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Seeing Domestic and Industrial Logistic in Context of CO₂ Emission: Role of Container Port Traffic, Railway Transport, and Air Transport Intensity in Thailand

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ABSTRACT

CO₂ emission has becoming a global issue with its increasing intensity and quantity. There are various factors that have been found that affect CO₂ emission positively or negatively. In this study, the author has selected three independent variables i.e., container port traffic, railway transport and air transport intensity so that their impact can be studied on CO₂ emission. The author has gathered data from Thailand in context of the above-mentioned variables for 27 years. After application of several tests and approaches such as unit root tests, co-integration test and VAR model estimation, the results of these approaches have been obtained. The order of integration, scholastic properties, co-integrated relationships and short and long run relationships have been explored by the use of these approaches. According to these results, the impact of all the independent and control variables have been found as significant on CO₂ emission. After the detailed discussion of results obtained by the author, some of the benefits related to this study have been discussed. These benefits may be for many people such as researchers, government and other authorities.

Keywords: Domestic and Industrial Logistic, CO₂ Emission, Container Port Traffic, Railway Transport, Air Transport Intensity

JEL Classifications: L92, L93

1. INTRODUCTION

The role of good logistic performance with low carbon emission is highly recognized, because of key role of transport sector in carbon dioxide emission. Rising CO₂ emission, a main component of greenhouse gas emission, in emerging economies has captured the attention of analysis (Anderson et al., 2016; Zhang and Da, 2015). According to anecdotal evidence, the CO₂ emission has increase multifold during last couple of decades. Increasing CO₂ emission is mainly emanated by the transport sector, domestic logistic, industrial and agriculture output (Oshiro and Masui, 2015; Yao et al., 2016; Yu et al., 2017). Moreover, energy generation process is also skewed towards the nonrenewable resources such as crude oil and natural gas. In addition, use of nonrenewable energy in the logistic sector also aggravating the carbon dioxide emission in the country.

This manuscript aims to explore the impact Thailand's domestic logistic on the carbon dioxide emission in the country. This study particularly investigates the role of container port traffic, railway transport, and air transport intensity in carbon dioxide emission in Thailand. Few studies also support the role of country's logistic on the carbon dioxide emission (Zhang et al., 2019). The key reason behind the intensive carbon dioxide emission is mainly derived from the use of nonrenewable energy resources and fossil fuels in transport sector in Asian countries. Pongthanaisawan and Sorapipatana (2013) also supported the fact that rising crude oil demand in transport sector of Thailand is also aggravating the CO₂ emission. The study employed the time series data of Thailand from 1989 to 2007 to explore the linkages between energy demand in transport sector and CO₂ emission. Furthermore, the study also forecast the future trend and relationship between two variables for

2030. In addition, the study also proposed that two reform scenario which may control the emission of CO₂ in Thailand such as: fuel shifting in transport sector and energy efficient transportation.

Rising carbon dioxide and greenhouse gas emission in Thailand has become a matter of concern for policy makers. Currently, Thailand has made effort to keep the CO₂ emission below the global average, yet the more miles need to go for efficient energy generation to control environmental degradation (Hossain, 2011; Lee et al., 2013; Yildirim et al., 2014; Ahmed et al., 2017a; 2017b). Therefore, in order to meet Paris Agreement, country has to strive to control CO₂ emanation by fuel switching to renewable energy options. Various studies in the literature has explored the impact of renewable energy resources on carbon dioxide emission (Budzianowski and Postawa, 2017; Leung and Yang, 2012; Saidur et al., 2011). Uniqueness of this research is to empirically measure the impact of container port traffic, railway transport, and air transport intensity on CO₂ emission in case of Thailand. The study aims to tamp gaps in literature of carbon dioxide emission in Indonesia by employing the multivariate time series model to empirically estimate the role of Thailand domestic logistic on CO₂ emission.

This study has following objectives:

- To explore the impact of container port traffic on carbon dioxide emission in Thailand
- To investigate the role of railway transport in carbon dioxide emission of Thailand
- To measure the contribution of air transport in CO₂ emission in Thailand

The past studies in literature on checking carbon dioxide emanation has very positive and feasible policy implications (Grubb et al., 2015; Khobai and Le-Roux, 2017; Waheed et al., 2018). Those studies enable the policy makers and environmentalist to pay substantial importance to adoption of renewable energy resources in transport, to control degrading environment and carbon dioxide emission. Moreover, previous studies have extended the scope of forthcoming research on the basis of robust theoretical framework. The aim of this research is to serve on the same lines. The study is organized as follows: Section two shed lights on the theoretical back ground and literature review; Section three discusses methodology and data analysis; Section four enlightens about empirical findings of the study; and the last section includes concluding remarks and policy recommendation.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Industries are being held responsible for their life-cycle impact on environments. Likewise logistic industry is also responsible for its detrimental environmental impacts such as CO₂ and greenhouse gas emission. Therefore, in order to become more sophisticated industrial logistics need to pay attention on its energy efficiency (Van Woensel et al., 2001). Logistic Transportation is highly accountable for the environmental degradation, due to emanation of hazardous gases. Such hazardous emission not only

responsible for environmental degradation but also escalate the natural resource rents. Saleem et al. (2018) empirically explored the impact of air-railway transportation, bilateral aid flows, energy demand, and environmental degradation of next 11 countries from the period of 1975 to 2015. The findings of their study confirm the environment Kuznets curve (U shape) relationship between Air-railway transports with CO₂ emission. The empirical findings also supported that railway and air transportation in logistic has positive contribution in exacerbating the emission of CO₂, whereas their impact on increasing natural resource rents are not significant.

2.1. Container Port Traffic and CO₂ Emission

Domestic logistic sector is highly transport intensive which is highly depended on the fuel based energy generation. Consequently, excessive consumption of fuel based energy in logistics has caused environmental security issues across the world. Liao et al. (2009) mentioned in their study that CO₂ emission of truck based transportation has high contribution in pollutant gas emission. It's also support the role of container and truck based logistics on the carbon dioxide emission. The study proposed the solution that substituting the long haul trucks with intermodal trucks can proved as good logistic solution of high CO₂ emission. According to Sim (2018) increasing international trade of South Korea has aggravated the emission of CO₂, particularly at container terminals of port. The increasing trade activity at container terminals of South Korea is intensifying the emission of hazardous gases. By employing system dynamic approach study depicts that container terminal of port annually produce 108.18 kg of carbon dioxide from mainly five processes: container maneuver, container at berth, container loading, container unloading, and transportation of container. The container maneuver comprises 51.13% of carbon dioxide emission, container unloading constitutes about 37.34% of carbon dioxide emission, and container delivery causes 9.92% of carbon dioxide emission.

Moreover, Cullinane et al. (2016) also empirically estimate the carbon dioxide emission from the containers at berth during 2012. The scope of their study is limited to three largest port of Taiwan such as: Taichung, Keelung, and Kaohsiung. The findings of the study indicate that Kaohsiung port is responsible for 58.7% emission in ports alone. Therefore, prudential measures to avoid the untoward environment situation are highly required to control CO₂ emission. Martínez-Moya et al. (2019) also investigated the impact of container traffic on carbon dioxide emission at Mediterranean area, situated in Valencia, Spain. The findings of the study illustrate the contribution of terminal tractors and rubber tire cranes in high CO₂ emission. They proposed in their research that replacement of tractors powered by fuel with tractors powered by LNG will mitigate the emission of CO₂ at terminals. Hence, on the basis of aforementioned studies following hypothesis is built: H1: Containers traffics intensity at port is positively associated with the carbon dioxide emission in Thailand.

2.2. Railway Transport and CO₂ Emission

Efficient logistic industry is attributing to efficient energy consumption in transportation of merchandize goods. Adoption of efficient energy transport has very key role in alleviating the carbon dioxide emission at ports which has severe environmental

consequences. Due to limitation in gathering carbon dioxide emission data at port because of privacy few empirical studies have found the relative energy efficiency of rail transport in logistics. However, few studies indicate the absolute positive impact of rail transport on CO₂ emission. Khan et al. (2018) empirically examine the contribution of air transportation, railways and container port traffic impact on energy demand, economic growth, and custom duties by using data of 16 lower income and 26 lower middle income economies from 1990 to 2015. By using panel data econometrics techniques, the study inferred the key role of railway transportation in high energy demand in logistics. However, despite of higher energy consumption of rail transport in logistic, its fuel efficiency is relatively higher than container transportation.

According to Regmi and Hanaoka (2015) the modal switch from road to rail transportation between Laos and Thailand along Laem Chabang Port–Thanaleng corridor has expected to down 30% carbon dioxide emission relative to baseline scenario. Likewise, Tao et al. (2017) also supported that modal shift from road transportation of goods to rail or water transportation has considerable potential to control the emission of CO₂ in port. For this purpose, study proposed analytical framework of subsidy to substitute road transport with rail transport in logistics. For analyzing the framework, face to face interviews and group discussion was conducted to fetch the essential data. The results of the research illustrate that carbon alleviation of 2586.8t may easily achieved by granting the 200 (Renminbi/20-feet equivalent unit) to shipper who both use rail and road transport in Yiwu City. Therefore on the basis of discussed literature following hypothesis is proposed:

H₂: Railway Transport in logistics has key role in increasing the carbon dioxide emission of Thailand.

2.3. Air Transport and CO₂ Emission

The contribution of aviation industry in environmental degradation has a great challenge for policy makers which are also seeking sustainable growth in the country. The environment social cost of aviation industry and transport cannot be negated. Zhou et al. (2016) indicated in their study that due to massive expansion of Chinese civil aviation industry from 1988, the demand of aviation fuel consumption drastically increased which led the high emission CO₂ in china. Study proposed the solutions to circumvent the massive emanation of greenhouse gasses due aviation industry such as: procurement of low carbon jet fuel, research on highly efficient and low fuel consuming aircrafts. Moreover, Fukui and Miyoshi (2017) also affirmed the role of air transport and aviation in carbon dioxide emission in the country. They quote the case study of USA aviation industry which was slammed with aviation fuel tax to check the emission of CO₂ in USA. For estimating the results, the study used simultaneous regression model of unbalanced panel data of US airlines from 1995 to 2013. The results of the study confirm the negative impact of fuel tax on energy consumption and CO₂ emission. Calculation of the study illustrates that increase in aviation fuel tax by 4.3 cent caused decrease in CO₂ emission by 0.18%. González and Hosoda (2016) also investigated the potential threats of aviation on environmental degradation due to CO₂ emission (Bakhtyar et al., 2017). In order to check the CO₂ emission by aviation industry in Japan, Aviation fuel tax is levied to control the consumption of fuel based energy.

By employing the Bayesian structural model of time series data of fuel consumption of Japan’s aviation industry from 2004 to 2013 the study found that lower aviation fuel consumption due to fuel tax decreased the CO₂ emission from jet. Therefore, it can be inferred that air transport intensity in logistics has also positive contribution in increasing the level of CO₂ emission in Thailand. Hence, on the light of above discussion the following hypothesis is built:

H₃: Air transport in logistics has positive impact on increasing the carbon dioxide emission of Thailand.

3. METHODOLOGY

3.1. Data

In this section, the first thing is to explain the data collected for research purposes in context of its database, time period, country of study etc. In this regard, the data for this study has been gathered for the variables such as CO₂ emission, container port traffic, railway transport and air transport intensity. This data comprises of the time period of 27 years and gathered from different sources in Thailand. The databases which have been used by the author in this regard include world bank and global economy, which are considered to be the most authentic sources for the purpose of data collection.

3.1.1. Model specification

The dependent, independent and control variables have been categorized and given measurement units as follows: CO₂ emission CDE is the dependent variable of this study that is measured in units of thousands of tons. The first independent variable, container port traffic CPT is measured by the units of number of twenty foot containers passing through the port. The next independent variable in the list is railway traffic intensity RTI and has been measured by the units of number of passengers using the railway service per day. The last independent variable, air transport traffic ATI has been measured by using the units of number of passengers using the air transport service per day. In addition to these variables, two control variables have also been included in this study. These control variables include population growth and energy consumption. Population growth POP has been measured by the units of number of people living in the country while energy consumption ENE is measured by the units of billion kilowatt hours. All the above mentioned variables are used in order to formulate the following regression equation:

$$CDE_t = \alpha + \beta_1 CPT_t + \beta_2 RTI_t + \beta_3 ATI_t + \beta_4 POP_t + \beta_5 ENE_t + \varepsilon_t$$

It must be noted here that CDE represents CO₂ emission in the above equation. In the same way, CPT shows container port traffic, RTI represents railway transport intensity, ATI represents air transport intensity, POP is used to denote population growth and ENE represents energy consumption. In the last, ε_t represents the error term.

3.2. Estimation Procedure

3.2.1. Unit root test

Application of unit root test is the next step after the collection of time series data and generating a regression equation. The

basic motive behind the use of this test is to explore the order of integration and stochastic properties of the variables. The use of these tests is necessary because the variables with specific order of integration provide accurate results when moved forward in the research process (Enders, 1995). Presence of random order of integration results in the ambiguous and unclear and even inaccurate results. This shows the importance of unit root tests. Several unit root tests are generally in use such as LLC and IPS and the author has opted LLC unit root test for this study. This test basically operates on the basis of null and alternate hypothesis where null hypothesis shows that unit root is present in the collected data and at the same time data is non stationary. The whole contrary concept is shown by alternate hypothesis which indicates that unit root is not present in the gathered data while it is in stationary state. As level and first difference series are involved in the unit root tests, if most of the variables of any series reject the null hypothesis, it will indicate that the data is stationary and vice versa.

3.2.2. Co-integration test

In the series of steps that are involved in research process, the next step is to determine and analyze the long run as well as co-integrated relationships between the variables. In general, co-integration tests are used for this purpose and order of integration is an important concept that must be satisfied before the application of these tests (Engle and Granger, 1987). In this study, the author has particularly applied two stage Engle Granger test that involves augmented Dickey Fuller as well as Dickey Fuller test (ADF and DF). Just like unit root test, null and alternate hypotheses act as basis on which the evaluation of the results of co-integration test depends. The null hypothesis is explained by the absence of co-integration between the variables while the alternate hypothesis is explained by the presence of co-integration among the variables. The following equation may be considered in this regard:

$$\Delta \hat{e}_t = \alpha_1 \hat{e}_{t-1} + \varepsilon_t$$

OR

$$\Delta \hat{e}_t = \alpha_1 \hat{e}_{t-1} + \sum_i \alpha_{i+1} \Delta \hat{e}_{t-1} + \varepsilon_t$$

3.2.3. VAR model

After the determination of order of integration and the presence or absence of co-integration between the variables, the long run and short run relationships between the variables can be effectively explored by using VAR model that was introduced by Sims (1980). VAR model is specifically designed for the economic time series data and a flexible framework of this model can be applied by the author in order to explore the economic time series data. As there is no confirmation of existence of long run relationships between the variables, therefore VAR model can be used with the condition that all the variables involved in the study are endogenous (Sims, 1980). This model can only be used if the data gathered is stationary. If it is non stationary, first difference must be applied in order to make it stationary. As a result of application of first difference, when the data becomes stationary, only then VAR model will be effective but will not involve error correction terms in the procedure. The following equation can be used in accordance with the VAR model:

$$\begin{pmatrix} \Delta A_t \\ \Delta B_t \end{pmatrix} = \alpha_0 + \alpha_1 \begin{pmatrix} \Delta A_{t-1} \\ \Delta B_{t-1} \end{pmatrix} + \alpha_2 \begin{pmatrix} \Delta A_{t-2} \\ \Delta B_{t-2} \end{pmatrix} + \dots \\ + \alpha_p \begin{pmatrix} \Delta A_{t-p} \\ \Delta B_{t-p} \end{pmatrix} + \alpha_{p+1} \begin{pmatrix} D_{t-4} \\ D_{t-4} \end{pmatrix} + U_t$$

In this equation, α_0 represents the constant, U_t is the innovation term.

The author may determine the number and lengths of lag by using AIC criterion. As discussed above, as VAR model is specifically used for economic related data, the relationship between different variables related to economics can be explored with the persistence of some chance of error in the results. A p^{th} order of VAR equation can be shown as,

$$Y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + e_t$$

4. EMPIRICAL RESULTS

4.1. Results of Unit Root Test

As the author has applied LLC unit root test in the study in accordance with the purposes discussed in the earlier section of the study, the results of LLC unit root test have been given in Table 1. Two distinct series i.e., level and first difference series can be clearly seen in the table along with their relative values. In the first series i.e., level, all the variables have accepted the null hypothesis except air transport intensity which indicates that the data in this particular series is having non stationary state. As the application of VAR demands that the data must be in stationary state, the first difference is applied on the data. This application of first difference results in the conversion of non-stationary data into stationary data. This is because of the fact that all the variables in first difference series have rejected the null hypothesis with different random significance levels. These results of LLC test can be summarized by stating that the collected data was non stationary in level series while becomes stationary when it is first differenced.

4.2. Results of Co-integration Test

As the author has applied ADF and DF tests of co-integration so that the presence of any co-integrated or long run relationship can be probed, the results have been given in the Table 2. According to

Table 1: Panel unit root test – LLC

Variable	Level	1 st Difference
CDE	-5.8254 (0.245)	-6.0274*** (0.000)
PCT	-5.2864 (0.244)	-4.2754** (0.000)
RTI	-6.2753 (0.464)	-9.2754*** (0.000)
ATI	-6.2642** (0.743)	-7.9136*** (0.000)
POP	-7.9273 (0.352)	-8.2864** (0.000)
ENE	-6.2486 (0.002)	-7.2874*** (0.000)

Here, ** represents the five percent significance level while *** represents ten percent significance level of rejection

Table 2: Co-integration test

Co-integration	CDE	PCT	RTI	ATI	POP	ENE
Dickey Fuller	-4.196	-5.174	-3.275	-2.264	-3.396	-5.375
Augmented DF	-5.278	-7.825	-5.024	-7.245	-8.542	-8.245

the results presented in the table, it is clearly evident that no value of any variable has rejected the null hypothesis of no co-integration in the current scenario. This shows that there is no co-integration or co-integrated relationship present between the variables included in the study. It can also be evaluated that no long run relationship has been identified in the results of this test. All this has happened because of the acceptance of null hypothesis of no co-integration by all the variables.

4.3. Results of VAR Model

After the exploration of order of integration and long term relationships between the variables, the author has used VAR model in order to explore the short term relationships between the variables. The results obtained by the application of this model have been presented in Table 3. There are certain factors in the table that enhance the significance and validity of the results obtained by VAR model application. One of the most important indications in this regard is that the value of F statistic is greater than one and in the same fashion, the value of R square lies between zero and one. The impact of independent and control variables can be effectively studied by the use of results shown in Table 3. In the table, it can be clearly seen that container port traffic has significant impact on air transport intensity with significance level of 1%. In the same

fashion, railway transport intensity has significant impact on all the other independent and control variables with the significance level of 1, 5 and 10% randomly. The impact of air transport intensity has also been found as significant on air transport intensity with 10% significance level. Similarly, the control variables show their own impacts on different variables accordingly with different significance levels. To put these results in a nut shell, it can be said that all the independent and control variables have significant impacts on other variables.

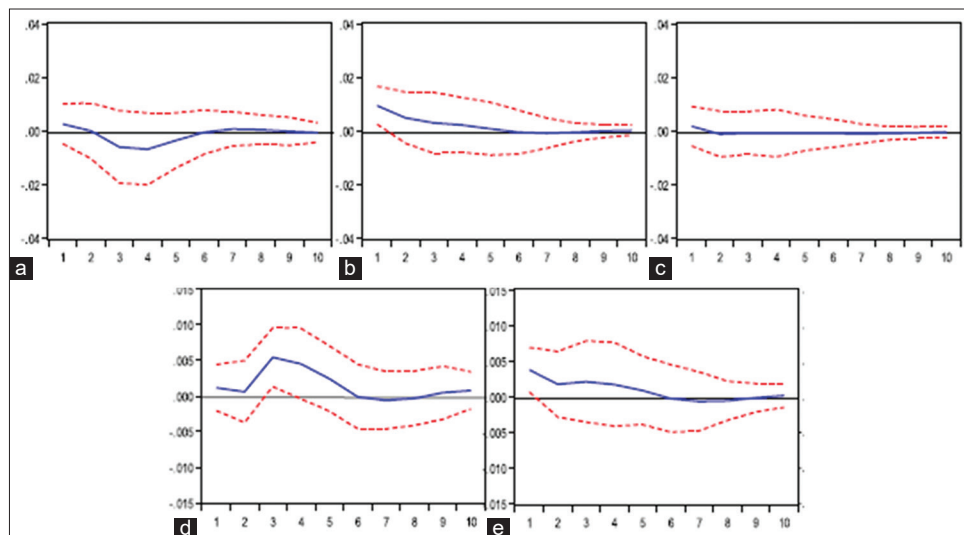
4.4. CC Response to Independent and Control Variables

In the Figure 1 given below, the responses of the independent and control variables have been determined to the shocks given by the dependent variable, CO₂ emission. These responses have been presented in the form of some graphs. In these graphs, the red line represents the limit set in accordance with the shock given by CO₂ emission while the blue line shows the response of the independent variables as well as control variables. The results will be smooth and accurate only when the response to the shock remains within the limit. If any of the red or blue lines crosses each other, it will create variation in the results. Therefore it is very much necessary that the blue line stays within the red line.

Table 3: Vector autoregressive estimates

VAR estimation	CPT	RTI	ATI	POP	ENE
CPT (-1)	0.826464***	-0.826483	0.286483*	-0.028643	-0.082464
CPT (-2)	-0.278648***	0.275246	0.193764	-0.028684	0.002453
RTI (-1)	-1.274648***	-0.286484*	-0.027684**	0.846824**	0.926388**
RTI (-2)	0.384679**	-0.273684***	-0.926842***	-0.724873**	-0.297468***
ATI (-1)	-0.274689**	-0.002486	0.825374***	0.027846	-0.028464
ATI (-2)	-0.284794***	-0.046826	0.713543***	-0.027548	-0.082648
POP (-1)	-0.284794***	0.286484**	0.613444***	0.538645**	0.002754
POP (-2)	0.826484***	0.024876	-0.522363	0.936484**	-0.927464***
ENE (-1)	3.182369***	0.926483***	0.483699***	-0.274568**	-0.284588*
ENE (-2)	-0.273648***	0.273684***	-0.397468***	0.274684**	0.926489**
C	23.28479***	-8.024768***	21.29748**	7.926490*	13.27368***
R-squared	0.286484	0.275784	0.275784	0.286485	0.836582
Adj. R-squared	0.725884	-0.273572	0.193649	0.597395	0.624345
F-statistic	8.826845	0.725384	25.29479	42.27595	25.24634

Figure 1: (a) CC Response to PCT (b) CC response to RTI (c) CC response to ATI (d) CC response to POP (e) CC response to ENE



5. DISCUSSION AND CONCLUSION

5.1. Discussion

As already discussed, this study was designed in order to study the impact of container port traffic, railway transport intensity and air transport intensity on CO₂ emissions. This impact was supposed to be studied in the presence of two control variables i.e., population growth and total energy consumption. Three basic hypotheses were designed in this regard. The first hypothesis that container port traffic has significant impact on CO₂ emission has been accepted by the results obtained by the application of various tests and approaches. The results obtained are in accordance with a previous study (Watanabe, 2004). The next hypothesis that railway transport intensity has significant impact on CO₂ emission has also been accepted in the study. This acceptance has been shown by another past study (Milford and Allwood, 2010). The last basic hypothesis was that the air transport intensity has significant impact on CO₂ emission. The results have also accepted this hypothesis as also discussed in past study (Alonso et al., 2014). Apart from these variables, two control variables, population growth and energy consumption have also been found to be significant in context of CO₂ emission. This result can also be found in a past study (Wei et al., 2007).

5.2. Conclusion

Container port, railway transport and air transport are the most important types of transports used in many countries for various purposes. This study has been conducted so that the impact of the traffic intensities of these types of traffic can be studied in context of CO₂ emission. The author has collected data from Thailand about these variables for 27 years from reliable data bases. Several tests and approaches were run on this collected data and results were obtained from them. The tests that were applied in the study include unit root test, co-integration test and most importantly VAR model estimation. These results showed that the impact of container port traffic, railway transport intensity, air transport intensity, population growth and energy consumption has significant and positive impact on CO₂ emission. After discussing results in detail, the author has identified various implications and benefits of this study. After that, some limitations have also been discussed by the author along with some recommendations to improve them.

5.3. Implications

Several theoretical, practical and policy making implications have been identified by the author in this study. This study provides literature and information about different transport systems such as container port, air and railway transport as well as their impacts on CO₂ emission in Thailand. Researchers may use this literature in their studies for review purpose and may also improve the scope of the study. In addition, this study may also provide assistance to transportation companies of ports, air and railway to come up with some ways to control CO₂ emission in the atmosphere. Less emission of CO₂ will result in the betterment of the environment. Moreover, this study may also guide the policy and regulation authorities of government to devise environment friendly policies by putting some limitations on transport companies so that the amount of CO₂ emission may be decreased in the atmosphere.

5.4. Limitations and Future Research Indications

First of all, the sample size of the data is very limited to be used for analysis purpose. The study involves only some specific concepts and techniques for the analysis of collected data. In addition, this study is limited to Thailand only. Another point in this regard is that the study is based on a few variables. The future researchers may take care of some points for conducting an effective research in future. They may look for other countries as well and use tests and approaches other than the ones that are used in this study. In addition to that, they may also increase the data sample size and may move to some other variables to increase the scope of their study.

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