model, with MAPE and RMSE values of 3.48 percent and 4.03 percent, respectively, followed by the Fuzzy model, with MAPE and RMSE values of 5.05 percent and 6.05 percent, respectively. The next in rank was the BP model, with MAPE and RMSE values of 7.14 percent and 8.59 percent, respectively. Later, the ANN model was also found with MAPE and RMSE values of 9.08 percent and 9.77 percent, respectively, followed by the regression model with MAPE and RMSE values of 17.42 percent and 18.25 percent, respectively.

4.4 CO_2 Emission Forecasting based on the SEM-var(1) model

From the results of the analysis, it was found that the SEM-var(1) model is a suitable model to be used in forecasting in the medium term (1-10 years). Therefore, the researcher defined a new scenario policy using a scenario of green technology (Gev) set by the government at least 20 percent according to sustainable development policy under environmental law and energy consumption (Eev), which is below the carrying capacity stipulated in 2022 under environmental law. In response to the findings, the researcher has used the SEM-var(1) model to perform CO_2 emission forecasting over the next 10 years (2020-2029) in order to understand the growth rate of Thailand's greenhouse gases in the future, as shown in Fig. 3.

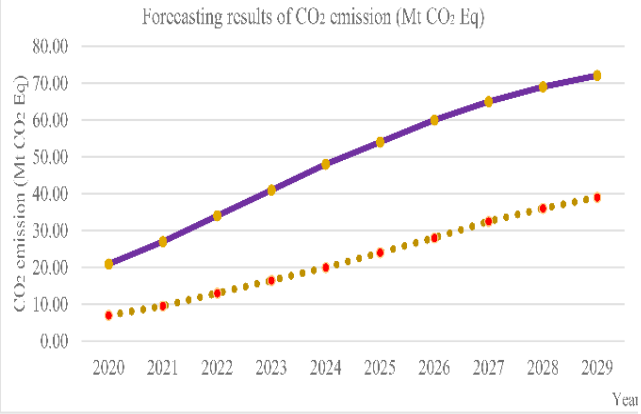

Fig. 3. The forecasting results of CO_2 emission from 2020 to 2029 in Thailand.

Fig. 3 shows that CO_2 emissions in the next 10 years are from 2020 to 2029 in Thailand, which is the medium-term forecast within the sustainability policy of the country. The results of the analysis show that CO_2 emissions continue to increase with an increased growth rate at a rate of 25.01 percent (2029/2020) or 72.05 Mt CO_2 Eq. (from 2020–2029), which is higher than the carrying capacity set below at 65.04 Mt CO_2 Eq. (from 2020–2029). Therefore, when the researcher defines a new scenario policy, it results in a future CO2 emissions growth rate at a continuous decreasing rate with an increase of only 7.05 percent (2020/2029) or 39.01 Mt CO_2 Eq. (from 2020–2029), which is lower than its stipulated carrying capacity.

5. Conclusion and Discussion

Referring to this research, it has created the SEM-var(1) model to analyze the correlation of causal factors of the core sectors; be it economic, social and environmental. Within these sectors, there are a number of variable indicators, including income (GDP), the rate of urbanization (Uv), the structure of industries (Iv), trade balance (Emv), indirect foreign investment (Fv), employment rate (Esv), health and illness (Hsv), the prevalence of social security (Ssv), consumer protection (Csv), education rate (Esd), energy consumption (Eev), oil consumption rate (Oev), energy intensity rate (Eei), carbon dioxide emissions (CO_2), renewable energy rate (Erv), and green technology (Gev). In addition, the model has incorporated new scenario policies on energy consumption (Eev) and green technology (Gev). From the research results, it has found that the economic sector has both direct and indirect effects on the social and environmental sectors. Similarly, the social sector has both direct and indirect effects on the economic and environmental sectors, whereas the environmental sector has only an indirect effect on the economic and social sectors. The effect was proven at a significance level of 0.01. Furthermore, the results also showed that the economic sector has the ability to adjust to equilibrium more quickly compared to the social and environmental sectors, and it was followed by the social sector. This outcome indicates that the environmental sector has the weakest ability to adjust to equilibrium. These findings were held to be imperative for governments to formulate a new scenario policy as a national strategy by defining green technology below 20 percent. Especially in the economic sector, the structure of industries was found to be the indicator that had the greatest influence on the economic sector. Also, environmental law says that the government needs to make energy use a new scenario policy in order to keep it within its defined carrying capacity and ensure sustainable development.

For this research, the SEM-var(1) model was developed for mid-term forecasting (2020–2029), which was deemed the most suitable model for future forecasting. It is the model with the highest performance compared to other models in the past. Different properties of the model were assessed in detail and accounted for use as a tool for policy-making and planning in Thailand. Upon comparing the forecasting outcome between the absence and the presence of the new scenario policy, it was found that future CO_2 emissions (2020–2029) are seen to generate different growth rates because the defined new scenario policy allows the decreased growth rate of CO_2 emissions while floating within carrying capacity. Hence, the SEM-var(1) model can be the best decision planning tool. Also, the results of this research can be used to make sure that Thailand has the right policies and plans for the future so that it can be sustainable.

A thorough review of relevant research was carried out, and a large number of both domestic and international studies in various sectors were revisited. This exploration allowed the researcher to discover a research gap in comparison to past research. The SEM-var(1) model is the first developed model that has applied research principles together with deploying advanced statistics to strengthen the weaknesses of past models. The model is appropriately perceived as useful to be used for further research and to generate a body of knowledge in research and academic circles. In addition, the highlights of this research can be appropriately applied to various sectors and contexts in the absence of spuriousity, as has been found in other models in the past. Upon applying the model for long-term future forecasting, it is proven to be particularly suitable because of its primary development for medium-and-long-term forecasting. This research can be used as a starting point for more research, especially mixed-method research, by all researchers and people interested in different fields of study.

In this research, the researcher has chosen to use LISREL software along with EVIEWS software in order to create a body of knowledge as well as future research. At the same time, the selection of indicators must be made thoroughly and cover the relevant sectors. Additionally, the new scenario policy must be developed from the findings of research only. If research findings are not considered, the model will not be able to help formulate proper and appropriate policies. Yet it may result in a large error in future forecasting, which will cause more harm than good, ultimately leaving the country with no solution. Within those constraints, being the first research in the field necessitates careful consideration of an appropriate conceptual framework. It, thus, relies on advanced statistical knowledge and the application of model advantages and disadvantages in a proper manner. As a result, the findings may require more time to analyze comparatively, and more research should be done in order to identify weaknesses. However, due to the lack of data in mixed research, only quantitative research was developed. In fact, the researcher has relied on the knowledge, capabilities, research experience, and research ideas to produce research of the highest quality and most beneficial to Thailand and other countries in the future.

For this research, it was conducted using a qualitative approach to seek solutions in determining an administrative measure for use of environmental management in Thailand. The details are as follows.

The problem of the degradation of natural resources and the environment has become an important problem that requires cooperation from many countries around the world. This can be seen in three United Nations environment summits to call on the international community to become aware of the problem, together with the presentation of the principles and concepts of global environmental management, as follows:

Sustainable Development aims to balance development in the economy, society, and the environment. It is to be ensured that the economic prosperity of a country, the formation of stability in public welfare, and the good health of the people must go hand in hand with the protection and preservation of environmental quality for the benefit of all generations.

The Pre-protection Principle aims to apply the best methods or technology at a particular time into practice or operation and claims that the clarity of scientific data or no other information supports the potential harm or damage to humans and the environment. The means of using the best method or technology and related to the principles of action is to take any action to prevent damage to humans and the environment.

The Environmental Risk Management Principle is to carefully study the likelihood or probability of the risk of damage to the environment and human beings and choose the best method of managing environmental risks by taking actions to reduce or avoid the risk of damage to the environment as well as humans.

The Polluters' Pay Principle is to allow the person who causes environmental damage to bear the cost of preventive action and repair or restore damage, including compensation for bodily injury and property.

The Liability and Compensation Principle is to develop the country's environmental liability law to be in accordance with the polluter principle, compensating damages and restitution to the victims, including the cost of repairing the damage.

The principles and concepts of environmental management are the national guidelines for many countries, including Thailand, to use in formulating environmental management policies and developing laws for environmental management accordingly, which will be beneficial to protection, prevention, and solutions to environmental issues.

Enforcement of environmental management laws is an important government tool for protection, prevention, and solution of environmental problems. For the enforcement of environmental laws in Thailand, it evolves around environmental laws such as the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), and the Factory Act, B.E. 2535 (1992). The laws are used as core command and control measures, including taking civil measures for liability and compensation, and there are other promotional measures to ensure the compliance of the acts with the law. Command and control measures include administrative measures as primary measures to empower government officials to manage the environment, such as issuing orders for general use or secondary laws, and administrative sanctions, while criminal measures are also deemed important measures used to create conditions for strict compliance with the law. The criminal measures include imprisonment for a period of time and heavy fines for the purpose of preventing wrongdoing or preventing violations of the law. A civil measure is a measure adopted for the purpose of having the polluters responsible for their actions in compensating the victims of bodily or property damage from the actions of the offenders or compensating more easily by designating civil liability as strict liability.

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